905R88002

U.S. EPA Region 5 Waste Minimization/P2 Conference 1998

Sponsored by:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY REGION 5

David A. Ullrich, Acting Regional Administrator
Robert L. Springer, Director, Waste, Pesticides and Toxics Division

Presenters Include:

3M Company	Indiana Dept. of Environmental Management - Office of P2	Rayovac Corporation
AERC/MTI	Illinois State University	Rowan Catalyst, Inc
Argonne National Laboratory	Illinois Waste Management & Research Center	Roy F Weston
BASF Corporation	Industrial Towel & Uniform, Inc.	Screenprinting & Graphic Imaging Association International
Battelle Memorial Institute	INFORM, Inc.	STV Inc
Center for Neighborhood Technology	Iowa Waste Reduction Center	Tenneco Packaging
CMTI/Purdue University	Ispat Inland Inc.	The Excellence Group, Inc
Crown International Inc	Leonhardt Plating Company	United Technologies Electronics Controls
Cummins Power Generation	Madison Chemical Co.	University of Illinois Chicago
DaimlerChrysler	Michigan Manufacturing Technology Ctr. - Energy, Environment Health & Safety	University of Illinois - Champaign-Urbana
DOE - Kansas City Plant	Michigan Technological University	University of Minnesota Duluth
Dover Industrial Chrome	Minnesota Attorney General's Office	University of Wisconsin Extension
Eli Lilly and Company	Motorola, Inc	U S EPA Headquarters
EPI Electrochemical Products Inc	One Hour Cleaners	U.S. EPA Region 5
G E. Medical Systems	Printers' National Environmental Assistance Center (PNEAC)	Whirlpool
Hennepin County - Environmental Protection Division	Procter & Gamble	Wisconsin Department of Natural Resources
Honda Transmission Mfg (HTM)	Progressive Recovery, Inc.	

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Exhibitors Include:

Abonmarche Environmental Inc.	Competitive Edge Environmental Management Systems Inc	New Earth Concepts
AbsorbTech	Core Laboratories	New Protectaire Systems Co.
Airtech Environmental Services Inc.	Dexsil Corporation	Philips Lighting Co.
Argonne National Laboratory	DOE Kansas City Plant	RadTech International N.A.
BASF Corporation	EnviroPure Solutions	U.S. EPA
Branson Precision Cleaning	EPI	Wisconsin Department of Natural Resources
CETCO	Illinois Environmental Protection Agency	
Challenge, Inc.	Michigan Department of Environmental Quality	

Coordinated by:

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

Assistance provided by:

Chad Cliburn and Megan Gavin
U.S. EPA Region 5, Waste Management Branch

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

PROCEEDINGS MANUAL

December 14 - 16, 1998

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The United States Environmental Protection Agency (U.S. EPA) has compiled these abstracts to provide information which may be helpful in implementing Waste Minimization/P2 programs. However, U.S. EPA does not endorse any of these products or recommendations set forth in the enclosed abstracts. Furthermore, these abstracts have not been reviewed for conformance to regulatory requirements.

Section A-1

AGENDA

U.S. EPA REGION 5 WASTE MINIMIZATION/P2 CONFERENCE
AGENDA

Mon. Dec. 14th	Name/Organization	Title of Paper	Name/Organization	Title of Paper
8:30 am - 5:00 pm	Registration Desk will be open throughout conference			
	Keynote Speakers			
10:30 am - 12:00 pm	David A. Ullrich Acting Regional Administ. U S EPA Region 5	Plenary Speaker		
	James Carlson - Director of P2 and Remediation DaimlerChrysler	Plenary Speaker		
	Liz Cunningham - Director of Environment, Health and Safety Tenneco Packaging	Plenary Speaker		
	Thomas W. Zosel - Manager, Environmental Initiatives 3M Company	Plenary Speaker		
12 00 pm - 1 30 pm	LUNCH	LUNCH	LUNCH	LUNCH
1.30 pm - 3:00 pm	**General Case Study**		**Waste Minimization/Pollution Prevention Tools**	
	TBA		Mark Dorfman INFORM, Inc.	The Power of Right To Know Data To Track and Promote P2 of Persistent and Bioaccumulative Toxicants
	Roger Price/Bob Briggs STV Inc.	An Employee Driven WM/P2 Study at a Specialty Chemicals Plant	Christopher Start/Scott Wells Michigan Manufacturing Technology Center	MEDS: A Technology Decision Support Tool for Industrial Job Shops
	Curt Elliot Procter & Gamble	Waste Source & Cost Reduction at a Cosmetic Manufacturing Facility	Lee Paddock Minnesota Attorney General's Office	"Valuing" Environmental Performance
	Sherri Gruder University of Wisconsin Extension Solid and Hazardous Waste Educ Ctr.	Transport Packaging Savings	John Heckman Roy F Weston, Inc	P2 through Life Cycle Management
3 00 pm - 3 15 pm	BREAK	BREAK	BREAK	BREAK
	Laboratories		**Metal Pretreatment**	
3 15 pm - 4:45 pm	Peter Ashbrook/Todd Houst University of Illinois at Urbana-Champaign	Waste Minimization Options for the Laboratory Worker	Tom Barnett/Jim Sherman Ispat Inland Inc	Magnetic Separator Usage in Steel Processing Alkali Cleaning Solution Applications
	Keith Trychta Argonne National Laboratory	Waste Minimization and P2 Program at Argonne National Laboratory	Steve Hale/Sam George Madison Chemical Co , Inc	Metal Pretreatment Sealing Processes Containing No Chromium or Molybenum
	Kathy Carney Batelle Memorial Institute	Laboratory Pollution Prevention	Paul Randall U S EPA, NRML	Evaluation of Silanes to Replace Chromates in Metal Pretreatment Prior to Painting
			Keith O Legg Rowan Catalyst, Inc	Metal Finishing P2 by Chrome Plating Replacement
5 00 pm - 7:00 pm	Exhibitor Reception			

U.S. EPA REGION 5 WASTE MINIMIZATION/P2 CONFERENCE
AGENDA

Tues. Dec. 15th	Name/Organization	Title of Paper	Name/Organization	Title of Paper
	Alternatives to Solvents		**Metal Finishing**	
8 30 am - 10.00 am	Daniel Marks Progressive Recovery	Innovations in Solvent Recycling Systems	Eric Olander EPI Electrochemical Products Inc.	Alkaline Non-Cyanide Silver & Copper Plating Processes
	Shayla Barrett CMTI/Purdue University	Halogenated Solvent NESHAP Compliance Through Solvent Substitution and Pollution Prevention	Joseph Leonhardt Leonhardt Plating Company	Innovative Water Conservation at Leonhardt Plating
	Robert Fallon Eli Lilly and Company	Case Study: Alternatives to Solvents in Bulk Pharmaceutical Equipment Cleaning	John W Sutherland Michigan Technological University	Waste Reduction in Machining Processes
	Mark Waldrop BASF Corp.	A Process to Vacuum Vapor Degrease Metal Parts with N- Methyl - Pyrrolidone	N Rajogopalan Illinois Waste Management & Research Center	Putting the Squeeze on Metalworking Fluids
10:00 am - 10:15 am	BREAK	BREAK	BREAK	BREAK
	Printing		**Implementation/Guidance**	
10:15 am - 11:45 am	Dan Marx Screenprinting & Graphics Imaging Association International	Screen Printing P2 An Emerging Vision	Timothy Bock Crown International, Inc	Shifting Paradigms
	Joe Mattson Industrial Towel & Uniform, Inc.	New Solvent Recovery Technology for Launderable Printer Wipers	Dianne Dorland University of Minnesota, Duluth	Lurking Pollution Problems in Process Changes
	Allan Bartnik The Excellence Group Inc.	TQ Focus Yielded P2 Results	Dan McGrath Great Cities Institute, University of Illinois at Chicago	An Empirical Evaluation of the Adoption of Pollution Prevention
	Wayne Pferdehirt Printer's National Environmental Assistance Center-University of Wisconsin	Printer's National Environmental Assistance Center: Your Partner in Compliance and Waste Prevention		
11 45 am - 1.15 pm	LUNCH	LUNCH	LUNCH	LUNCH

U.S. EPA REGION 5 WASTE MINIMIZATION/P2 CONFERENCE AGENDA

Tues. Dec. 15th	Name/Organization	Title of Paper	Name/Organization	Title of Paper
	Painting/Coatings		**Electronics/Materials Management**	
1 15 pm - 2:45 pm	S Jean Hall CMTI/Purdue University	Reduction of Emissions via Technology Development in Conductive Plastics	Chaitanya Daiya Motorola Inc	P2- Make It Work
	Mark Dhennin Cummins Power Generation	Pollution Prevention Assessment of an Electrodeposition Coating System	Rudolph Dawson United Technologies Electronics Controls	Use of Silicone Conformal Coating on Circuit Boards at UT Electronic Controls
	Mary Jakeway Whirlpool Corporation	Air Emissions Reductions in the Painting Process	Stanley E. Childs U S Army Environmental Center	U.S Army Hazardous Substance Management System (HSMS) Implementation
2·45 pm - 3:00 pm	BREAK	BREAK	BREAK	BREAK
3:00 pm - 4·30 pm	**Vehicles**		**Dry Cleaning**	
	Sue Sommerfelt Iowa Waste Reduction Center	Taking Automotive P2 on the Road	Sylvia Ewing Center for Neighborhood Technology	Building Partnerships for P2 in the Fabri-care Industry
	Thomas Bierma Illinois State University	The Chemical Management Program at GM Electro-Motive Division	Dave Wintz Indiana DEM	Indiana's Five Star Program for Dry Cleaners
	Lee Sanders Honda Transmission Manufacturing	After the Party - The Real Value of ISO 14000 Certification	Chris Birk One Hour Cleaners	Waste Minimization and Compliance One Dry Cleaner's Story
5:00 pm - 7:00 pm	Exhibitor Reception			

U.S. EPA REGION 5 WASTE MINIMIZATION/P2 CONFERENCE AGENDA

Wed. Dec. 16th	Name/Organization	Title of Paper	Name/Organization	Title of Paper
	U.S. EPA Initiatives		**Recycling/Reuse**	
8:30 am - 10:00 am	Mary Setnicar U.S. EPA Region 5	Partners for Environmental Voluntary Programs	Raymond Balfour Rayovac Corporation	Who Supports Reusable Rather Than Single Use Products?
	Daniel Hopkins U.S. EPA Region 5	Persistent, Bioaccumulative and Toxic Initiative	William Wehrle BASF Corporation & Agricultural Container Research Council	Waste Minimization in the Agricultural Products Industry Update on the Agricultural Container Research Council
	Doug Heimlich U.S. EPA Headquarters Waste Minimization Branch	Draft RCRA PBT Chemical List	J J. Rao G.E. Medical Systems, NB-913	Recycling and P2 at G E Medical Systems
	Chad Cliburn U S EPA Region 5	Waste Minimization Projects within Region 5	Linda Sharkey AERC/MTI	Mercury in the Environment
10:00 am - 10:15 am	BREAK	BREAK	BREAK	BREAK
10:15 am - 11 45 am	**Air Emissions**		**State and Local P2 Initiatives**	
	Rick Bauer CMTI/Purdue University	Technical Assistance and Training Program Wood Furniture & Kitchen Cabinet Manufacturing NESHAP	Tim Lindsey Illinois Waste Management and Research Center	Proven Methods for Promoting the Adoption of P2 Innovations Case Study Examples
	Marcia Mia U.S. EPA Headquarters	Pollution Prevention in the Pharmaceutical Industry	Lynn Persson Bureau of Cooperative Environmental Assistance Wisconsin DNR	Wisconsin's Innovative Environmental Initiatives
	Ariel Schrodt Dover Industrial Chrome, Inc.	Elimination of Fume Emission in Hard Chromium Plating Through Use of A Perfluorinated Surfactant	Jake Smith Hennepin County Dept of Environmental Services, EPD	Promoting Pollution Prevention Activities for Hazardous Waste Generators in Hennepin County

SPECIAL THANKS TO THE FOLLOWING U.S. EPA MODERATORS:

Andrew Anderson.....Air Emissions Session

Duncan Campbell.....Metal Finishing Session

Megan Gavin.....Recycling/Reuse Session

Phil Kaplan.....U.S. EPA Initiatives Session

Mario Mangino.....Laboratories Session

Tom Matheson.....Alternatives to Solvents Session

Mike Mikulka.....Paintings and Coatings Session

Joel Morbito.....Implementation/Guidance & Electronics Sessions

Nate Nemani.....Metal Pretreatment Session

Denise Reape.....General Case Studies Session

Peggy Schwebke.....Dry Cleaning Session

Mary Setnicar.....Keynote Speakers Session

Dolly Tong.....Waste Minimization/P2 Tools Session

Donna Twickler.....State and Local Initiatives Session

Gary Westefer.....Printing & Vehicles Sessions

Section B-1

LIST OF SPEAKERS

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

Attn	FirstName	LastName	Title	Company	Phone/Fax	PaperTitle	Address
Mr	Peter	Ashbrook	CHMM, Assistant Director	Chemical Safety Section Division of Environmental Health and Safety University of Illinois at Urbana-Champaign	(217) 244-9278	Waste Minimization Options for the Laboratory Worker	Environmental Health & Safety Bldg 101 S. Gregory Urbana, IL 61801-3070
Mr	Raymond	Balfour	Vice President	Rayovac Corporation	(608) 275-4584 (608) 278-6666	Who Supports Reusable Rather Than Single Use Products?	601 Rayovac Drive Madison, WI 53711-2497
Mr	Tom	Barnett	Staff Engineer, Environmental Affairs Dept.	Ispat Inland Inc.	(219) 399-6296 (219) 399-1354	Magnetic Separator Usage in Steel Processing Alkali Cleaning Solution Applications	3210 Watling Street East Chicago, IN 46312
Mr.	Shayla	Barrett	Process Engineer	CMTI/Purdue University	(765) 463-4749 (765) 463-3795	Halogenated Solvent NESHAP Compliance Through Solvent Substitution and P2	2655 Yeager Rd. #103, W. Lafayette, IN 47906
Mr.	Allan	Bartnik	Senior VP Quality & Environmental Systems	The Excellence Group, Inc.	(812) 428-2350 (812) 429-9693	TQ Focus Yielded P2 Results	1405 W. Missouri Street Evansville, IN 47710
Mr.	Rick	Bauer	Professional Assistant	CMTI/Purdue University	(765) 463-4749 (765) 463-3795	Technical Assistance and Training Program Wood Furniture & Kitchen Cabinet Manufacturing NESHAP	2655 Yeager Rd. #103, W. Lafayette, IN 47906
Mr	Thomas	Bierma	Professor of Environmental Health	Illinois State University	(309) 438-7121 (309) 438-2450	The Chemical Management Program at 20 GM C6s Electro-Motive Division	5220 Health Sciences Illinois State University Normal, IL 61790-5220

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

Attn	FirstName	LastName	Title	Company	Phone/Fax	PaperTitle	Address
Mr	Chris	Birk	Owner	One Hour Cleaners	(765) 472-1319 (765) 472-3752	Waste Minimization and Compliance. One Dry Cleaner's Story	P.O Box 1249 Peru, Indiana 46970
Mr	Timothy	Bock	Environmental, Health & Safety Manager	Crown International, Inc	(219) 294-8341 (219) 294-8083	Shifting Paradigms	P O Box 1000 Elkhart, IN 46515-1000
Mr	Bob	Briggs	Environmental Scientist	STV Inc.	(412) 392-3500 (412) 392-3501	An Employee Driven Waste Minimization P2 Study at a Specialty Chemicals Plant	4 Gateway Center Suite 325 Pittsburgh, PA 15222
Mr	James	Carlson	Director of P2 and Remediation	DaimlerChrysler	(248) 576-7340 (248) 576-7369		800 Chrysler Dr. CIMS482-00-51 Auburn Hills, MI 48326-2757
Ms	Kathy	Carney	Manager, Hazardous Waste Operations	Battelle Memorial Institute	(614) 424-4935 (614) 424-4902	Laboratory Pollution Prevention	505 King Ave Columbus, OH 43201
Mr	Chad	Cliburn	Waste Minimization Coordinator	U S EPA	(312) 353-5617 (312) 353-4778	Waste Minimization Projects within Region on PBT Initiatives for EPA	77 West Jackson Blvd. Chicago, IL 60604-3590
Ms	Liz	Cunningham	Director of Environment, Health and Safety	Tenneco Packaging	(847) 576-6141 (847 576-2652		1900 West Field Ct. Lake Forest, IL 60045
Mr	Chaitanya	Daiya	Director of Environmental, Safety & Industrial Hygiene	Motorola Inc	(847) 576-6141 (847) 576-2652	P2 -- Make It Work	1301 East Algonquin Rd. Schaumburg, IL 60196

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

Attn	FirstName	LastName	Title	Company	Phone/Fax	PaperTitle	Address
Mr.	Rudolph	Dawson	EHS Manager	United Technologies Electronics Controls	(219) 358-3213 (219) 358-0695	Use of Silicone Conformal Coating on Circuit Boards at UT Electronic Controls	3650 West 200 N Huntington, IN 46750
Mr.	Mark	Dhennin	Materials Engineer	Cummins Power Generation	(612) 574-5886 (612) 574-8088	Pollution Prevention Assessment of an Electrodeposition Coating System	1400 73rd. Avenue, NE Minneapolis, MN 55432
Mr.	Mark	Dorfman	Senior Research Associate	INFORM, Inc.	(212) 361-2400	The Power of Right To Know Data to Track and Promote P2 of Persistent and Bioaccumulative Toxicants	120 Wall Street, 16th Floor New York, New York 10005-4001
Ms	Dianne	Dorland	Professor, Head Chemical Engineering Department	Dept of Chemical Engineering University of Minnesota Duluth	(218) 726-7127 (218) 726-6907	Lurking Pollution Problems in Process Changes	10 University Dr. Duluth, MN 55812-2496
Mr.	Curt	Elliott	Site Environmental Leader	Procter & Gamble Cosmetic/Fragrance Products	(410) 785-4482 (412) 785-4553	Waste Source & Cost Reduction at a Cosmetic Manufacturing Facility	11050 York Road Hunt Valley, MD 21030-2098
Ms	Sylvia	Ewing	Pollution Prevention Manager	Center for Neighborhood Technology	(773) 278-4800 (773) 278-3840	Building Partnerships for P2 in the Fabri-care Industry	2125 W. North Ave. Chicago, IL 60647
Mr	Robert	Fallon	Engineering Consultant	Eli Lilly and Company	(765) 477-4074 (765) 477-4822	Case Study. Alternatives to Solvents in Bulk Pharmaceutical Equipment Cleaning	P O. Box 685 Lafayette, IN 47902
Mr.	Sam	George	Vice President & Director of Corporate Affairs	Madison Chemical Co., Inc.	(812) 273-6000 (812) 273-6002	Metal Sealers Containing No Chromium or Molydbenum	P.O Box 1599 Madison, IN 47250

U.S. EPA REGION 5 WASTE MINIMIZATION/P2 CONFERENCE
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Attn	FirstName	LastName	Title	Company	Phone/Fax	PaperTitle	Address
Ms	Sherri	Gruder	Source Reduction & Recycling Specialist	Solid & Hazardous Education Center University of Wisconsin Extension	(608) 262-0398 (608) 262-6250	Transport Packinging Savings	610 Langdon St , Rm 527 Madison, WI 53703
Mr	Steve	Hale	Director of Research & Development	Madison Chemical Co , Inc	(812) 273-6000 (812) 273-6002	Metal Sealers Containing No Chromium or Molydbenum	P.O Box 1599 Madison, IN 47250
Mr.	S. Jean	Hall	Professional Associate	CMTI/Purdue University	(765) 463-4749 (765) 463-3795	Reduction of Emissions via Technology Development in Conductive Plastics	2655 Yeager Rd. #103, W Lafayette, IN 47906
Mr	John	Heckman	Project Manager, Strategic Environmental Management Practice	Roy F. Weston,Inc	(303) 980-6800 (303) 980-1622	P2 Through Life Cycle Management	215 Union Blvd Suite 600 Lakewood, CO 80228
Mr	Daniel	Hopkins	Regional Team Manager, Toxics Team	U S EPA Region 5	(312) 886-5994 (312) 353-4778	PBT Initiatives	77 West Jackson Blvd Chicago, IL 60604-3590
Ms.	Mary	Jakeway	Supervisor, Environmental Engineering	Whirlpool	(740) 383-7607 (740) 383-7507	Air Emissions Reductions in the Painting Process	1300 Marion-Agosta Rd. Marion, OH 43302
Mr	Keith O.	Legg		Rowan Catalyst, Inc.	(847) 680-9420 (847) 680-9682	Metal Finishing P2 by Chrome Plating Replacement	917 Warwick Lane Libertyville, IL 60048
Mr.	Joseph	Leonhardt	Environmental Manager	Leonhardt Plating Company	(513) 242-1410 (513) 242-0411	Innovative Water Conservation at Leonhardt Plating	5753 Este Avenue Cincinnati, OH 45232

U.S. EPA REGION 5 WASTE MINIMIZATION/P2 CONFERENCE
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Attn	FirstName	LastName	Title	Company	Phone/Fax	PaperTitle	Address
Mr.	Tim	Lindsey	Manager, Pollution Prevention Program	Illinois Waste Management and Research Center	(217) 333-8955 (217) 333-8944	Proven Methods for Promoting the Adoption of P2 Innovations: Case Study Examples	1 E. Hazelwood Drive Champaign, IL 61820
Mr	Daniel	Marks	President	Progressive Recovery, Inc.	(618) 286-5000 (618) 286-5009	Innovations In Solvent Recycling Systems	3210 Watling Street East Chicago, IN 46312
Mr	Dan	Marx	Senior Associate, Government Affairs	Screenprinting & Graphic Imaging Association International	(703) 385-1335 (703) 273-2870	Screen Printing P2 An Emerging Vision	10015 Main Street Fairfax, VA 22031
Mr.	Joe	Mattson	Product Manager	Industrial Towel & Uniform, Inc	(920) 729-6100 (920) 729-6707	New Solvent Recovery Technology for Launderable Printer Wipers	2700 S 160th St., New Berlin, WI 53051-3600
Mr.	Dan	McGrath	Research Professor	Great Cities Institute, University of Illinois at Chicago	(312) 355-1276 (312) 996-8933	An Empirical Evaluation of the Adoption of P2	College of Urban Planning and Public Affairs University of Illinois at Chicago, Chicago, IL 60607-7067
Ms.	Marcia	Mia	Chemical Engineer	U S. EPA, Office of Compliance	(202) 564-7042 (202) 564-0009	P2 in the Pharmaceutical Industry	401 M Street, SW 2224A Washington, DC 20460
Mr	Eric	Olander	Vice President	EPI Electrochemical Products Inc	(414) 786-9330 (414) 786-9403	Alkaline Non-Cyanide Silver & Copper Plating Processes	17000 W. Lincoln Ave New Berlin, WI 53151
Mr.	Lee	Paddock	Director of Environmental Policy	Minnesota Attorney General's Office	(651) 296- 6597 (651) 297-4139	Valuing Environmental Performance	900 NCL Tower 445 Minnesota St. St. Paul, MN 55101

U.S. EPA REGION 5 WASTE MINIMIZATION/P2 CONFERENCE
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Attn	FirstName	LastName	Title	Company	Phone/Fax	PaperTitle	Address
Ms	Lynn	Persson	Waste Minimization Coordinator	Bureau of Cooperative Environmental Assistance, Wisconsin DNR	(608) 267-3763 (608) 267-0496	Wisconsin's Innovative Environmental Initiatives	P O Box 7921 Madison, WI 53707
Mr	Wayne	Pferdehirt	Co-Director	Printers' National Environmental Assistance Center (PNEAC)	(608) 265-2361 (608) 262-6250	The Printers' National Environmental Assistance Center: Your Partner in Compliance and Waste Prevention	University of Wisconsin, Solid & Hazardous Waste Education Center 610 Langdon Street, Room 532 Madison, WI 53703-1195
Mr	Roger	Price	Sr. Environmental Engineer	STV Inc.	(412) 392-3500 (412) 392-3501	An Employee Driven Waste Minimization Pollution Prevention Study at a Specialty Chemicals Plant	4 Gateway Center Suite 325 Pittsburgh, PA 15222
Mr	N	Rajagopalan	Research Engineer	Illinois Waste Management & Research Center	(217) 244-8905 (217) 333-8944	Putting the Squeeze on Metal Working Fluids	1 E. Hazelwood Dr. Champaign, IL 61820
Mr	Paul	Randall	Engineer	U.S EPA National Risk Managment Research Laboratory	(513) 569-7673 (513) 569-7677	Evaluation of Silanes to Replace Chromates in Metal Pretreatment Prior to Painting	26 West Martin Luther King Dr. Cincinnati, OH 45268
Mr	J J	Rao	Manager- RCRA Compliance/Pollution Prevention	G.E Medical Systems, N8-913	(414) 785-5427 (414) 785-5322	Recycling & P2 at G.E Medical Systems	P O Box 414 Milwaukee, WI 53201
Ms	Lee	Sanders	Environmental Coordinator	Honda Transmission Manufacturing (HTM)	(937) 843-5555 (937) 843-4151	After the Party-The Real Value of ISO 14000 Certification	6964 St Rt. 235 N. Russells Point, OH 43348

U.S. EPA REGION 5 WASTE MINIMIZATION/P2 CONFERENCE
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Attn	FirstName	LastName	Title	Company	Phone/Fax	PaperTitle	Address
Dr	Ariel	Schrodt	President	Dover Industrial Chrome, Inc.	(773) 478-2022 (773) 478-0008	Elimination of Fume Emission in Hard Chromium Plating Through Use of A Perfluorinated Surfactant	2929 N. Campbell Ave. Chicago, IL 60618
Ms	Mary	Setnicar	Chief, P2 and Special Initiatives Section	U S. EPA Region 5	(312) 886-0976 (312) 353-4788	Partners for Environmental Voluntary Program	77 West Jackson Blvd. Chicago, IL 60604-3590
Ms	Linda	Sharkey	National Accounts Manager	AERC/MTI	(973) 691-7300 (973) 691-7326	Mercury in the Environment	3 Goldmine Road Flanders, NJ 07836
Mr	Jake	Smith	Environmentalist	Hennepin County Dept of Environmental Services, Environmental Protection Division	(612) 348-8146 (612) 348-8532	Promoting Pollution Prevention Activities for Hazardous Waste Generators in Hennepin County	417 N. 5th St. Minneapolis, MN 55401
Ms	Sue	Sommerfelt	Waste Reduction Specialist for the Mobile Outreach for P2 (MOPP) and Program Coordinator	Iowa Waste Reduction Center	(319) 273-8905 (319) 268-3733	Taking Automotive P2 on the Road	1005 Technology Parkway Cedar Falls, IA 50613-6951
Mr	Christopher	Start	Environmental Engineer	Industrial Technology Institute	(734) 769-4113 (734) 213-3408	The Manufacturing Environment Decision Support (MEDS) Tool	P O Box 1485 Ann Arbor, MI 48106
Mr	John	Sutherland	Professor, Associate Chair and Director of Graduate Studies	Michigan Technological University	(906) 487-3395 (906) 487-2822	Waste Reduction in Machining Processes	815 R. L. Smith ME-EM Bldg 1400 Townsend Dr Houghton, MI 49931
Mr	Keith	Trychta	Waste Minimization/ P2 Coordinator	Argonne National Laboratory	(630) 252-1476 (630) 252-7190	Waste Minimization and P2 at Argonne National Laboratory	9700 S. Cass Avenue Building 330 Argonne, IL 60439

U.S. EPA REGION 5 WASTE MINIMIZATION/P2 CONFERENCE
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Attn	FirstName	LastName	Title	Company	Phone/Fax	PaperTitle	Address
Mr	David	Ullrich	Regional Administrator	U S EPA Region 5	(312) 353-4778		77 West Jackson Blvd Chicago, IL 60604-3590
Mr	Mark	Waldrop	Market Development Specialist	BASF Corporation	(734) 324-6715 (734) 324-6749	A Process to Vacuum Vapor Degrease Metal Parts with N-Methal Pyrrolidone	1609 Biddle Ave Wyandotte, MI 48192
Mr.	William	Wehrle	Chairman of the Board, Agricultural Container Research Council	BASF Corporation	(919) 547-2113 (919) 547-2419	Waste Minimization in the Agricultural Products Industry Update on the Agricultural Container Research Council	26 Davis Drive Research Triangle Park, NC 27709-3528
Mr.	Dave	Wintz	Environmental Manager	Indiana DEM Office of P2/Technical Assistance	(317) 233-1184 (317) 233-5627	Indiana's Five Star Program for Dry Cleaners	P.O Box 6015 Indianapolis, IN 46206-6015

Section C-1

LIST OF EXHIBITORS

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

Company	Address	Phone	Product/Service
Abonmarche Environmental, Inc	95 W Main Street Benton Harbor, MI 49022	(616) 927-2295	Pollution Prevention Programs Develop contingency plans, RISK management plans, spill prevention control and counter-measures, stormwater pollution prevention plans, NPDES plans, NPDES permits, process safety management, spills in environmental media cleanups and hydrogeologic investigations.
AbsorbTech	421 Lexington Drive Buffalo Grove, IL 60089	(847) 520-5890	Launderable oil absorbents and solvent recovery for printer towels
Airtech Environmental Services Inc.	601A Country Club Drive Bensenville, IL 60106	(630) 860-4740	Airtech performs air emissions testing and monitoring.
Argonne National Laboratory	9700 S. Cass Ave., ITD 201 Argonne, IL 60439	(630) 252-9124	Argonne National Laboratory has developed cutting-edge technologies for pollution prevention, waste minimization and remediation of hazardous wastes in air, soil and water. Argonne's display will include information on the Laboratory's Technology Transfer Program and partnership opportunities, and highlight the accomplishments of the Laboratory's Waste Minimization and Pollution Prevention Program.
BASF Corporation	3000 Continental Drive Mount Olive, NJ 07828	(973) 426-2835	NMP is a highly polar, slow evaporating organic solvent that replaces ozone-depleting and other regulated solvents It is an excellent solvent for paints and coatings, including polyurethanes, epoxies, acrylics, nitrocellulose lacquers, and printing inks In addition, several plastics, including polystyrene, polyesters, and polyvinyl chloride are soluble in NMP. When heated, NMP is an excellent solvent for hydrocarbon oils, chlorinated paraffin drawing compounds, and even carbon deposits. NMP is not a hazardous air pollutant or hazardous waste, and it is readily degraded in sewage treatment plants
Branson Precision Cleaning	41 Eagle Road Danbury, CT	(847) 358-2499	Branson Ultrasonics is a manufacturer of vapor degreasers and aqueous ultrasonics cleaning systems.
CETCO	1350 W Shure Drive Arlington Heights, IL 60040	(800) 527-9948	Granular cross-linked polyacrylate super absorbent polymer that absorbs and retains large volumes of aqueous solutions Product comes in granular or pad form

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

Company	Address	Phone	Product/Service
Challenge, Inc.	7950 Georgetown Rd., Ste.200 Indianapolis, IN 46268	(317) 875-5068	Challenge develops, manufactures and markets environmentally sound industrial chemicals used in manufacturing processes Chosen markets include metal finishing, repetitive decorative painting and metal working fluids.
Competitive Edge Environmental Management Systems, Inc	2717 W. Argyle Street Chicago, IL 60625	(773) 784-8803	EMS Program Implementation, ANSI/RAB Certified Training, RAB Certified EMS Professionals, GAP Analysis and 3rd Party Auditing
Core Laboratories Inc.	2400 Cumberland Drive Valparaiso, IN 46383	(219) 464-2389	Environmental Laboratory Services
Dexsil Corporation	One Hamden Park Drive Hamden, CT 06617	(203) 288-3509	Environmental Field Test Kits.
DOE Kansas City Plant	2000 E. 95th Street Kansas City, MO 64131	(816) 997-2711	The KCP manufactures products using saft materials and processes eith the minimizatoin of waste and pollution, starting at the design stage reather than at the end of the manufacturing process. We have experience conducting process waste assessments and reengineering manufacturing processes to produce and replace hazardous chemicals We can share our expertise through a DOE-funded program for small businesses called the Small Business Technical Assistance Program, which offers assistance at no charge to U.S.-owned small businesses.
EnviroPure Solutions	100 Bridge Street Wheaton, IL 60187	(630) 871-1001	Water and wastewater treatement systems and services for industrial water users. Chemical and process waste minimization systems are also offered. Primary markets serves are metal finishers, electronics production and food processing.
Electrochemical Products Inc. (EPI)	17000 W. Lincoln Avenue New Berlin, WI 53151-2781	(414) 786-9330	Alkaline non-cyanide plating process for silver and copper
Illinois EPA	1701 S. First Ave., Ste. 600 Maywood, IL 60153	(708) 338-7863	IEPA Office of Pollution Prevention brochures describing Program Activities including Graduate Student Intern Program, P2 Facts sheets by Industry Sector including dry cleaner Star Program, Greater Printer Project, Small Business Program and Illinois Waste Management Center P2 Programs.

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

Company	Address	Phone	Product/Service
Michigan DEQ Pollution Prevention Section	P.O. Box 30457 Lansing, MI 48909-7957	(517) 241-8177	
New Earth Concepts	1370-N Nealon Drive Portage, IN 46368	(219) 764-0727	Environmental absorbents - oil/water separator and like products
New Protectaire Systems Co.	8N450-A Tameling Ct. Bartlett, IL 60103-9550	(847) 697-3400	Eliminates particulate emissions from paint spray booths. Paint recovery high payback Paint recovered can by used over in the plant Reduces hazardous material disposal. Paint sludge remover converting hazardous paint sludge to non-hazardous
Philips Lighting Co	650 E. Diehl Rd , Ste 101 Naperville, IL 60563	(630) 505-7785	Mercury reduced TCLP compliant fluorescent and high pressure sodium lamps and electronic ballasts.
RadTech International N.A.	3 Bethesda Metro Center, Suite 700 Bethesda, MD 20814		RadTech International N.A is a not-for-profit association dedicated to fostering technical, scientific and educational advancement in the manufacture and use of ultraviolet (UV) and electron beam (EB) curable products Samples of end use applications, a hands-on demonstration and RedTech publications will be featured
U.S. EPA	Waste Minimization National Plan 401 M Street SW MC5302W Washington, DC 20460	(703) 308-8489	Branch of the 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
Wisconsin DNR	P O. Box 7921 Madison, WI 53397	(608) 267-3763	The WDNR's Bureau of Cooperative Environmental Assistance (CEA) coordinates and integrates pollution prevention, waste reduction, business recycling, small business clean air assistance, hazardous waste minimization and other voluntary and innovative approaches to environmental protection within Wisconsin DNR CEA's Business Sector specialists can help you find compliance assistance and pollution prevention information specific to your business and can help your business be recognized for pollution prevention and ISO 14000 and other EMS efforts.

Section D-1

SPEAKER BIOGRAPHICAL SKETCH AND PRESENTATION MATERIALS

Peter Ashbrook
Raymond L. Balfour
Tom Barnett
ShaylaBarrett
Allan C. Bartnik
Rick J. Bauer
Thomas J. Bierma
Chris Birk
Timothy M. Bock
Bob Briggs
James Carlson
Kathy Carney
Stanley Childs
Chad Cliburn
Liz Cunningham
Chaitanya Daiya
Rudolph Dawson
Mark Dhennin
Mark Dorfman
Dianne Dorland
Curt G. Elliott
Sylvia Ewing
Robert T. Fallon
Sam George
Sherri Gruder
Steve T. Hale
S. Jean Hall
John R. Heckman
Doug Heimlich
Daniel Hopkins
Mary Jakeway
Keith O. Legg
Joseph Leonhardt
Tim C. Lindsey
Daniel Marks
Dan Marx
Joe Mattson
Dan T. McGrath
Marcia Mia
Eric Olander
Lee Paddock
Lynn Persson
Wayne Pferdehirt
Roger Price
N. Rajagopalan
Paul M. Randall
J.J. Rao
Jim Reed
Lee Sanders
Ariel G. Schrodt
Mary Setnicar
Linda Sharkey
James Sherman
Jake Smith
Sue Sommerfelt
Christopher Start
John W. Sutherland
Keith Trychta
David Ullrich
Mark Waldrop
William Wehrle
Scott Wells
Dave Wintz
Thomas W. Zosel

Peter C. Ashbrook/Todd A. Houts

Chemical Safety Section
Division of Environmental Health and Safety
University of Illinois at Urbana-Champaign

"Waste Minimization Options for the Laboratory Worker"

Biographical Statement

Todd A. Houts and Peter C. Ashbrook have jointly been responsible for the chemical waste management program at the University of Illinois at Urbana-Champaign for over 10 years. Information about this program can be found at http://www.ehs.uiuc.edu/~chem/. They write a column on laboratory waste minimization for *Chemical Health & Safety* magazine. Mr. Ashbrook is coeditor of the book, *Pollution Prevention and Waste Minimization in Laboratories*, published by CRC/Lewis Publishers.

Waste Minimization Options for the Laboratory Worker

Todd A. Houts, CHMM and Peter C. Ashbrook, CHMM
University of Illinois at Urbana-Champaign
Presented at the USEPA Region 5 Waste Minimization Conference December 14, 1998

Introduction

Chemical usage in laboratories commonly involves relatively small quantities of a wide variety of chemicals. In research laboratories, and other laboratories to a lesser extent, processes that use chemicals are frequently changing. As a result, waste minimization approaches that work well in industry are often of limited value in laboratories. On the other hand, waste minimization practices are sometimes easier to implement in laboratories because the individual worker is often the most appropriate person to implement these practices. In this presentation, we will examine waste minimization objectives for laboratories, followed by general and specific strategies.

Overall Objectives

When many people talk about waste minimization, they often focus only on reducing or eliminating chemical waste; however, this is not the underlying objective. We submit that for waste minimization to be successful, it must do at least one of the following:

- save time
- save money
- improve safety

Those pushing waste minimization would do well to remember these motivators.

General Waste Management Strategies

Briefly, general management strategies for chemical wastes in order of priority are:

- Waste reduction
- Reduce scale
- Recycle
- Reclaim (chemical and/or energy content)
- Treat (incineration or chemical treatment)
- Stabilization and landfill

Other Considerations

A common approach is to hire a Waste Minimization Coordinator. While this is a good start, the Coordinator should develop programs and procedures that result in permanent changes in the way of doing business, so that progress continues to be made after the Coordinator leaves the company. It is easy to start programs and have short term successes, but often these fade after the excitement of the initial efforts pass.

Unlike the situation in industry, waste minimization options for laboratories are usually not capital intensive. Waste minimization successes in laboratories are often achieved in quantities of less than one kilogram at a time. (Less than one fourth of our research laboratories generate more than 100 kg of waste in a year.) In most cases the labor involved in detailed studies of waste minimization options and the purchase of new equipment will need to be kept small to see any positive impact on time or costs. Therefore, we believe that providing laboratory workers with waste minimization tools and strategies is the most effective way of accomplishing waste minimization in laboratories.

Recommend Laboratory Waste Minimization Strategies

We have developed a list of ten strategies that can make a positive impact in most laboratories.

The first strategy is **good housekeeping**. One does not need to be neat to an extreme; however, if there is so much clutter that there is no counter space, workers will be inefficient. Likewise, if clutter has obstructed aisle space or safety equipment like eyewash units, safety showers, and fire extinguishers, accidents are more likely and safety is compromised in the event of an emergency. In the absence of good housekeeping, excess supplies are likely to be purchased and experiments may need to be run extra times to obtain good data, both of which result in extra waste generation. Lastly, in the event that a regulatory inspector visits your laboratory, the impression made by housekeeping will have a major influence on how the visit turns out. Good housekeeping comes at a price—some labor is involved to keep things clean and organized—but it is time well spent.

The second strategy is **label all chemical containers** with proper names (not codes). Proper identification of chemicals is essential if one wants to perform quality work, safely. When containers are not labeled, time and money are required to characterize the materials and disposal tends to be more expensive because of the uncertainties involved. Labeling is necessary to evaluate potential chemical hazards. No one wants to handle unlabeled chemicals because there is always the chance that something unexpected will happen. Proper labeling is essential in emergency situations, when laboratory workers are often unavailable to decipher codes.

A third strategy is to **document procedures.** Having documented procedures allows for the possibility of considering alternative procedures that may use fewer or less hazardous chemicals. Documented procedures also make it easier to evaluate potential hazards. Although it takes time to document procedures, the time spent is more than made up by standardizing procedures and for training new persons.

A fourth strategy is to **review procedures annually**. This strategy makes sense from a philosophy of continual improvement. The annual review, which need not be a big effort, can be made for efficiency reasons, cost concerns, and/or safety issues.

A fifth strategy is to **inventory chemicals annually**. An annual inventory meets several needs. One can dispose of outdated or deteriorated chemicals, some of which may present hazards. The inventory can identify purchase needs, so that experiments aren't held up for lack of the appropriate reagents. Lastly, the inventory is likely to result in organization of chemical storage

so that items can be found more easily.

A sixth strategy is to **centralize chemical purchasing**. Putting a single person in charge of chemical purchases in a laboratory may seem a bit bureaucratic. However, this strategy prevents duplicate purchases and reduces the amount of chemicals that may end up as waste or present hazards.

A seventh strategy is to **use alternatives to mercury**. Chemical wastes containing mercury tend to be much more expensive to dispose of than other chemical wastes. Equipment containing mercury, such as thermometers and manometers, break with distressing frequency. Using reagents or equipment that are mercury free eliminates the cost of disposal from spills and waste. From the safety point of view, mercury compounds tend to be pretty toxic; alternatives tend to be not as hazardous.

An eighth strategy is to substitute for **chromic acid cleaning solutions**. Many chemists were trained to clean all glassware with chromic acid. Chromic acid must be disposed of as a hazardous waste, even if it is neutralized first. It also presents a significant safety hazard as a strong oxidizing, corrosive acid. In many cases, such a strong cleaning agent is not required. Instead, alternative cleansers, some as innocuous as simple detergents, work just fine.

A ninth strategy is to **avoid lecture bottles**. Superficially, lecture bottles would seem to be a good idea because of their small size relative to regular compressed gas cylinders. From a waste minimization point of view, there are drawbacks because they are easy to lose track of and the cylinders themselves are usually not refillable. From a cost point of view, disposal is often extremely expensive, especially if the vendor won't take them back. Larger cylinders don't have these problems because they are rented and the entire cylinder may be returned to the vendor at any time. From the safety point of view, although lecture bottles have less material with which to present a hazard, they are much easier to squirrel away into nooks and crannies presenting unexpected hazards to unsuspecting individuals in the future. If you are uncomfortable with purchasing large cylinders, most vendors offer smaller cylinders that are a little larger than lecture bottles, but which are returnable and reusable.

The tenth, and last, strategy for this presentation is to **be prepared for spills**. This means providing secondary containment where liquids might spill, and having appropriate absorbents, neutralizing agents and proper personal protective equipment readily available. Having containment and spill prevention supplies will probably cause laboratory workers to perform duties more safely, minimize the area affected by a spill, and make spill cleanup as efficient as possible. Having appropriate personal protective equipment readily available will keep laboratory workers from being tempted to subject themselves to inappropriate risks in cleaning up spills.

Analytical Laboratories

In analytical laboratories, procedures tend to be better defined than in research laboratories and are more likely to be used repeatedly for relatively long time periods. Common waste minimization strategies for these laboratories are:

- use of automated equipment
- reduce scale
- use alternative techniques that don't generate hazardous wastes
- develop a good understanding of the study objectives to make sure that all analytical requests are necessary

Summary and Conclusions

This presentation was not designed to be comprehensive. Given the nature of this symposium, we have tried to select ideas and concepts that would supplement those in other presentations. Each laboratory has its unique aspects. Laboratory pollution prevention efforts will be most successful if the laboratory workers are viewed as allies rather than the enemy. While certain waste minimization procedures (e.g. good housekeeping) are applicable to all laboratories, it is impossible to become very specific with wastes minimization plans when a large number of laboratories are involved. We believe that the approach used by OSHA in its Laboratory Standard, under which each laboratory is required to have a Chemical Hygiene Plan but the specifics are to be prepared by each laboratory, would also have value for waste minimization. Such an approach puts the onus on the laboratory workers to identify waste minimization opportunities and to adopt policies to encourage their development.

Raymond L. Balfour

Rayovac Corporation

"Who Supports Reusable Rather Than Single Use Products?"

Raymond L. Balfour

EDUCATIONAL BACKGROUND

Engineering

Bachelor's degree, U. of Nebraska (1959)

Master's degree, U. of Nebraska (1961)

Law Cornell University (1964)

MBA Temple University (1971)

EMPLOYMENT AND PROFESSIONAL EXPERIENCE

Since 1965: Worked for major battery manufacturers

Since 1979: Vice President, Rayovac Corporation
Madison, Wisconsin

Past Chairman, Dry Battery Section of the National Electrical Manufacturers Association (trade association of U.S. dry cell battery manufacturers)

Since mid-1980's: Involved as industry representative with environmental issues about dry cell battery contents and disposal.

- Involved in policy making with members of legislatures and regulatory agencies.
- Speaker at environmental conferences.

WHO SUPPORTS REUSABLE RATHER THAN SINGLE USE PRODUCTS?

One of the most effective ways to minimize waste and prevent pollution is through reusable rather than single use products. But who supports this approach? The answers to this question may, to some extent, be product specific. But regardless of the product, a number of groups—users, manufacturers, and government and private environmental organizations—each have an interest, and their interests may differ.

To illustrate, I want to present a case study involving batteries and, more particularly, rechargeable alkaline batteries sold under the brand name "Renewal", which were introduced in the United States in 1993 by Rayovac Corporation. My case study requires comparisons of Renewal batteries with primary (i.e., nonrechargeable or single use) alkaline batteries and also with rechargeable nickel cadmium (Ni-Cd) batteries.

Comparative Attributes

Let's begin by comparing some of the principal attributes of the three product categories.

Many internal modifications were made to a primary alkaline battery to make it rechargeable. As a result of tradeoffs, the capacity of the Renewal battery is slightly lower than a primary alkaline on initial use, and there is a gradual capacity fade through the many successive cycles of use. But the resulting rechargeability allows each Renewal battery to replace seven or more primary alkalines. The actual number of obtainable cumulative hours of service, and the number of recharge cycles necessary to obtain those hours of service, depend upon a number of factors, such as depth of discharge, frequency of charging, type of application, and other user practices.

Renewal batteries are superior to Ni-Cds in many important respects. Renewal batteries:

- Are fully charged and ready to use when purchased;
- Hold their charge for five years in storage;
- Perform three times longer on initial use than a fully charged Ni-Cd; and,
- Have no memory problems.

Renewal batteries can be used in most of the applications where primary alkalines are used. And although Ni-Cds are necessary in cordless products requiring high energy drains (e.g., power tools), there are many household products in which Renewal batteries work as well as or better than Ni-Cds.

Pollution Prevention

Primary alkaline batteries, the most frequently used household batteries in the United States, have the environmental advantage of being nontoxic and safe for disposal in municipal solid waste. Since they are not rechargeable and presently are not economically recyclable, they have sometimes been criticized as an example of a "use it once, then throw it away" product.

Ni-Cds have the advantages of being reusable and recyclable, but are toxic because of their metal contents. Collection programs for these batteries are mandatory in several states, and a voluntary collection program is in effect in all other states.

Renewal batteries provide an important new pollution prevention alternative: a rechargeable, nontoxic household battery having performance characteristics similar to primary alkalines. The Renewal batteries represent a pollution prevention technology because:

- One Renewal battery can reduce the cubic volume of used batteries, since it can supply hours of service equivalent to seven or more primary alkaline batteries of the same size; and,

- In applications where a Renewal battery can be used as an alternative to a Ni-Cd, the Renewal battery reduces pollution caused by toxic metals.

Cost Savings

As many consumers have learned, "green" products often sell at higher prices than their environmentally inferior alternatives.

Not so with Renewal batteries, which offer a real "win-win" opportunity for battery users. The fact that one Renewal battery can replace seven or more primary alkalines of the same size means that, in addition to practicing pollution prevention and conservation, many battery users can save money by converting to Renewal products. It has been Rayovac's experience that the greatest appeal

of Renewal batteries to most consumers is the substantial cost savings which the batteries represent.

Government Recognitions

The environmental advantages of Renewal batteries have been recognized by several government authorities.

In February 1993, the Minnesota Pollution Control Agency concluded that the Renewal battery "...represents a significant environmental improvement over primary batteries ...[and] poses no unreasonable hazard when placed in and processed or disposed of as part of a mixed municipal solid waste". See Attachment #1.

In April 1996, Environment Canada, the Canadian version of the US EPA, authorized Rayovac to label Renewal batteries with the Environmental Choice Program Ecologo. Neither primary alkaline batteries nor Ni-Cds are eligible to use the Ecologo.

Under federal battery legislation signed by President Clinton in May 1996, Ni-Cds are expected to be collected. In addition, the US EPA is authorized to promulgate similar requirements for "...other rechargeable batteries...[that] are toxic and may cause substantial harm to human health and the environment if discarded into the solid waste stream for land disposal or incineration". But because they are already known to be safe for disposal in the solid waste stream, rechargeable alkaline batteries are excluded from this potential future regulation.

Earlier this year, the California Department of Toxic Substances Control issued a certification statement saying that "The Rayovac Renewal Rechargeable Alkaline Battery System is certified as a Pollution Prevention Technology.... Renewal Rechargeable Alkaline batteries can prevent pollution by reducing the quantity of disposed primary alkaline batteries of the same size in most applications for which the primary alkaline batteries are appropriate. Under standard laboratory test conditions, that simulated typical consumer product applications, after 25 charging cycles to specified voltage cutoff points at specified resistance loads, the Renewal system's batteries supplied hours of service equivalent to seven or more primary alkaline batteries of the same size." See Attachment #2.

The Greater Cincinnati Waste Free Fridays program is run by the City of Cincinnati Office of Environmental Management, the Hamilton County Environmental Services Department, and Cinergy Corp., a major utility. The mission of the Waste Free Fridays program is to identify ways in which to

promote a behavior shift in the community, so that people will be more environmentally responsible in their daily activities. Late last year the Waste Free Fridays program launched an extensive public relations program to promote Renewal batteries as a pollution prevention program. See Attachment #3.

A similar public relations program is currently being conducted on the east side of San Francisco Bay, through a partnership between the Alameda County Waste Management Authority & Source Reduction and Recycling Board and Rayovac Corporation. See Attachment #4.

Additional government recognitions of Renewal batteries are expected.

Commercial Endorsements

An increasing number of manufacturers and distributors of battery powered devices have endorsed the use of Renewal batteries in their products. These endorsements reflect two conclusions:

- Users of the battery powered devices will be satisfied with the performance of Renewal batteries. This threshold question must be answered satisfactorily before an endorsement is even considered.

- Use of Renewal batteries will save money for the users of the battery powered devices. Lowering the operating costs of the battery powered devices makes it more likely that the devices will be purchased.

Companies such as Texas Instruments, General Electric, RCA and Thomson Consumer Electronics now include Renewal batteries in the packages of some of their own products.

In the future, additional original equipment manufacturers are expected to design products to use Renewal batteries as power sources.

Battery Manufacturers

On an economic level, rechargeable alkalines can provide cost savings to battery users, but might substantially reduce industry profits if widely adopted. To the manufacturer, there is more profit in seven or more packages of primary alkaline batteries than there is in one package of the same size and number of rechargeable alkalines.

None of the major worldwide producers of primary alkaline batteries—including Duracell, Energizer, Matsushita, Sanyo, Sony, Toshiba, Philips and Varta—sells the rechargeable versions. The short list of companies that do manufacture rechargeable alkalines includes Rayovac, the #3 player in the United States market, and a handful of no-name companies in other parts of the world: Battery Technologies Inc./Pure Energy in Canada, Young Poong in Korea, and Grand Battery Technologies in Malaysia.

To promote the use of rechargeable alkaline batteries, federal and state officials interested in waste minimization and pollution prevention should take an active role in breaking the wall of silence by increasing public awareness of this new technology.

Conclusion

This case study shows that major worldwide manufacturers of alkaline batteries do not support the use of reusable alternatives. The question is, to what extent does the same condition exist with other products?

The antidote to a "do nothing, ignore it" attitude by major manufacturers is an effort by users, government officials and environmentalists to publicize the existence of a reusable product and to promote its use. In some cases, the reusable product may come from smaller, more innovative manufacturers.

STATE OF MINNESOTA
POLLUTION CONTROL AGENCY

In the Matter of the Request for an Exemption of Rayovac Rechargeable Alkaline Manganese Batteries from the Requirements of Minn. Stat. § 115A.9157 (1991)	FINDINGS OF FACT, CONCLUSIONS, AND ORDER ADOPTING EXEMPTION

FINDINGS OF FACT

1. Minn. Stat. § 115A.9157, subd. 2 (1991), prohibits a person from placing in mixed municipal solid waste a rechargeable battery, a rechargeable battery pack, a product with a nonremovable rechargeable battery, or a product powered by rechargeable batteries or rechargeable battery pack, from which all batteries or battery packs have not been removed.

2. Minn. Stat. § 115A.9157, subds. 3 to 8 (1991), provides, in general, that a manufacturer of rechargeable batteries or products powered by rechargeable batteries: (1) is responsible for the costs of collecting and properly managing its waste rechargeable batteries and waste rechargeable products; and (2) shall establish pilot and permanent statewide collection programs for its waste rechargeable batteries and waste rechargeable products;

3. Minn. Stat. § 115A.9157, subd. 9 (1991), allows the Minnesota Pollution Control Agency (MPCA) Commissioner to exempt a new type of rechargeable battery from the requirements of Minn. Stat. § 115A.9157 (1991) if it poses no unreasonable hazard when placed in and processed or disposed of as part of a mixed municipal solid waste stream.

4. MPCA staff received a letter on December 22, 1992, from the Rayovac Corporation (Rayovac) requesting an exemption of Rayovac rechargeable alkaline manganese (RAM) batteries under the provisions of Minn. Stat. § 115A.9157, subd. 9 (1991).

5. In its exemption request, Rayovac submitted laboratory test data and other information showing that the RAM battery would not be considered a hazardous waste under Minnesota hazardous waste rules.

6. In its exemption application, Rayovac submitted information showing the RAM batteries meet the mercury content requirements of Minn. Stat. § 325E.125, subd. 2, paragraph (a) (1991).

7. In its exemption request, Rayovac asserted that RAM batteries manufactured by Rayovac after January 1, 1996, would meet the mercury content requirements of Minn. Stat. § 325E.125, subd. 2, paragraph (e) (1991).

8. In its exemption request, Rayovac submitted laboratory test data regarding the concentrations of 20 different metals in the RAM batteries.

ATTACHMENT #1

9. In its exemption request, Rayovac asserts that the RAM batteries manufactured by Rayovac are, in general, identical to nonrechargeable alkaline manganese batteries. Test data submitted by Rayovac in the exemption request confirm this fact.

10. Minnesota statutes and rules governing batteries currently do not prohibit the placement of nonrechargeable alkaline manganese batteries in mixed municipal solid waste. Likewise, manufacturers of nonrechargeable alkaline manganese batteries are not required to provide a collection system to ensure that non-rechargeable alkaline manganese batteries are not disposed of in mixed municipal solid waste.

11. In its exemption request, Rayovac asserts that the number of charge/discharge cycles for the RAM batteries will be at least 10 for most users.

12. In its exemption request, Rayovac asserts that it does not intend to sell RAM batteries in Minnesota unless the requested exemption is granted.

13. MPCA staff met with Rayovac on September 21, 1992 and December 15, 1992, to discuss the RAM battery and Rayovac's plans to submit an exemption request.

14. The MPCA staff incorporates Rayovac's exemption request letter and its enclosures into these findings as part of the factual basis for the exemption.

CONCLUSIONS

1. Since Rayovac's rechargeable alkaline manganese battery is essentially identical to non-rechargeable alkaline manganese batteries yet the battery may be recharged, in general, at least 10 times prior to disposal thus potentially reducing significantly the number of primary batteries generated, Rayovac's RAM battery represents a significant environmental improvement over primary batteries.

2. Based on review of all of the information obtained in this matter, MPCA staff is of the opinion that the Rayovac rechargeable alkaline manganese battery, as detailed in Rayovac's exemption request, poses no unreasonable hazard when placed in and processed or disposed of as part of a mixed municipal solid waste. Therefore, MPCA staff believes the exemption is warranted.

3. The MPCA staff's finding in favor of providing an exemption for the Rayovac rechargeable alkaline manganese battery is supported by the record in this matter.

ORDER

NOW, THEREFORE, IT IS ORDERED, that Rayovac rechargeable alkaline manganese batteries are exempted from the requirements of Minn. Stat. § 115A.9157, pursuant to the authority vested in the MPCA Commissioner by Minn. Stat. § 115A.9157, subd. 9 (1991), with the following conditions:

1. The exemption is specific to the Rayovac rechargeable alkaline manganese batteries detailed in Rayovac's December 21, 1992, exemption request letter and its enclosures.

2. Rechargeable alkaline manganese batteries manufactured by Rayovac after January 1, 1996, shall meet the no mercury content limit specified in Minn. Stat. § 325E.125, subd. 2, paragraph (e) (1991).

3. By order of the MPCA Commissioner, this exemption may be modified or revoked in the future based on new or additional information regarding the hazard of the Rayovac rechargeable alkaline manganese batteries when placed in and processed or disposed of as part of a mixed municipal solid waste.

4. By order of the MPCA Commissioner, this exemption may be modified or revoked in the future based on future amendments to federal or state rules or regulations.

February 11, 1993
Dated

for Ann Glumac, deputy
Charles W. Williams
Commissioner

STATE OF CALIFORNIA
Department of Toxic Substances Control

CERTIFICATION No. 98-01-026

ISSUED TO: Rayovac Corporation, Madison, Wisconsin

The Rayovac Renewal® Rechargeable Alkaline Battery System is certified as a Pollution Prevention Technology pursuant to California Health and Safety Code Section 25200.1.5, subject to the conditions including the certification limitations/disclaimer set forth in the Certification Statement as published in the California Regulatory Notice Register on March 6, 1998, Register 98, Volume No. 10-Z, pages 579-583. Renewal® Rechargeable Alkaline batteries can prevent pollution by reducing the quantity of disposed primary alkaline batteries of the same size in most applications for which primary alkaline batteries are appropriate. Under standard laboratory test conditions, that simulated typical consumer product applications, after 25 charging cycles to specified voltage cutoff points at specified resistance loads, the Renewal® system's batteries supplied hours of service equivalent to seven or more primary alkaline batteries of the same size. The actual number of obtainable cumulative hours of service, depends on a number of factors, such as depth of discharge, frequency of charging, type of application, and other user practices.

The term of the Certification shall be for a period of three (3) years from the effective date unless otherwise specified in Title 22, California Code of Regulations or revoked prior to that date for cause.

Effective Date: April 6, 1998

Peter M. Rooney
Secretary for Environmental Protection

Jesse R. Huff
Director, Department of Toxic Substances Control

ATTACHMENT #2

Rayovac® RENEWAL®, The City of Cincinnati, Hamilton County Environmental Services and Cinergy are proud to present the "NO TRASH TALKIN'" Waste Free Friday Initiative. The "NO TRASH TALKIN'" program features Rayovac RENEWAL Rechargeable Alkaline and spokesperson, Michael Jordan, promoting Rayovac Rechargeable Alkaline batteries. The theme "Throw Away Less. Save More Money." emphasizes the environmental and money savings benefits of Rayovac Rechargeable Alkaline batteries.

The event is being promoted this December throughout the greater Cincinnati area through outdoor and bus board advertising as well as coupons distributed via Cinergy bill inserts.

ATTACHMENT #3

REDUCE - REUSE - RECYCLE
THROW AWAY LESS.
SAVE MORE MONEY.
alameda county
WASTE MANAGEMENT AUTHORITY &
SOURCE REDUCTION AND RECYCLING BOARD
For more info call toll free 1-877-STOPWASTE
www.stopwaste.org
AA
RAYOVAC
Rechargeable
Alkaline

ATTACHMENT #

Tom Barnett/James Sherman

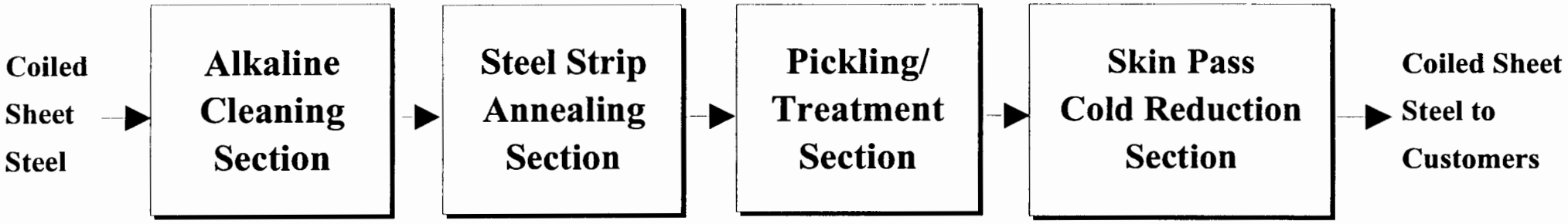
Ispat Inland Inc.

"Magnetic Separator Usage in Steel Processing Alkali Cleaning Solution Applications"

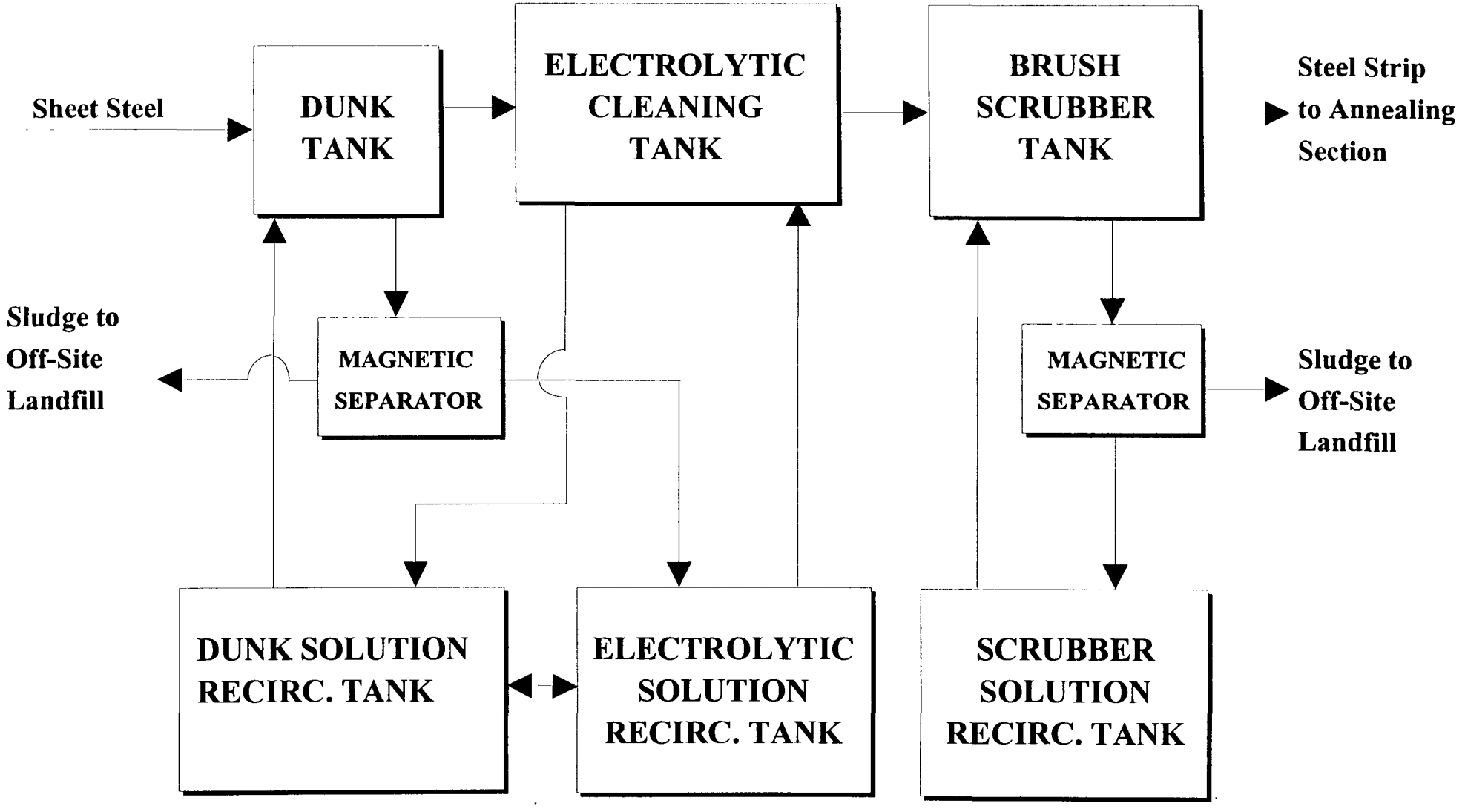
Tom Barnett

Mr. Barnett is currently a Staff Engineer in the Environmental Affairs Dept. and has been involved in environmental projects in both an industrial and environmental consulting capacity for more than 20 years. He has been involved in RCRA, CERCLA, TSCA and SARA related projects. Project responsibilities include review and interpretation of federal and state regulations, interaction with federal and state regulatory personnel, and project oversight for implementation and compliance. His current responsibilities are centered around implementation of Phase 1 RFI activities at the Ispat Inland Indiana Harbor Works Plant as well as negotiations and planning for Phase 2 implementation.

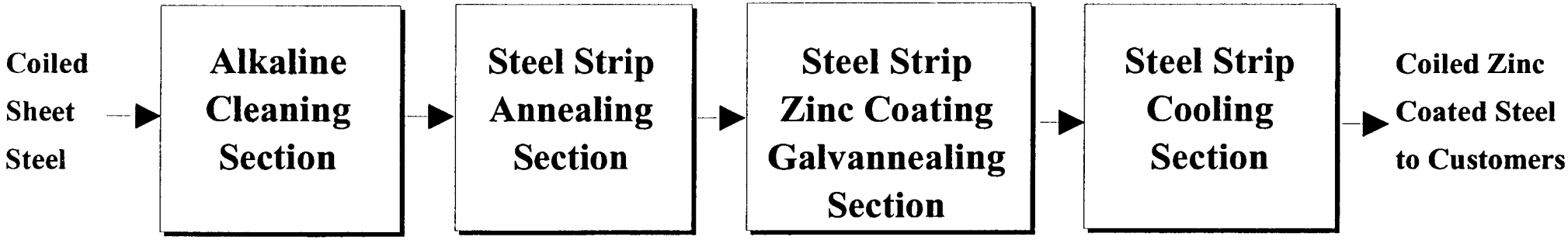
I/N TEK
CONTINUOUS ANNEALING AND PROCESSING LINE (CAPL)
PROCESS FLOW SCHEMATIC



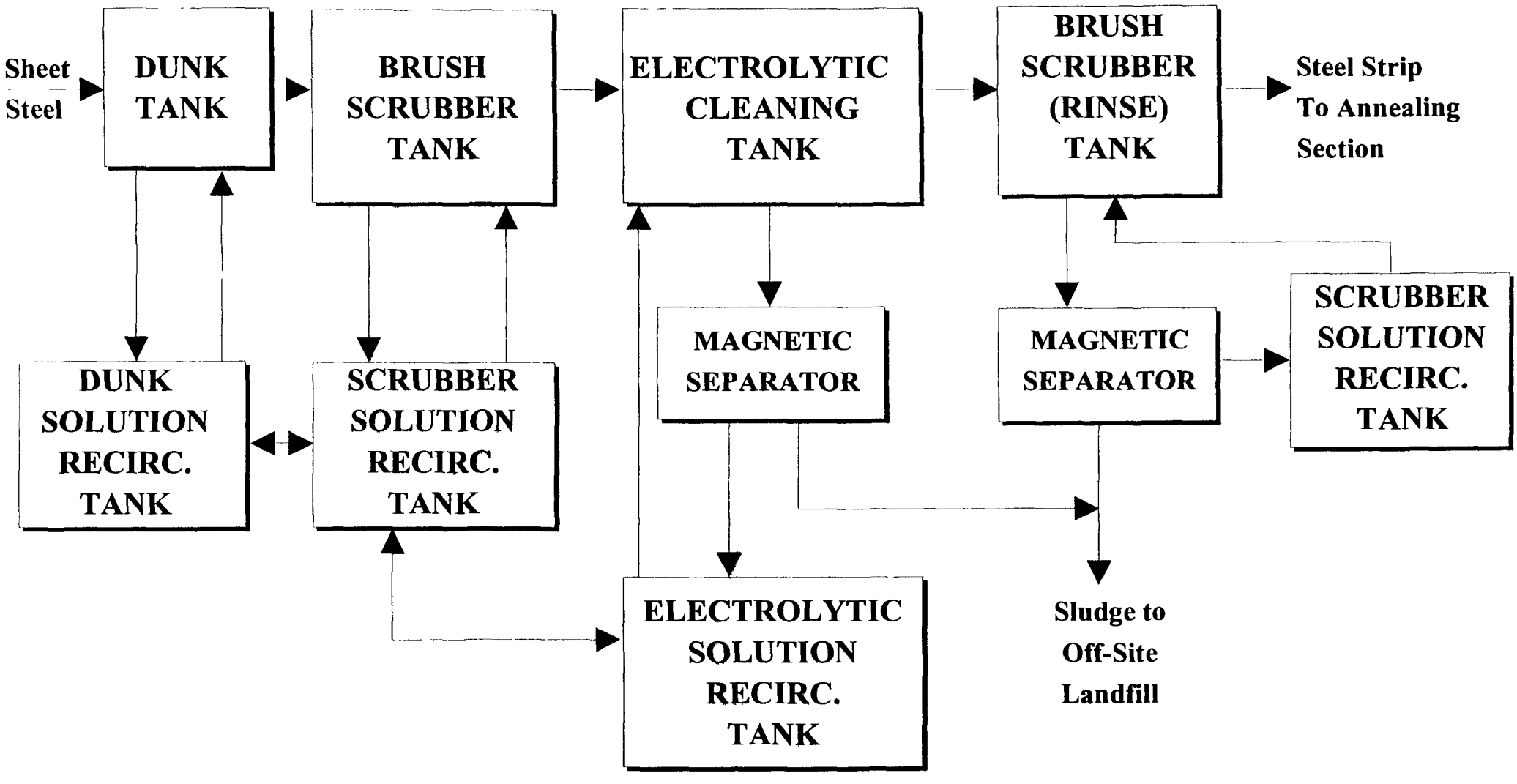
I/N TEK
CONTINUOUS ANNEALING AND PROCESSING LINE (CAPL)
ALKALINE CLEANING SECTION



I/N KOTE
CONTINUOUS GALVANIZING LINE (CGL)
PROCESS FLOW SCHEMATIC

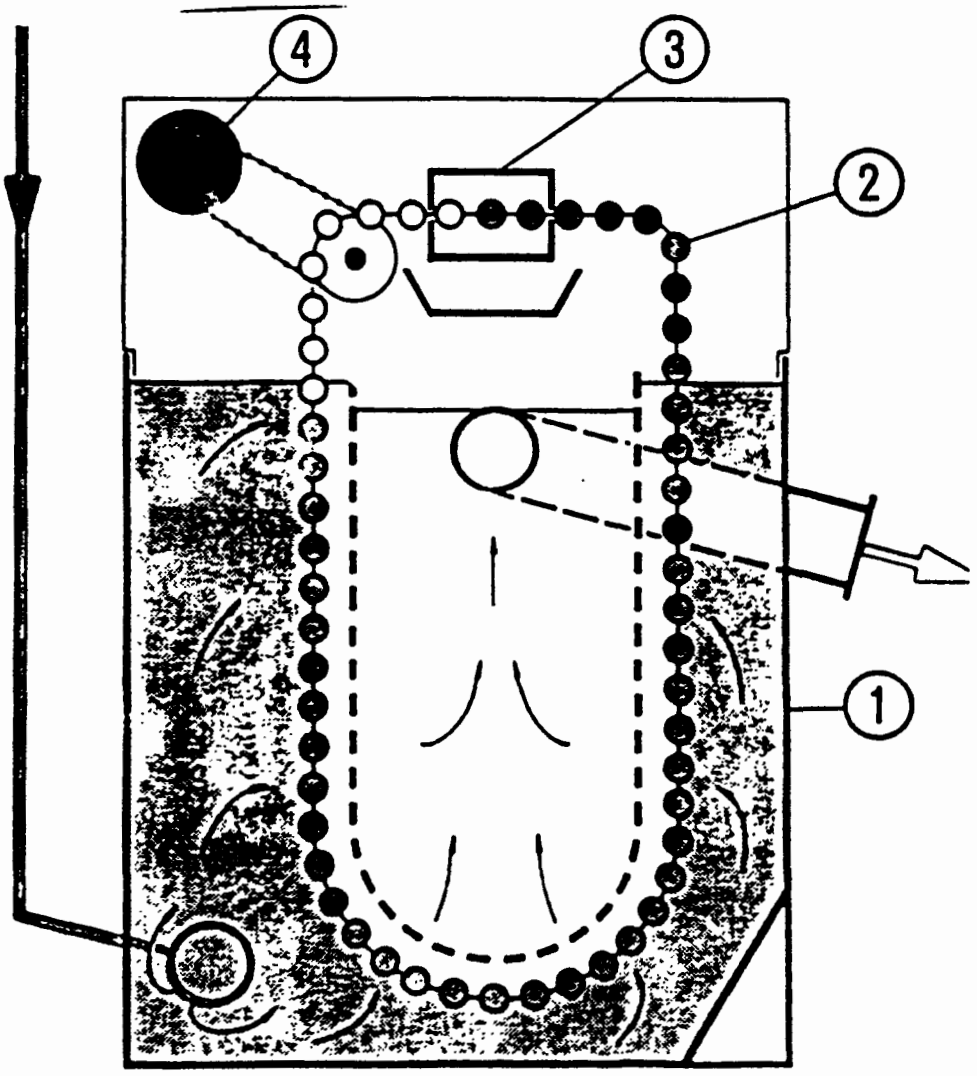


I/N KOTE
CONTINUOUS GALVANIZING LINE
ALKALINE CLEANING SECTION



ADVANCED FILTRATION CONCEPTS

BAR TYPE MAGNETIC SEPARATOR



PROJECT BENEFITS

- ELIMINATED "BLEED AND FEED" CONCEPT PREVIOUSLY USED TO MAINTAIN SOLUTION QUALITY
- REDUCED CLEANER CONSUMPTION
  - 66,280 GALLON REDUCTION IN ANNUAL CLEANER USAGE
  - ANNUAL SAVINGS OF ABOUT $215,000
  - 1.3 MILLION GALLON REDUCTION IN WASTEWATER REQUIRING TREATMENT
- IMPROVED CLEANING SOLUTION QUALITY
  - 70% REDUCTION IN IRON CONCENTRATION
  - 10% REDUCTION IN OIL CONCENTRATION
- REDUCED MAINTENANCE OF ROLL SEALS
  - NO LINE STOPS
  - LONGER LIFE
- REDUCED REPAIR TURN CLEANING COST
- REDUCED WWT COSTS - CHEMICALS/WATER/SEWAGE

Shayla Barrett

CMTI/Purdue University

"Halogenated Solvent NESHAP Compliance Through Solvent Substitution and P2"

Shayla Barrett

Shayla Barrett is a Process Engineer with the Indiana Clean Manufacturing Technology and Safe Materials Institute at Purdue University. He, along with other process engineers, is responsible for aiding Indiana manufacturers in achieving pollution prevention through technical assistance. Mr. Barrett focuses primarily on the metal coating and electroplating sectors and has seventeen years' experience as an Environmental Engineer at several electroplating manufacturers prior to joining the Institute in 1995.

Mr. Barrett majored in Chemical Engineering at the Georgia Institute of Technology and holds an Indiana Waste Water Treatment Operator's License.

CMTI

Halogenated Solvent NESHAP Compliance Through Solvent Substitution and Pollution Prevention

Pollution Prevention Grant

Indiana Department of Environmental Management's Office of Pollution Prevention and Technical Assistance (IDEM/OPPTA)

Halogenated Solvent NESHAP

- methylene chloride
- 1,1,1-trichloroethane
- trichloroethylene
- perchloroethylene
- carbon tetrachloride
- chloroform

Initial Survey

- 113 Indiana manufacturers (initial notification)
- 85 returned
  - 26 eliminated halogenated solvents
  - 17 not interested
  - 42 requested assistance
    - 6 never returned calls

Solvent Substitution

- Assisted 14 manufacturers
  - 8 aqueous cleaners
  - 4 non-halogenated solvents
  - 2 blast media

P2 Compliance

- Assisted 22
  - 1 not covered by NESHAP
  - 11 alternative standard
  - 9 equipment standard
  - 1 cold batch already in compliance

City	County	Initial Estimate Reductions/Savings (Tons)	(Dollars)	Proc. Mod.	Matl. Sub.
Huntington	Huntington	7	$18,200.00	X	
Fort Wayne	Allen	0.046	$59.80		X
Elwood	Madison	14.1	$36,660.00	X	
Oakland City	Gibson	15	$19,500.00		X
Tipton	Tipton	1.6	$4,160.00	X	
Huntington	Huntington	8	$20,800.00	X	
Columbus	Bartholomew	0.1	$260.00	X	
Indianapolis	Marion	0.03	$78.00	X	
Mooresville	Morgan	2	$2,600.00		X
Indianapolis	Marion	2	$5,200.00	X	
South Bend	St. Joseph	8	$10,400.00		X
Elkhart	Elkhart	1	$2,600.00	X	
Middlebury	Elkhart	0.5	$1,300.00		X
Plymouth	Marshall	30.5	$39,650.00		X
Warsaw	Kosciusko	3	$7,800.00	X	
Elkhart	Elkhart	6.5	$8,450.00		X
New Albany	Floyd	4	$10,400.00		X
South Bend	St. Joseph	15.2	$19,760.00		X
New Albany	Floyd	6	$7,800.00		X
Lagrange	Lagrange	2	$5,200.00	X	
Mishawaka	St. Joseph	2.5	$3,250.00		X
Indianapolis	Marion	0.46	$598.00		X
Plainfield	Hendricks	5	$13,000.00	X	
Jasper	DuBois	1	$1,300.00		X
		135.5	$239,025.80		

Total Halogenated Solvent Emissions Reduction

136 tons

Total Annual Cost Savings and Average Payback Period

$239,026

1.3 years

P² BRIEF

SOLVENT SUBSTITUTION/HALOGENATED SOLVENT NESHAP

July 1998

Pollution Prevention Technology
Transfer Final Report

INTRODUCTION

In March 1997, the Indiana Clean Manufacturing Technology and Safe Materials Institute (CMTI) entered into a contract with the Indiana Department of Environmental Management (IDEM) to provide assistance to Indiana manufacturers that were required to comply with the Halogenated Solvent National Emissions Standard for Hazardous Air Pollutants (NESHAP). CMTI assisted companies in replacing halogenated solvents with less hazardous solvents and/or modifying their process and/or equipment so that the company achieved compliance through pollution prevention

The United States Environmental Protection Agency (U. S. EPA) issued a final NESHAP for halogenated solvent cleaning on December 2, 1994, (59 FR 61801 and 59 FR 67750). This NESHAP applies to all facilities that use any of the listed solvents in a parts cleaning machine.

The regulated solvents are
- methylene chloride (CAS# 75-09-2),
- 1,1,1-trichloroethane (CAS# 71-55-6),
- trichloroethylene (CAS# 79-01-6),
- perchloroethylene (CAS# 127-18-4),
- carbon tetrachloride (CAS# 56-23-5), and
- chloroform (CAS# 67-66-3).

Facilities that used any of these solvents must have achieved compliance with the NESHAP by December 2, 1997.

The Halogenated Solvent NESHAP requires that companies using halogenated solvents for cleaning purposes institute measures to reduce the emissions of these solvents and/or find a suitable, nonhalogenated solvent substitute. This requirement results in a cleaner work environment, fewer hazardous emissions to the environment, and cost savings for the companies.

MANUFACTURING PROCESS

Facilities use the regulated solvents to degrease machined parts prior to coating or

assembly. The parts are either degreased in cold cleaning machines or vapor cleaning machines.

Cold cleaning machines fall into two categories: *immersion* or *remote reservoir*. An immersion cold cleaning machine immerses the parts in the unheated solvent. A remote reservoir cleaning machine pumps solvent into a sink-like work area that allows used solvent to drain back into the reservoir.

A vapor cleaning machine immerses the parts in the heated vapor of the halogenated solvent, allowing the solvent to condense on the parts, thereby, removing the oils.

ENVIRONMENTAL ISSUES

Many of the halogenated solvent cleaning machines, that were in use prior to the NESHAP, were old and did not have the controls necessary to prevent loss of solvent to the atmosphere. These machines allowed large quantities of halogenated solvent to be released into the work place and into the atmosphere. The halogenated solvents that escaped the machine not only contributed to work place and air pollution, but also represented a financial loss to the company.

P^2 PROJECT

CMTI initially mailed a halogenated solvent survey to all Indiana companies that had submitted the initial notification form required by the NESHAP.

The institute telephoned those companies that requested assistance. In some cases, the required compliance information was gathered during that telephone conversation, and, in other cases, a site visit was necessary to obtain the needed data. After gathering the initial data, the institute/company team determined if there was a suitable alternative to the halogenated solvent by analyzing the parts to be cleaned, the oils to be removed, and the extent of cleanliness required. It was discovered that those companies that had control over the parts cleaned were more apt to find a suitable substitute. If a suitable substitute was not found, the institute/company team analyzed the halogenated solvent cleaning machine to determine which pollution prevention options would achieve the greatest reduction in releases of halogenated solvent—thereby, achieving NESHAP compliance.

Thirty-six companies achieved NESHAP compliance by successfully adopting a nonhalogenated cleaner and/or implementing the appropriate pollution prevention measures.

POTENTIAL ENVIRONMENTAL AND COST BENEFITS

After the companies achieved NESHAP compliance by successfully adopting a nonhalogenated cleaner and/or implementing the appropriate pollution prevention measures, the annual halogenated solvents emissions reduction reached 136 tons. The annual cost savings of $239,026 resulted from the emission reductions and the use of solvent alternatives. The payback periods ranged from an immediate payback (nine companies) to eight years (one company) with an overall average of 1.3 years.

SB:ds

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Allan C. Bartnik

The Excellence Group, Inc.

"TQ Focus Yielded P2 Results"

Allan C. Bartnik

Allan C. Bartnik is Senior VP of Quality & Environmental Systems for The Excellence Group, Inc. Allan has been actively involved in the field of environmental compliance for over 13 years. The programs developed and implemented by Allan earned the corporations Evansville, Indiana facility, the Environmental Excellence Achievement Award from the City of Evansville, Water & Sewer Utility. Their success in reducing the use of listed HAP chemicals by 98% was highlighted in a State of Indiana publication titled Pollution Prevention for Printers.

Allan is additionally the President of National Compliance Programs, Inc. and the developer of the software application ChemLog for Printers, a chemical constituents management program sold nationwide.

TQ Focus Yielded P 2 Results

U.S. EPA Region 5
1998 Waste Minimization / P2 Conference
December 14 - 16, 1998

Allan C. Bartnik
Senior Vice President, The Excellence Group

Introduction . . .

- This case study will describe how total quality concepts were employed in our Evansville, Indiana printing facility to achieve lasting Pollution Prevention (P 2) results.
- Case study highlights will include our elimination of aerosol spray cans from Cutting Department operations and wash-up solvent reductions from press wash-ups.
- Quality improvement tools featured will be the Pareto chart, Plan - Do - Check - Act cycle and Auditing

Who we are . . .

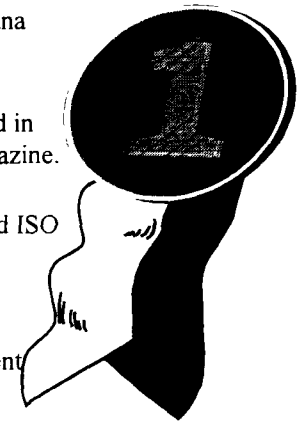
- In February of 1997, Koch Label Company, L. L. C. and Kal Grafx were merged into The Excellence Group, Inc. Our company manufactures a wide variety of pressure-sensitive and cut-and-stack labels. We utilize flexography, rotogravure and offset printing processes.
- Our Evansville, Indiana facility converts cut-and-stack and roll fed labels using flexography and rotogravure.

Our programs use P2 ideas of others. . .

- Many of the ideas we have implemented have come from networking sessions and seminars such as this.
- We have additionally learned a lot through our active participation in other groups.
- We have used the information gathered and adapted it to our unique needs.

- We are active participants in the IDEM Partners for P2 program. We serve on a steering committee of the Indiana Clean Manufacturing Technology and Safe Materials Institute. (CMTI Purdue University)
- We are active participants in the Evansville Chamber of Commerce Environmental Sub Committee. We are active participants in the Ozone Alert Days Program. Our program has been featured in two *Chamber Environmental Sub Committee luncheons.*
- We are active participants in the ACORN community education process.
- We participate actively in the GATF Continuous Improvement Network. (CIN)

- In Dec. of 1995, we received the Indiana Quality Improvement Award.
- May of 1996, our firm was highlighted in Package Printing and Converting magazine.
- In September of 1997, our firm earned ISO 9002 certification.
- In February 1998, we received the Environmental Excellence Achievement Award from the Environmental Management Corporation.

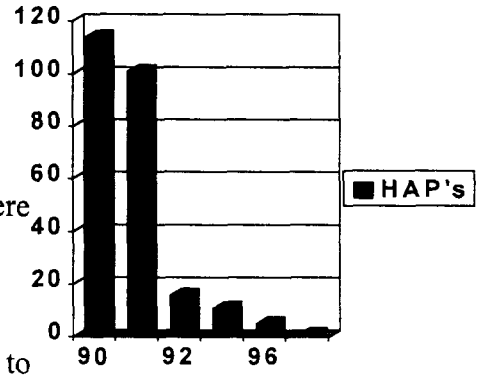


Pollution Prevention at IPS. . .

Our success story was highlighted in the IDEM publication ***Pollution Prevention for Printing.***

HAP listed chemicals were our initial focus.

We reduced HAP chemicals from 114 tons to less than 5 tons.



Pollution Prevention at IPS. . .

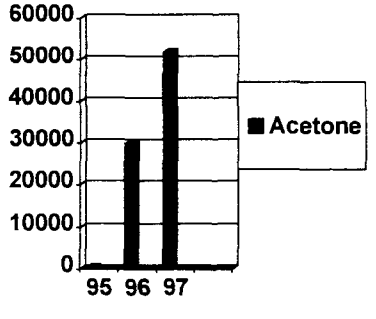
- We targeted HAP emissions from our use of aerosol spray cans in cutting department.
- We were using over 4,000 cans per year.
- Each can contained 60% hexane.
- Process modification eliminated over 1,500 pounds of VOC air emissions.

Pollution Prevention at IPS. . .

- We eliminated all water discharges from electroplating operations.
- We eliminated sodium hydroxide as a waste from our dechrome operation.
- Installed new dechrome and electroplating equipment with CMP. Process modification reduced waste by approx. 10 tons
- A new Renzmann solvent based parts washer eliminated 2 additional waste streams.
- This resulted in a reduction of approximately 6 1/2 tons of hazardous waste.

Reductions achieved:

- Via our solvent substitution program we expanded our use of **Non-VOC's.**
- Use increased from 300 lbs in 1995 to over 52,000 lbs in 1997.



- We have completed trials with the Evansville Association for Retarded Citizens to cut some of our waste cardboard for re-use in our manufacturing operation.
- We began saving and giving away "butt rolls" to local churches, schools, day care centers.
- We are working to identify recycling uses for several other solid wastes produced by our manufacturing operations.

Total Quality Concepts / Methods Employed

- Experts in the field of total quality and continuous improvement advise that quality improvement and waste reduction can be achieved if attention is focused on improving "processes."
- Our manufacturing operation consists of many different processes.

P2 reductions were a direct result of our using

- Pareto Charts
- Plan - Do - Check - Act continuous improvement cycle
- Auditing Techniques

In our application this consisted of:

1. Selecting a process and then examining the manner in which "work" was being performed.
2. Altering work practices.
3. Reviewing the process following work practice modification to ensure that desired reductions were achieved.
4. Making the change lasting by documenting a standard work method to be followed.
5. Performing audits to determine that employees were following the new standard work practices.
6. Repeating steps 2 through 5 above until satisfied with the outcome.
7. Selecting another process for improvement.

Process selection, using the Pareto Chart

- We found that the Pareto chart was a powerful tool which allowed us to isolate and select processes for waste reduction.
- The charts produce a picture and rank in order of importance, the sources of waste and the processes that should be targeted for continuous improvement.
- Our charts were constructed using information from Material Safety Date Sheets (MSDS's) and reports we file with local, state and federal authorities.

Although teaching you the techniques required to construct Pareto charts is beyond the scope of this presentation, I have provided references to books we have found helpful.

Application of the PDCA Cycle, planning

- You need to identify current work methods, involve others and prepare all for change.
- You need to totally understand the current method by which "work" gets done.
- You must involve others who are much closer to the process and solicit their in-depth understanding of how job tasks are actually carried out.
- Manufacturing processes are carried out on multiple shifts, different employees are involved and each brings to the process their own unique current best approach to getting work done. Development of "total understanding" requires that all such information be collected and considered.

Planning continued

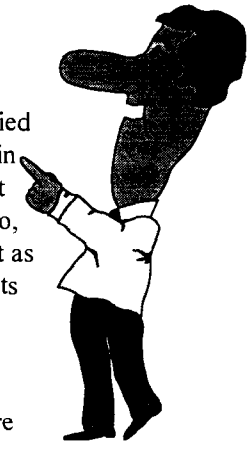
- All persons involved in the process should be informed of proposed changes and kept informed of outcomes.
- a systematic plan of action should be developed detailing what will be changed, who will be making suggested modifications, when the change will be implemented, where in the process the change will be initiated, how the change will be carried out, and the anticipated outcome.

Application of the PDCA Cycle, Doing

- Although you may be eager to begin making changes to the process, do not proceed to this step until you have developed a total understanding of the existing process, developed a systematic plan of action and informed all involved about the changes being implemented.
- Doing involves implementing the systematic plan previously developed.

Application of the PDCA Cycle, Checking

- This step requires that you and/or others examine results achieved as a result of modifying the process. If the anticipated outcome was achieved and you are satisfied with the result, move on to the next step in the cycle. If the desired outcome was not achieved, and checks indicate that all who, what, when, where steps were carried out as detailed in the plan, additional refinements need to be developed and the doing step repeated.
- It was our experience that the doing and checking steps need to be performed more than once.



Application of the PDCA Cycle, Acting

- This final step in the continuous improvement cycle is very important. Process changes that were initiated and proven successful need to be made lasting. Experts advise that development of a documented standard work method and employee training are keys to ensuring that the desired outcome will continue over time.

Application of auditing principles

- To close the continuous improvement cycle for specific projects, and ensure that waste reductions continue, we perform audits.
- Audits allow us to verify, via the collection of objective evidence, that we are actually doing what established policies, procedures or work instructions indicate is to be done.

Auditing principles continued

- Performance of an audit requires that persons not directly responsible for the process, familiarize themselves with the process and review documents detailing what should be happening.
- Once familiar with the process, the auditors interview a few persons who are performing work activities and examine pertinent records being maintained to satisfy themselves that workers are following established instructions and the desired outcome is being achieved.
- If it is discovered that prescribed activities are not being carried out, or activities do not comply with established policy or procedures, non-conformance reports are issued to Department Managers and corrective actions are initiated. Follow-up audits are conducted to verify that corrective actions were in fact taken and effective.

Examples of how we applied total quality concepts to yield P2 results

- In our Cutting Department, we use a number of guillotine cutters to either produce finished straight cut labels or as an intermediate step for labels that will have irregular shapes. To increase their life and improve performance, cutter blades are lubricated with silicone. Standard operating practices mandated that during each shift, equipment operators used aerosol spray cans of silicone, applying a light coating of spray onto the substrate.

- We learned that over 4,000 aerosol cans were used per year, each can was 10 ounces and each can contained 60% hexane, a listed hazardous air pollutant (HAP). Our established goal, eliminate the hexane, and if possible, the cans.

Example, spray can elimination

- Elimination of the hexane and the cans required major changes in our work methods. Successful completion of the goal required the involvement of suppliers, equipment operators, the Cutting Department Manager, our Maintenance Department Manager and Maintenance employees.

- The assembled team located a water based silicone alternate, and conducted tests to determine that it would meet our needs for lubrication without impacting finished goods produced. Elimination of the aerosol spray cans was achieved via brainstorming by team members and the development / implementation of compressed air driven spray guns to which air brushes were attached.

Example, spray can elimination

- A prototype was installed on one cutter and put to the test. After reviewing the successful outcome, all cutters were equipped with similar spray guns and aerosol spray cans eliminated. By applying the total quality approach, the team eliminated approximately 1,500 pounds of HAP / VOC emissions and eliminated cans.

- During the first follow-up audit, we discovered that a few of the guillotine operators continued to use aerosol spray cans rather than the new compressed air system. Closer examination and interviewing revealed that workers had been instructed and authorized to use the existing stockpile of spray cans. When a follow-up audit was performed, the stockpile of inventory had been exhausted and all operators were using the new system. No silicone aerosol cans have been purchased since our final audit and this project successfully closed.

Example, wash-up solvent reduction

- In our rotogravure printing operation, inks are transported to presses in metal pails. Following manufacturing, pails are taken to a solvent based parts washer for cleaning. Print stations are readied for the next production order by washing selected parts using solvent and rags. This necessary work practice creates spent solvent and soiled rags. Solvent is reclaimed and re-used in our parts washing operation. Rags are sent for incineration.

- It is recognized that press wash-ups can not be avoided or eliminated. We established a goal of reducing the amount of spent solvent generated from press wash up activities.

Example, wash-up solvent reduction

- Accomplishing the established goal required modification of standard make-ready and wash-up work practices and increased diligence on the part of Scheduling and Press Department Managers. Whenever possible, graphic designs containing "like colors" are placed into the production schedule so that the orders are produced in a series.

- Press Department Managers modified wash up work practices instructing employees to dismantle removable parts, sending them to the solvent based parts washer for cleaning. Crews replace dismantled parts with clean parts which are staged near printing equipment. The employee in charge of the parts washer even suggested that press crews use spatulas or scrapers to remove and re-use as much ink as possible from the removable parts prior to their cleaning.

Example, wash-up solvent reduction

- As you can see, realizing our goal required coordination and cooperation on the part of press crews, employees responsible for operating the parts washer, and staging clean parts for subsequent re-use. The team was able to reduce spent solvent collected for reclamation by approximately 3 - 4 tons per month.

- This continuous improvement project remains in the PDCA cycle as we continue to refine the plan. One unexpected side benefit was additionally achieved. We appear to have reduced the number of waste rags generated. It is our hope that this new work practice can become the standard in the future.

Summary

- We have found total quality concepts and tools extremely helpful in allowing us to identify P2 opportunities. The Pareto chart allows us to zero in on worthwhile projects. The PDCA cycle provides a thoughtful, systematic approach toward continuous improvement. **We feel that the performance of audits is a necessity to verify that results achieved are indeed lasting.**
- We feel that application of these tools and concepts in your operation will allow you to achieve reductions in the amounts of waste that you produce.

On behalf of the entire team at
The Excellence Group,

thank you for your attention.

I wish you success in your Pollution Prevention efforts.

Reference materials

1. Taylor, Henry M., Persistent Team Improvement from Pride, Quality Engineering, volume 3, number 4, 1991, pages 471-476.

2. Kimbler, D. L. and Gramopadhye, Anand K., Using Inspection Audits to Guide Certification and Training, Quality Engineering, volume 7, number 2, 1995, pages 357-370.

3. Staff of Conway Quality, Inc., Waste Chasers, A Pocket Companion to Quality and Productivity, 1997.

Rick J. Bauer

CMTI/Purdue University

"Technical Assistance and Training Program Wood Furniture & Kitchen Cabinet Manufacturing NESHAP"

Rick J. Bauer is a Professional Assistant for Coating Application Technology with the Indiana Clean Manufacturing Technology and Safe Materials Institute (CMTI) located at Purdue University. Rick has a Bachelor of Technology degree in Manufacturing Technology from the University of Northern Iowa and has been accredited as a Certified Industrial Technologist by the National Association of Industrial Technology. Prior to joining the CMTI staff, Rick was a Waste Reduction Specialist with the Iowa Waste Reduction Center (IWRC) at the University of Northern Iowa. At the IWRC, he provided on-site technical assistance to small businesses in Iowa, focusing on waste reduction and hazardous waste management practices. Rick was also involved in research projects designed to help reduce the volatile organic compounds (VOCs) released during automotive refinishing and industrial coating operations. Rick joined CMTI in February 1997 and is currently heading a NESHAP training program for the wood furniture industry.

Technical Assistance and Training Program
Wood Furniture and Kitchen Cabinet Manufacturing NESHAP

Rick J. Bauer

INTRODUCTION

In the fall of 1997, the Jasper Chamber of Commerce received a grant from the state of Indiana, acting by and through the Indiana Department of Commerce, to provide technical assistance and training for twenty-seven Indiana wood furniture and kitchen cabinet manufacturers and involving more than 1,000 finish line personnel. This grant award to the chamber was primarily due to the leadership role of the Jasper Area Environmental Managers Association and their partnership with the Indiana Clean Manufacturing Technology and Safe Materials Institute (CMTI).

BACKGROUND

The need for a technical assistance and training program became evident with the promulgation of a new environmental regulation. The regulation titled the "National Emissions Standard for Hazardous Air Pollutants" (NESHAP) forced wood furniture and kitchen cabinet manufacturers to change many of their coatings operations. This regulation not only restricts the chemicals that may be used for coating operations, it also requires the implementation of "work practice standards." The work practice standards outlined in the NESHAP include a written work practice plan, solvent accounting system, leak detection and maintenance plan, and an employee training program. The employee training program must include training in chemical storage and handling procedures, coating application equipment setup, and operation and maintenance procedures.

Environmental regulations, such as the NESHAP, can put an increased burden on already stressed company capital and staff. It was clear to the wood product manufacturers and CMTI that by working together, they could combine resources and ease the burden on individual facilities. But the question remained: How to organize this effort? The Jasper Chamber of Commerce and the Indiana Department of Commerce were aware of the wood product manufacturers' importance to the Indiana economy and the impact this regulation could have on the industry. In

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order to minimize the economic effects of the regulation, government and industry formed a grant-funded technical assistance and training program.

MANUFACTURING PROCESS

In most wood furniture and kitchen cabinet manufacturing facilities, coatings are applied to enhance the durability and aesthetic qualities of the product. The majority of these coatings are applied using manual spray operations, but the transfer efficiency (the percent of material that is applied to the part) in the average manual spray operation is very poor. In general, less than one-half of the material sprayed through the gun adheres to the targeted substrate. The rest of the sprayed material is lost as overspray. When applying coatings to substrates of complex geometry, such as chairs, the transfer efficiency may drop below 25%. This means that for every gallon sprayed, only about one quart of coatings material will adhere to the targeted surface.

In an attempt to improve the efficiency of the wood furniture coating process, the United States Environmental Protection Agency (EPA) requires that those companies that fall under the NESHAP use high transfer efficient spray equipment for most production operations. High transfer efficient spray equipment includes HVLP, air assisted airless, airless, and/or electrostatic spray equipment. These types of equipment can greatly improve the efficiency of coating application processes, without requiring major changes in the coating type or mixture. A spray equipment operator well trained in these technologies can achieve a high quality finish using far less material and emitting fewer pollutants into the atmosphere. It is important to remember, however, that using high transfer efficient equipment does not assure efficient coating applications. Improper setup and use of even high transfer efficient spray equipment can actually increase the VOC and toxic emissions released into the atmosphere. An operator untrained in equipment setup and operation may unknowingly apply a greater coating thickness than desired on the substrate, increasing material consumption. Improper use of this equipment may also result in a surface finish with uneven coverage or an undesirable texture known as "orange peel." If the surface finish is not acceptable, recoating may be required, increasing coating costs and emissions. Good spray technique includes proper spray gun settings, spray gun movement, spray distance, spray angle, and "triggering" of the gun at the end of each pass.

Testing performed by Purdue University and the University of Minnesota demonstrated that a three-inch <u>increase</u> in spray distance could result in up to a 13% <u>decrease</u> in transfer efficiency. Testing performed at the University of Northern Iowa indicated that a spray angle that varies as little as five degrees from perpendicular could diminish the transfer efficiency by as much as 4%. These numbers may sound relatively insignificant, but consider this: Spray operators who have not been trained in proper spray techniques usually have poor gun distance, poor gun angle, and poor triggering skills. Operators with poor spray techniques

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can easily use twice as much coating material as a well-trained sprayer, doubling emissions from the coating operation.

To complicate matters, different coatings and spray equipment types require different spray gun setups and minor changes in spray technique. High transfer equipment can only operate as an efficient tool if used correctly by a skilled operator. Generally, untrained spray operators have poor gun setup skills.

According to a study performed by the Pacific Northwest Pollution Prevention Research Center entitled "Transfer Efficiency and VOC Emissions of Spray Gun and Coating Technologies in Wood Finishing,"[1] the emissions released during a surface coating process are directly related to the skill of the spray gun operator. The study concluded that "the difference in transfer efficiency due to painter skill level with a single gun type were often larger than the differences between gun types" (referring to HVLP vs conventional equipment). In other words, the most influential factor in improving transfer efficiency is the operator's spray technique.

Prior to the NESHAP, only a very few companies provided a comprehensive hands-on training program for their spray equipment operators. In many cases, spray operators received little, if any, training in equipment setup and operation, prior to being placed on the coating line.

ENVIRONMENTAL ISSUES

Many of the solvents used in coating operations contain chemicals such as methyl ethyl ketone (MEK), toluene, and xylenes--all of which have been categorized by EPA as volatile organic compounds (VOCs) and volatile hazardous air pollutants (VHAPs). The EPA found the wood furniture and kitchen cabinet industry to be among the largest users of solvents in coating operations in the U.S. According to EPA, the wood furniture industry uses almost twice as much solvent in coatings operations as the automotive manufacturing industry.[2]

Spray coating emissions can be decreased significantly by increasing the transfer efficiency of the spray coating operation. In addition, as sprayers' skill increases, so does their constancy. The result is a decrease in rework required. Higher transfer efficiency also translates into decreased material usage, reduced waste, improved productivity, and extended life of potentially hazardous spray booth arrestor banks (particulate filters).

P^2 PROJECT

The training program developed by CMTI has two main goals. The first is to provide the necessary training and

[1] "Transfer Efficiency and VOC Emissions of Spray Gun and Coating Technologies in Wood Finishing," Pacific Northwest Pollution Prevention Research Center, 1992

[2] "U.S. EPA, Guideline Series: Control of Volatile Organic Compound Emissions from Wood Furniture Manufacturing Operations," EPA/453/R-96/007, April 1996

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materials to satisfy the NESHAP requirements. The second is to enhance the operators' skill level (beyond what is required by the rule) in order to improve their efficiency as a sprayer. CMTI exceeded the NESHAP training requirements to give companies an opportunity to improve their spray operators' skills and reduce material consumption and emissions in coating operations.

The technical assistance and training program developed by CMTI includes

- a written employee training program document, as required by the NESHAP, that is distributed to participating companies;
- a pre-training coating operations analysis at all participating plant sites;
- employee training, including hands-on training of the spray equipment operators in all participating companies, in accordance with the NESHAP;
- a post-training performance assessment review at all participating plant sites; and
- a written Work Practice Implementation Plan Manual, which is distributed to all member companies to assist in their compliance with federal regulations.

This training program stresses the importance of proper application, setup, and spray operator technique. It is designed to help spray equipment operators understand their importance in improving transfer efficiency of coating operations.

The camcorder is one of the most influential tools used in the training program. The operators are video taped during a coating operation. This helps them better understand what they can do to enhance their spray techniques. If you have ever taken a golf lesson and the golf pro video taped your swing, you know how beneficial this tape can be. The instructor can tell you what you are doing wrong, but until you see yourself on tape, you will not comprehend what you have been doing wrong. It works the same way with a spray gun operator. Many spray operators have been spraying for years and believe that they know the correct way to spray. They are convinced that they are using the correct spray technique, and no matter how hard you try, you are not going to get them to change--that is, until they see themselves on tape.

POTENTIAL ENVIRONMENTAL and COST BENEFITS

So why put such an emphasis on improving transfer efficiency? Let's say that a company uses 20,000 gallons of coatings annually and, on average, each gallon of coating contains six pounds of VOCs. All of the sprayers at the facility were achieving a 40% transfer efficiency. If that company could improve their sprayers' transfer efficiency by 10% (that is achieve an average transfer efficiency of 44%) that company would decrease VOC emissions by over six tons annually. They would also decrease their material usage by 2,000 gallons. If that material cost the company $10 per gallon, a $20,000 yearly savings would result.

To date, CMTI has provided operator training for more than 1,000 employees at twenty-eight plant locations. CMTI estimates that over eleven hundred employees will have gone through the training program by the end of 1998.

It is difficult to compile completely accurate data demonstrating the positive effects of the training program because of the different types of furniture products and their geometry as well as the variety and volume of these products that are manufactured; however, many improvements have been made in operator technique, and reduction in coatings material usage has been accomplished through increases in transfer efficiency. Some companies have reported that individual employees have reduced material consumption by as much as one-half, as a result of the program. Others report a significant decrease in the amount of visual overspray and concentrations of solvent vapor within the facility, as a direct result of employee training programs.

CMTI, using conservative figures, projects an annual state-wide reduction of 250 tons of VOCs and more than 75 tons of VHAPs as a result of the training program. It is estimated that, annually, this training program may reduce material usage by as much as 80,000 gallons, resulting in a saving to Indiana wood manufacturers of nearly $700,000. This amount does not include the savings resulting from reduced rework. If companies continue to monitor operator technique and reinforce the program's training, the VOC/VHAP reduction and the dollar savings could be significantly greater.

CONCLUSION

Spray operator training continues to be one of the most influential factors in improving transfer efficiency and also the most overlooked. Companies that adopt an operator training program can realize reduced material costs, reduced waste generation, and reduced VOC/VHAP emissions.

This project is an excellent example of companies working together with the state to the benefit of each. CMTI is proud to be a part of this program and hopes that other industrial sectors take note of the successes achieved through this project.

RB:ds

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Participants in the Indiana Department of Commerce Strategic Development Fund Grant.
Grant I.D. SDF-97-055

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SP003		26	19	X	X	X
SP004	X	60	42	X	X	X
SP005	X	52	70	X	X	X
SP006		12	11	X	X	
SP007	X	30	62	X	X	X
SP008	X	46	119	X	X	X
SP009		24	32	X	X	X
SP010		19	32	X	X	
SP011	X	19	49	X	X	X
SP012		12	15	X	X	X
SP013	X	52	73	X	X	X
SP014		40	59	X	X	
SP015		14		X		
SP016		10	16	X	X	X
SP017	X	78	88	X	X	X
SP018	X	90	81	X	X	X
SP019		18				
SP020	X	25	36	X	X	X
SP021		12		X		
SP022		10		X		
SP023		12				
SP024		10				
SP025		20	21	X	X	
SP027		15	22	X	X	
SP028	X	50	148	X	X	X
SP029		10		X		
SP030		12		X		
SP031		32	33	X	X	
SP032		34	53	X	X	
TOTAL	**10**	**844**	**1081**	**26**	**21**	**14**

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Projected Reductions Due To Operator Training
(as of October 22, 1998)

Company Project #	Material Cost (per yr.)	Gallons of Material (per yr.)	Tons of VOCs (per yr.)	Tons of HAPs (per yr.)	Projected Cost Reduction (per yr.)	Projected Material Reduction (gallons per yr.)	Projected VOC Reduction (Tons per yr.)	Projected HAP Reduction (Tons per yr.)
SP003	$ 224,000	32,000	80.0	24.0	$ 11,200	1,600	4.0	1.2
SP004	$ 630,000	90,000	225.0	67.5	$ 31,500	4,500	11.3	3.4
SP005	$ 553,000	79,000	197.5	59.3	$ 27,650	3,950	9.9	3.0
SP006	$ 315,000	45,000	112.5	33.8	$ 15,750	2,250	5.6	1.7
SP007	$ 504,000	72,000	180.0	54.0	$ 25,200	3,600	9.0	2.7
SP008	$ 483,000	69,000	172.5	51.8	$ 24,150	3,450	8 6	2.6
SP009	$ 315,000	45,000	112.5	33.8	$ 15,750	2,250	5.6	1.7
SP010	$ 336,000	48,000	120.0	36.0	$ 16,800	2,400	6.0	1.8
SP011	$ 322,000	46,000	115.0	34.5	$ 16,100	2,300	5.8	1.7
SP012	$ 259,000	37,000	92.5	27.8	$ 12,950	1,850	4.6	1.4
SP013	$ 476,000	68,000	170.0	51.0	$ 23,800	3,400	8.5	2.6
SP014	$ 665,000	95,000	237.5	71.3	$ 33,250	4,750	11.9	3.6
SP016	$ 224,000	32,000	80.0	24.0	$ 11,200	1,600	4.0	1.2
SP017	$ 805,000	115,000	287.5	86.3	$ 40,250	5,750	14.4	4.3
SP018	$ 1,015,000	145,000	362.5	108.8	$ 50,750	7,250	18.1	5.4
SP020	$ 455,000	65,000	162.5	48.8	$ 22,750	3,250	8.1	2.4
SP025	$ 350,000	50,000	125.0	37.5	$ 17,500	2,500	6.3	1.9
SP027	$ 252,000	36,000	90.0	27.0	$ 12,600	1,800	4.5	1.4
SP028	$ 1,246,000	178,000	445.0	133.5	$ 62,300	8,900	22.3	6.7
SP031	$ 392,000	56,000	140.0	42.0	$ 19,600	2,800	7.0	2.1
SP032	$ 336,000	48,000	120.0	36.0	$ 16,800	2,400	6.0	1.8
Total					**$ 507,850**	**72,550**	**181.4**	**54.4**
Projected Totals for the Twenty-nine Companies					**$ 701,317**	**100,188**	**250.5**	**75.1**

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Case Study
Projected Reductions Due To Operator Training

Transfer Efficiency	Coating Usage (gallons)	Cost of Coatings	VOC Emissions (tons)	Reduction in Coating Usage (gallons)	Reduction in Coatings Cost	Reduction in VOC Emissions (tons)
25%	34,667	$ 520,000	107.28	-13000	-195,000	-40.23
30%	28,889	$ 433,333	89.40	-7222	-108,333	-22.35
35%	24,762	$ 371,429	76.63	-3095	-46,429	-9.58
40%	**21,667**	**$ 325,000**	**67.05**	-	$ -	-
41%	21,138	$ 317,073	65.41	528	$ 7,927	1.64
42%	20,635	$ 309,524	63.86	1,032	$ 15,476	3.19
43%	20,155	$ 302,326	62.37	1,512	$ 22,674	4.68
44%	19,697	$ 295,455	60.95	1,970	$ 29,545	6.10
45%	19,259	$ 288,889	59.60	2,407	$ 36,111	7.45
50%	17,333	$ 260,000	53.64	4,333	$ 65,000	13.41
55%	15,758	$ 236,364	48.76	5,909	$ 88,636	18.29
60%	14,444	$ 216,667	44.70	7,222	$ 108,333	22.35
65%	13,333	$ 200,000	41.26	8,333	$ 125,000	25.79
70%	12,381	$ 185,714	38.31	9,286	$ 139,286	28.74
75%	11,556	$ 173,333	35.76	10,111	$ 151,667	31.29
80%	10,833	$ 162,500	33.53	10,833	$ 162,500	33.53
85%	10,196	$ 152,941	31.55	11,471	$ 172,059	35.50
90%	9,630	$ 144,444	29.80	12,037	$ 180,556	37.25
95%	9,123	$ 136,842	28.23	12,544	$ 188,158	38.82
100%	8,667	$ 130,000	26.82	13,000	$ 195,000	40.23

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Thomas J. Bierma

Illinois State University

"The Chemical Management Program at GM's Electro-Motive Division"

The Chemical Management Program at GM's Electro-Motive Division[1]

A Presentation By:
Thomas J. Bierma and Frank Waterstraat, Illinois State University;
Ed Vacherlon, General Motors, Electro-Motive Division; and
Mike Podolak, D.A. Stuart Company

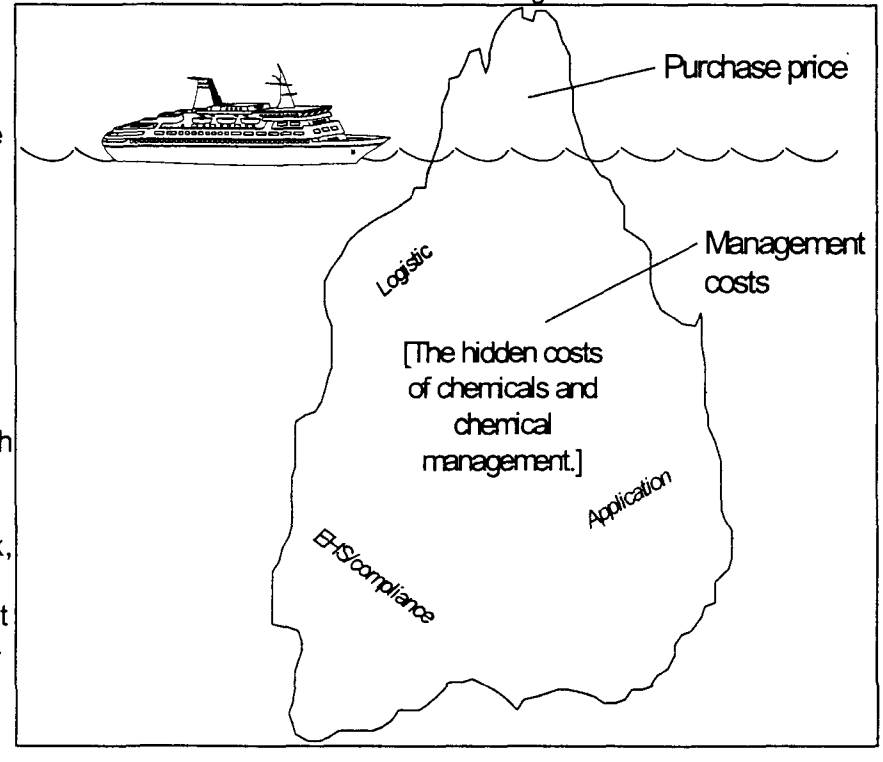
It takes more than bright people to produce a continuous stream of pollution prevention innovations for a company. There are many factors working against the implementation of P2 programs. The day-to-day responsibilities of production and responding to frequent "crises" leave little time for studying much less implementing P2 opportunities. The costs and responsibilities for many systems that produce waste fall on different departments which have little incentive to cooperate. Chemical purchase decisions are decentralized in most organizations, and numerous chemical suppliers compete for small pieces of a chemical pie. Neither chemical users nor chemical suppliers have a clear incentive to reduce chemical use.

Some companies are using an innovative approach to combat these problems and dramatically increase the rate of P2 implementation. They are using a radically new way of buying their chemicals, which we call *Shared Savings Chemical Management*. In this presentation, we will explain the fundamentals of *Shared Savings* and demonstrate how it has produced dramatic results at General Motors' Electro-Motive Division.

The Hidden Cost of Chemicals

Imagine chemical costs as a large iceberg (Exhibit 1). The visible portion of the iceberg - the part above the water - represents chemical purchase costs. However, the use of chemicals creates numerous "hidden" costs for the firm, such as ordering, storage, compliance, treatment, and waste disposal costs. Chemicals can also create headaches for company personnel such as dealing with problems of chemical quality, incompatibility with the production system, paperwork, and health and safety concerns. These all represent the hidden cost of chemicals - the portion of the iceberg below the water.

Exhibit 1. The chemical cost iceberg.



Most "hidden" costs fall into one of three categories: logistic, EHS/compliance, and application.

- *Logistic costs* include all those related to acquiring and handling the chemicals.
- *EHS/compliance costs* are those required to maintain regulatory compliance and assure the desired level of environment, health, and safety (EHS) performance.
- *Application costs* are those related to the performance of the chemicals in the production process.

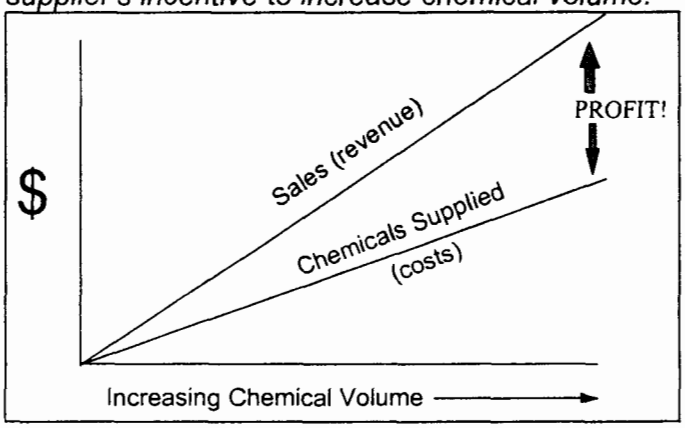
Thus, chemical purchase costs are only a small portion of total cost of chemicals for the typical chemical user. In fact, one U.S. auto company estimates that hidden costs, the portion of the iceberg below the water, is 5-7 times greater than the purchase price of the chemicals, the tip of the iceberg. As with real icebergs, the portion above the water often attracts the most attention, but the portion below the water produces the greatest threat. The supply relationship between a chemical user and chemical supplier can have a dramatic effect on the size of the chemical cost iceberg.

Inherently wasteful relationships

Ideally, chemical suppliers should be applying their expertise to reduce the chemical cost iceberg. Yet, we have found that the financial incentives of traditional supply relationships between chemical users and chemical suppliers makes significant chemical cost reductions difficult. In many instances, the traditional chemical supply relationship produces continuous *increases* in chemical cost rather than reductions.

The traditional chemical supply relationship creates the wrong financial incentives for the supplier; it rewards chemical waste and inefficiency rather than chemical performance and efficiency. In traditional chemical supply relationships, chemicals are sold to the chemical user. The supplier increases profit by increasing the volume of chemicals sold (see Exhibit 2). The supplier is continuously driven to increase chemical sales, just the opposite of what the chemical user desires.

Exhibit 2. Traditional supplier relationship - a supplier's incentive to increase chemical volume.



Aside from promoting waste, this "volume conflict" creates an inherent adversarial relationship between the buyer and seller which inhibits the free exchange of useful information that could increase chemical performance and reduce chemical usage as well as costs. It creates mistrust between users and suppliers, reducing the ability of both parties to work together to improve the total financial potential of the supply relationship.

Shared Savings Chemical Management

A ***Shared Savings Chemical Management*** strategy, however, is very different. In a *Shared Savings* relationship, financial incentives align the supplier's performance goals with those of the chemical user. The typical financial arrangement in a *Shared Savings* relationship is based on a fixed fee mechanism. Instead of purchasing chemicals, the user pays a fixed fee (per month or per unit of production) to the supplier. The supplier in turn agrees to meet the "chemical performance needs" of a plant or process. In other words, the supplier sells chemical services and chemical performance rather than the chemicals themselves. Typical features of a *Shared Savings* relationship are presented in Exhibit 3.

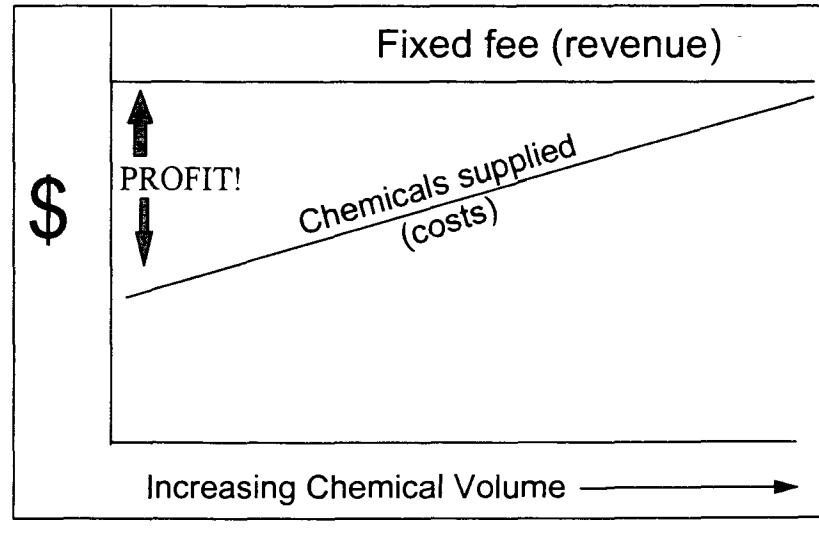
Exhibit 3. Shared Savings Chemical Management relationships - some typical characteristics

- User no longer "buys" the chemicals. They are owned by the supplier until used in the production process.
- Supplier receives a fixed fee per month or per unit of production in exchange for chemical performance.
- Supplier profits through chemical volume and cost reduction, not chemical sales.
- Supplier provides on-site chemical management, including comprehensive logistic, EHS/compliance, and chemical application services.
- One supplier serves as a primary, or "Tier 1," chemical manager, overseeing the supply of chemicals from "Tier 2" suppliers.

Since revenues are fixed, the supplier has an incentive to reduce chemical costs to increase profits. Cost reductions are achieved primarily through improvements in chemical management and use efficiency. As shown in Exhibit 4, the cost reduction incentive aligns the interests of the chemical supplier with the interests of the chemical user - to drive chemical volumes down. This is just the opposite of the typical chemical sales relationship.

In a chemical management relationship the goal is to continuously reduce chemical use and waste while continuously improving product and process quality. The supplier and the user "share the savings" gained through chemical volume reduction and improved processes. To achieve these benefits, the user and supplier must assume responsibilities based on their respective core competencies. Simply stated the user defines chemical performance specifications

Exhibit 4. Shared Savings relationship - a supplier's incentive to decrease chemical volume.



and the supplier takes direct responsibility for insuring the chemicals meet the users performance specifications.

Chemical Management at GM's Electro-Motive Division

General Motors produces locomotive engines at it's Electro-Motive Division (EMD) plant in LaGrange, Illinois, a suburb of Chicago. Deregulation of the railroad industry in the 1980's produced a dramatic decline in demand for locomotives and the EMD plant experienced a series of cutbacks in production and employment. The ongoing need to reduce costs and improve efficiency led EMD in the early 1990's to begin exploring Shared Savings Chemical Management as an alternative to their traditional approach to chemical supply.

In 1994, EMD began a Shared Shavings program with the D.A. Stuart Company. Under the contract, Stuart serves as a Tier I supplier for coolant, cleaners, oils, and water treatment chemicals for the entire plant. EMD no longer purchases these chemicals. Instead, the chemicals are provided by Stuart in addition to an array of chemical management services ranging from ordering and inventory management to chemical maintenance and problem-solving (see the program summary in Exhibit 5). In exchange, Stuart receives a fixed monthly fee.

An immediate benefit to EMD was a reduction in chemical costs. Stuart was able to offer an initial contract that was 30% less than the amount the EMD had previously spent on these chemicals. In addition, Stuart guaranteed an annual reduction of 6% in their fees for the first three years, and 3% for for the next five years. As impressive as these savings are, they address only the "tip of the iceberg." As illustrated by the pollution prevention examples below, the *Shared Savings* program at EMD has produced significant savings in the lower portion of the chemical cost iceberg as well.

P2 Examples at EMD

Eliminating Sodium Nitrite in Parts Washers

Three large volume parts washers were using a rust preventative (RP) containing sodium nitrite, a SARA 313 reportable chemical. The use of sodium nitrite solution had been increasing, from about 9 drums per month in 1996 to more than 11 drums per month in the first half of 1998. Approximately 1 drum of cleaner was also used each month along with the RP. EMD was concerned about the increased use of RP and its potential impact on employee health and safety.

A team of Stuart and EMD personnel analyzed the process and were able to identify a superior cleaner-RP for the system. The new solution was less hazardous and contained no sodium nitrite or other SARA 313 material. In addition, it had a longer process life, performed better, and cost less than the previous RP!

Exhibit 5. Summary of Shared Savings Chemical Management Program

GM's Electro-Motive Plant, LaGrange, Illinois

Began first *Shared Savings* program: 1994

Name of current program: Chemicals Management Program (CMP)

Supplier: D.A. Stuart Company

Chemical Footprint: Machining fluids (coolants), cleaners, oils, water treatment and miscellaneous small-volume chemicals

Financial Terms:

- Fixed monthly fee based on historical chemical usage and production.
- Management fees for selected services

Performance Expectations: Annual fee reductions of 6% for three years and 3% for the next five years.

Supplier Services:

- Acquisition and inventory control
- Monitor and coordinate chemical usage
- Research and improve chemical performance
- Ongoing reporting and communication
- Product and process engineering development
- EHS compliance and training
- Continuous waste minimization
- Filter management

Benefits:

- More than a 30% reduction in chemical costs.
- More than a 50% decrease in coolant usage and coolant waste, while increasing coolant performance.
- Elimination of biocide additions of central coolant systems.
- Elimination of sodium nitrite from washers and a reduction in cleaner usage and waste
- Improved inventory control reduced inventory costs, product consolidation.
- Training and other programs to improved health and safety protection.
- Chemical tracking for easier compliance reporting.
- Reduced VOC emissions.
- Many other improvements which reduce labor overtime, improve process efficiency, improve product quality, and reduce rework.

As a result of switching to the new cleaner-RP and improvinging the control of chemical feed rates, usage of cleaner and RP dropped from almost 12 drums per month to 2.5 drums per month, an 80% reduction in chemical volume. In addition, the new chemical cost 25% less per drum. Together, that produced an overall 85% reduction in chemical costs! Moreover, the new cleaner-RP performed much better. Rust problems related to the cleaners were practically eliminated, further reducing EMD's expenses for production downtime, scrap, and rework.

Reducing VOCs through Aqueous Washing

Located in the Chicago metropolitan area, the EMD plant has placed a high priority on controlling volatile organic compounds (VOCs). Clean Air Act requirements continue to tighten restrictions on VOC emissions. In their search for remaining sources of VOC in the plant, EMD and Stuart identified a parts washer that uses a common petroleum solvent. Though the solvent has excellent cleaning capabilities and minimizes rusting, it is a major contributor to the plant's overall VOC emissions.

EMD and Stuart personnel formed a project team to convert the process to aqueous cleaning. EMD will pay for the new washer, but Stuart is responsible for research, development, and testing of the new aqueous cleaner. Once the project is completed, the new washer should eliminate VOC emissions from the process and cut overall plant emissions in half. In addition, chemical costs should decline. Though the aqueous cleaner will cost four times as much per gallon as the original solvent, Stuart expects as much as a 95% reduction in the amount of cleaner used per year. EMD will benefit from the reduced VOC emission, but employee health and safety concerns will also improve with elimination of the petroleum solvent.

Eliminating Biocides and Reducing Coolant Waste in Central Systems

EMD uses two, large-volume central coolant systems for many of their machining operations. In 1994, shortly after the beginning of the Chemicals Management Program, one of Stuart's first responsibilities was helping to solve some of the problems with these systems. One of the most common problems was bacterial growth. Over time, the coolant became "rancid" due to bacterial growth. This bacteria created offensive odors, produced dermatitis among workers, and caused the coolant to separate into oil and water components reducing its effectiveness. In addition, they were experiencing periodic releases of ammonia from the coolant systems. The cause of the ammonia odor was unknown, but it was strong enough to disrupt work in the area, nearly resulting in the shut-down of operations on several occasions.

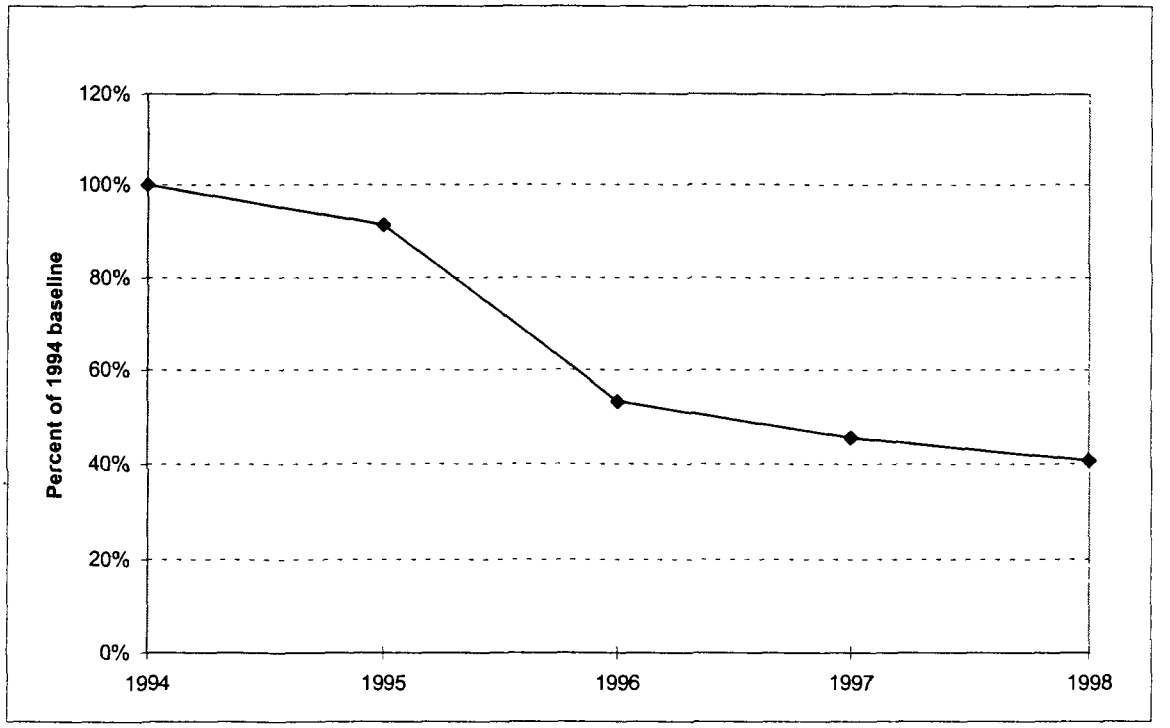
EMD's solution at the time was to add strong biocide each weekend to the coolant systems to control bacterial growth. Two biocides were used in an alternating pattern to minimize the development of resistant bacteria. The biocides were highly toxic as well as expensive, and cost EMD thousands of dollars per week.

The EMD/Stuart study team examined an array of alternatives, and in 1995 the two systems were converted to a new coolant. The new coolant worked better and lasted longer, reducing the plant's coolant consumption from over 100,000 gallons per year to about 94,000 gallons per year. However, the systems continued to have problems. As a result, the team began to investigate alternatives to the common practice of controlling bacterial growth using biocides. One promising approach was the use of pH to control bacterial activity. Studies suggested that if the coolant was carefully maintained at a slightly higher pH, bacterial activity and its associated problems could be significantly reduced without the addition of biocides. Using pH rather than biocides would also allow the coolant formulation to be simplified.

In 1996, the plant stopped using biocide and controlled coolant pH with potassium hydroxide. In addition, they switched coolant again - this time to a more simple formulation. The outcome was dramatic. Problems associated with bacteria - dermatitis, odors, and coolant deterioration - were practically eliminated. In addition, the systems no longer released ammonia, which the team had traced to an amine by-product produced by one of the biocides. Once the biocide was eliminated, so was the ammonia.

The new coolant also had a longer process life. Instead of changing-out the coolant every year in the large-volume systems, the systems now require emptying only once every two and a half years. This is scheduled to perform routine maintenance on the equipment, and most of the coolant is reused in the system. Exhibit 6 presents the trend in coolant usage compared to a 1994 baseline. Elimination of the biocides,

Exhibit 6. Reductions in coolant usage.



introduction of the new coolant, and a better coolant management program have cut coolant usage by more than half, as well as improve employee health and safety..

Maintenance and downtime costs have been reduced since the coolant is only removed on a bi-annual schedule. EMD saved money on the disposal of waste coolant since waste coolant haulage has declined with declining coolant volume. The new coolant also provides substantially better rust prevention, dramatically reducing downtime, scrap, and rework expenses. In fact, EMD used to have a line item in the budget for rust rework in these areas. The rust rework line item is no longer needed.

The Role of Shared Savings in P2

Any one of these P2 examples might have been implemented without a *Shared Savings* program and without the intimate involvement of the chemical supplier. However, Stuart provided valuable chemical expertise and research resources which EMD did not have available. Stuart's personnel simplified and expedited the analysis of the chemical problems as well as pilot tested the solutions. The *Shared Savings* program with D.A. Stuart is clearly the reason why EMD was able to generate a continuous series of P2 innovations since 1994.

Each of these P2 examples produced significant reductions in chemical usage for EMD. In a traditional sales relationship, D.A. Stuart would have experienced significant reductions in their sales revenues. While a supplier in such circumstances might contribute to a chemical user's P2 effort in order to avoid loosing an account, it would be foolish to direct the resources and expertise of the company to *maximize* the reduction in chemical use. However, under the *Shared Savings* program, D.A. Stuart *gained* significantly from these reductions. The *Shared Saving* program provided a strong incentive to Stuart to apply the full resources and expertise of their company to resolve EMD's chemical problems and maximize chemical reductions.

Conclusions

Traditional chemical supply programs have inherent financial incentives that promote waste and reward suppliers for increased chemical usage. *Shared Savings* programs reverse this financial incentive by converting chemical waste into profit for both the chemical supplier and chemical user. The *Shared Savings Chemical Management* relationship between GM's Electro-Motive Division and the D.A. Stuart Company has produced not only significant chemical cost reductions for EMD, but has also dramatically reduced chemical volumes and chemical waste . From the experience at EMD and dozens of other plants with Shared Savings programs, it is clear that changing the nature of the chemical supply relationship can accelerate the adoption of P2 innovations.

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[1] This work is adapted from Bierma, T.J., Waterstraat, F.L. 1997, *Innovative Chemical Supply Contracts: A Source of Competitive Advantage*. TR-31. Illinois Waste Management and Research Center, Champaign, Illinois.; and from Bierma, T.J., Waterstraat, F.L. (forthcoming) *Chemical Management: Reducing Waste and Cost Through Innovative Chemical Supply*, John Wiley & Sons, NY.

Chris Birk

One Hour Cleaners

"Waste Minimization and Compliance: One Dry Cleaner's Story"

BIO

Chris Birk, is one of the shareholders/owners of the family owned drycleaners and oversees its daily operation. Chris graduated from Purdue University in 1978 with a degree in computer science and also involved with computers (he has done computer work for the World Wildlife Fund, Washington DC, a conservation entity). He is a recently elected member of the board of directors of the Indiana Drycleaners and Launderers Association. IDLA is a joint state association with IFI (International Fabricare Institute- the worldwide association of professional drycleaners and launderers). His personal goal of being on the board of IDLA is to see the furthering of education of all drycleaners including the area of environmental management. He was elected to chair the membership committee of IDLA. He has been involved in the drycleaning business since it was bought (some of that as a youth). He has read extensively on all aspects of the cleaning business, attended various seminars, shows and sessions whenever possible. He has also attended IFI's wetcleaning course held this year. He is an active participant on the fabricare forum on the internet, sharing his knowledge with other cleaners on many issues including wetcleaning and waste reduction issues along with learning from others on the forum. He oversees and does most all the equipment maintenance, modification and installation, and has quite a bit of experience in electrical control circuitry applications. A technical bulletin was written by IFI on cleaning band uniforms in which he supplied the information and received acknowledgement for providing the information. He has recently written and had published a letter to the editor in American Drycleaner magazine on professional wetcleaning.

Chris is single. He is active in his church, has serving in many roles including teaching a senior high Sunday school class, and is a lay speaker. He is also active in the Boy Scouts of America (30 year veteran of the program), having served in all local district committee positions and committees, serving on 3 National Jamboree staffs, receiving several recognition awards including the highest award the local council can bestow (Silver Beaver award), and as a youth obtained the rank of Eagle Scout. His hobbies outside of work, church and scouting include showing his 1978 Pontiac Trams that he restored, having owned it from when it was new. Conservation, the saving of our resources and the environment are not new concepts to him.

One Hour Cleaners -- 1 cleaners success story

I. Introduction

a. *Who we are:* One Hour Cleaners -- Peru, Indiana
b. *Years in business:* 40 years, started as a One Hour Martinizing, we (my folks/brother/myself) have owned for 32 years, incorporated as BDC Enterprises, Inc.
c. *Size of cleaners:* There are 3 cleaners in the town, volume wise we rank at the number 1 or 2 spot. County used to have an air force base until it was closed in the early-mid1990's, which dramatically impacted the local economy, as over 1200 families plus other military personnel moved out over a very short period of time.
d. *Method of cleaning:* Perc in a 3rd generation dry to dry machine installed in 1983 with refrigeration technology installed on it in 1998.
e. *Where we came from:* original equipment was a transfer unit installed in 1958.
f. *Other status:* CESQG-while legal, all our drycleaning hazardous waste goes to Safety Kleen, all other items such as fluorescent bulbs to the local solid waste districts annual hazardous waste day collection. We use recycled poly bags for our outgoing garments and collect them for recycling, along with hangers.
g. *Recognition:* Participate in IDEM's 5 star program, first award a "3 star rating in 1996," have applied for a higher star rating due to additional solvent conservation. Local solid waste district has recognized us for a 50% reduction in trash through recycling of all cardboard, office paper, plastics and aluminum cans. Was a winner in the American Drycleaner's 1984 Annual Plant design contest (American Drycleaner is one of the major trade magazines).
h. *Wetcleaning:* Approximately 25% of the garments coming in our doors currently.
i. *Wetcleaning other:* Been involved in beta testing of at least one wetcleaning detergent and have done comparison of other wetcleaning products and their results.
j. *Wetcleaning training:* Was to IFI's wetcleaning course in Silver Spring MD in 1998.
k. *Trade memberships:* Am a member of International Fabricare Institute (IFI) and the state association of drycleaners where I serve on the board of directors of the state association (IDLA).
l. *Other participation in the industry:* Involved in educating other cleaners on the "fabricare" forum (an email forum)
m. *Water conservation methods:* Own a Maytag Neptune with its decreased water usage used on many of our washable goods to conserve water (have owned it since it was first available)

n. *Other water conservation:* Have a water chiller so that water used for cooling in the drycleaning machine is recirculated and re-chilled so that we do not waste water.
o. *Perc consumption:* Over the years (1960's with transfer unit, it was several hundred gallons a year, of course this was with an air force base in full swing because of the Vietnam War and before the polyester revolution to prior to "The Problem" of around 135+ gallons a year, to now around 60 to 70 gallons a year. Back in the 1960's we cleaned as many garments in one day as we do nearly all week now. This had to do with the local economy, the garments and fabrics, and was before the 1970's polyester revolution. (This statement could be made by a lot of drycleaners on their volume.)
p. *Other waste reduction methods:* The current machine, have made changes in the way the cleaning process works so that we triple the usage of the drycleaning filters, cutting by 1/3 the amount of hazardous waste that has to be hauled away by Safety Kleen. Working on testing some methods to reduce that even further.
q. *"Restrictions":* We had in order to stay under the 140 gallon limit prescribed by NESHAP, and gave up some cleaning contracts (band uniforms) as that increased volume would have pushed us over the 140, now we are back doing them again and enjoying the increased revenue and greater solvent mileage.

II. The Problem -- Out of Compliance

a. Failure to record one perc purchase during a time of crisis (auto accident destroying a good part of our building)
b. The inspection and discovery of the problem
c. Our response-quick immediate action to be compliant along with concern over our 5 star status.

III. The Result

a. Back in compliance
b. Increased solvent mileage (meaning less "air pollution") allowing us to move forward and qualify for higher star rating.
c. allowed to increase volume with solvent mileage basically doubled.

IV. The role of recognition.

a. Competitive edge-in our case, State of Indiana actively promotes its "5 Star" cleaners, on a web site, with brochures and with literature that goes out with environmental license plates.
b. For those who are environmentally concerned. I live a mile from a closed landfill. No one wants a landfill in their backyard, and we do not want any hazardous waste ending up in a landfill.

c. Play a role in protecting our environment by qualifying and staying qualified in the recognition program. One can be either leaders or followers or "do nothings" when it comes to environmental management.

V. Summary

In relationship to increasing wetcleaning volume substantially, we are in a town that the sewer plant is running at full capacity so increasing wecleaning volume more would not be "helpful" at this point in time. We read and see on tv about the water shortages and dwindling water supplies. With the current drycleaning system with the water chiller, no water is wasted or used, as it is all "recycled" and used over and over again in cooling the machinery. It is a closed loop situation.

What recognition programs such as Indiana Department of Environmental Management's 5 star program does is give added incentive to take additional initiatives to ever further the results and go beyond just what the laws require. With the recognition in the program, and the requirements of the program, it gives all an opportunity to realize a higher vision/goal and know that it is possible.

Also IDEM has the CTAP program that is Compliance Technical Assistance Program, which allows businesses to discuss confidentially various aspects of their business and be able to come into compliance if they are not. The CTAP program also puts on various training sessions yearly for perc drycleaners, so all are aware of the state/federal regulations and how they effect us. This gives the businesses great insight into what is required and expected. So that instead of just enforcing the laws, they help train the businesses in what is required. For it is far better to have a business in compliance and handling their wastes properly than to just discover them someday in the future when they have been improperly handling their waste. So it is prevention before a problem than pollution after later on. Businesses view programs such as CTAP as government helping business (kind of like a joint venture) to meet the regulations, not just enforcing them.

So often we think that the only reason that businesses take any conservation or environmental measures is because the law requires it. This is not the case at all. Many drycleaners recognize the importance of conservation of solvent and other supplies not only on the bottom line but in the health and safety of themselves and their staff. In many smaller cleaners, members of the family work every day in the plant, so there is the definite concern for the workers. A quotation I read recently said that rules do not make a good operator, a good operator must always be thinking about how to improve his operation, above and beyond what the rules say. You can see that we had been long involved in recycling, water conservation, trash reduction, making efforts to reduce our solvent consumption and decrease the amount of waste produced and then disposing of them in the appropriate manner. A lot of this is not required by the law or even by the recognition program, but it is a way to be a good corporate citizen in protecting the environment.

Timothy M. Bock

Timothy M. Bock received a B.A. in Physics & History from Indiana University South Bend. He is a Registered Environmental Manager, registration number REM 7415 (National Registry of Environmental Professionals), and is the Environmental, Health & Safety Manager at Crown International, Inc., Elkhart, Indiana.

He currently serves on the State of Indiana Clean Manufacturing Technology Board, the Elkhart County Solid Waste Management District Advisory Committee, the Board of Directors of the Environmental Management Association of Northern Indiana, Inc., and the Greater Elkhart Chamber of Commerce Environmental Council, where he also serves as Eartha Award Chairperson and Pollution Prevention Issues Coordinator.

He is a past president of the Environmental Management Association of Northern Indiana, Inc., the American Society of Safety Engineers, Michiana Chapter, and served on the Pollution Prevention Performance Measurement Methods Project Work Group at the Indiana Clean Manufacturing Technology & Safe Materials Institute.

He is a past recipient of the Industrial Waste Award from the Indiana Water Pollution Control Association (1996) and the Distinguished Service Award from the Elkhart County Solid Waste Management District (1997). He led the efforts at Crown International that resulted in the company's receipt of the 1996 Indiana Governor's Award for Excellence in Pollution Prevention, the 1996 Industrial Waste Award from the Indiana Water Pollution Control Association, and the 1997 Distinguished Recycling Award from the Elkhart County Solid Waste Management District.

Timothy M. Bock

Crown International, Inc.

"Shifting Paradigms"

SHIFTING PARADIGMS

Abstract: No one can dispute the fact that dramatic environmental improvements have been achieved the past 28 years under federal command and control regulations, with most decisionmaking also taking place at the federal level. Equally indisputable is that our achievement of the next level of environmental protection and improvement depends on our ability to change many of the paradigms we have that can prevent us from achieving that next level of environmental protection. Recognizing that environmental decisionmaking and priority-setting is more effectively made at the local level, rather than federal or state levels, and that pollution prevention solutions are far more protective of the environment than reactive "command and control" measures, are the key paradigm shifts we need to make.

"Hi, we're the EPA and we'd like to come help you prevent pollution!" Although not a direct quote, the underlying tone in the letter I received from Region 5 sent that message. Not by nature a cocky person, I went out on a limb and responded "Thanks, but no thanks—we've got everything under control here," and proceeded to trumpet our accomplishments in the pollution prevention arena.

I soon forgot what I'd done, but immediately remembered it weeks later when I received a telephone call from Region 5. Much to my surprise, the call was an invitation to speak at their December 1998 conference. They had me. "Walk your talk" resounded through my head. I accepted.

Not one to seek speaking engagements, I felt this was important, because EPA was in the very role that I strongly believe should be their primary role: That of "encourager". Concentrate efforts and resources in encouraging states and industry to prevent pollution, rather than regulating industry to the nth degree, which consumes valuable resources in paperwork exercises, instead of creatively improving processes to prevent pollution and decrease costs.

Disclaimer #1: I am not naïve enough to believe that we would be better off without the agency, as suggested by the keynote speaker at a luncheon I recently attended. The threat of enforcement will always have to be there, because there will always be bad apples. While "freeing" the states to do their own thing may sound like a good idea, we'll always need oversight to some extent to ensure that other types of bad apples don't trade their state's future environmental quality for more immediate awards, such as attracting new business. Research also makes sense at a national level, to maximize resources by not reinventing the wheel 50 times.

So that's my vision of the new EPA: Encourager, Researcher, and last resort Enforcer.

What about the role of the states? Encouragers, Performance Monitors, and Facilitators.

The primary thrust of Indiana today is to be an *encourager*. The Governor awards deserving companies with his "Excellence in Pollution Prevention" award. Another initiative from the Governor is the Toxics Reduction Challenge that he issued this year primarily to industry, but not exclusive-- municipalities can pledge, as the City of Elkhart has. Those that accept the challenge pledge to further the goals of reducing toxic releases to the environment, whether that be actual toxic use reduction or promotion of toxics reduction.

The goal of the Commissioner of the state agency (the Indiana Department of Environmental Management--IDEM) is to increase pollution prevention staff and reduce regulatory staff as efforts come to fruition. As he recently stated in a local presentation, in reference to pollution prevention being the "third generation" of environmental protection, "Our job and challenge is to facilitate this new way of thinking." In the past year, his first at the helm, the Commissioner has been in Elkhart at least 3 times that I personally know of, each time promoting pollution prevention. To the best of my knowledge, that's 3 times more than any of his predecessors—at least in the past 7 years.

Beyond increasing the visibility of the Commissioner, another way in which the agency is "facilitating this new way of thinking" is through Pollution Prevention Challenge Grants, $5,000 grants provided to businesses for assistance in implementing pollution prevention projects. Another avenue is through the organization of a group aptly named "Partners for P2". Initial membership began with recipients of the Governor's Excellence in Pollution Prevention award, and soon expanded to include recipients of IDEM Pollution Prevention Challenge Grants, members of the state Clean Manufacturing Technology Board, and most recently, those accepting the Toxics Reduction Challenge.

The group's mission, "The Partners for P2 instills the passion for pollution prevention in businesses and organizations by promoting successful approaches to achieve a measurable reduction in pollution in Indiana," may seem lofty, but initial success is measurable: The "1st Indiana Pollution Prevention Conference and Trade Show", co-hosted by the Partners, IDEM, and the Indiana Clean Manufacturing Technology and Safe Materials Institute this past September, attracted more than 275 attendees!

Another key effort by the state is to *measure performance* by actual environmental improvement, rather than the number of enforcement actions. The first report was issued this year, and I believe was very well received. It was eye-opening, and revealed the unique differences and needs of each area of the state. While one county may be struggling to reduce toxics emitted to the air, their next–door neighbor may be drowning in waste tire dumps.

The state is also thinking more "regionally" to *facilitate* local solutions to local problems. A new IDEM office is slated to be opened for the North Central region that Elkhart is part of, with the intention of focusing more on the area's diverse industry and needs. In addition to the Commissioner, IDEM staff has also taken to the road on a regional basis, holding public meetings to focus more on regional issues and needs.

Disclaimer #2: Upon her first review of this paper, my wife commented that it seemed to be a sales pitch for Elkhart and/or Indiana. While not my intent, she brought up a good point: We're doing everything right in Elkhart and Indiana! Okay, maybe we're not perfect, but we do have a lot of great things happening, and my purpose is to share those successes in the hopes of them spreading like disease!

How do we get to the point where regulators can devote most of their energy into being Encouragers, Researchers, Performance Monitors, and Facilitators? By opening our minds and creativity to partnerships. Move from our current polar extremes and meet somewhere in the middle. Allocate resources where the most environmental impact will be made. Share successes. And shift our paradigms.

Paradigm Shift #1: "The words 'pollution' and 'industry' go hand-in-hand."

This is a key paradigm that we must change before we can even contemplate changing those that follow. It also best illustrates the importance of environmental decisionmaking and priority-setting taking place at the local level.

According to the Indiana Department of Environmental Management (IDEM), regarding the state of Indiana's environment:

- The drinking water contaminates posing the most immediate health risks to humans are bacteria and nitrates.

- Ingestion of paint chips from the walls of their home is the major source of lead poisoning for children.

- Industry's contribution of nitrogen oxides and volatile organic compounds (VOC's) to the environment is only 18% and 28%, respectively, of total emissions in Indiana.

One or more of these environmental issues are a key concern for each community in Indiana. Yet industry's contribution to these health risks is minimal to none. I'm particularly aware of Lagrange County, a rural farming community located east of Elkhart, where a high incidence of miscarriages is suspected to be due to high nitrate levels in the groundwater. I can't speak for the residents there, but I know groundwater would be my primary concern, not the VOC's emitted by the handful of industry that is located there.

The major source of solid waste in many Indiana Solid Waste Management Districts is residential--not industrial. Using command and control tactics on industry is not going to help those districts one iota in achieving State solid waste reduction goals. Rather, the goals will be achieved because the members of the district Boards and Advisory Committees are all residents of the district, and represent all sectors of the community--local government, citizens, environmental organizations, business, and industry.

My intention with the preceding paragraphs is not to deny or understate Industry's contributions of pollutants to the environment; rather, by pointing out that industry is not the sole source, my hope is that the door has been opened to make this a "we" problem-- not "they", and to recognize that each community is unique in its environmental concerns and needs.

Paradigm Shift #2: "Environmental command and control regulations will eventually eliminate pollution."

As my children would say, "Not!" In fact, I posed this as a question to my 11-year-old son, after explaining the condition of the environment 28 years ago, and where it stands today. His concerned response: "It will take hundreds of years, Daddy"--a figure not far from my own guesstimate. My son and I aren't the only ones to realize this. One of the staunchest supporters of pollution prevention in Indiana is an activist organization, which realized a long time ago that the only way to eliminate pollution is to prevent it from being generated in the first place.

Another skeptic of this paradigm is a respected colleague who began his career as a regulatory inspector. After several years of frustration with the ineffectiveness of command and control regulation, he left to join industry to have a positive impact on environmental protection: "I felt that I could accomplish more environmental protection working in industry than in government." And he has. As a leader in this area, from leading professional environmental organizations to teaching courses at IVY Tech, he has taken countless "environmental rookies" under his wing and developed them into environmental professionals. I believe that I can safely state that he, more than any other individual in our area, has been most responsible for the visibility and activeness of environmental affairs in our community.

Only industry can eliminate pollution generated by industry-- unless we eliminate industry. Since I expect that the majority of Americans aren't willing to give up their current standard of living, eliminating industry is probably not an option.

How, then, can we encourage economic growth and at the same time encourage industry to eliminate pollution?

Paradigm Shift #3: "Force industry to eliminate pollution by embarrassing them."

Will industry eliminate pollution through tactics such as embarrassment? I believe "yes" to some extent. However, in my experience, coercion at best results in gaining only what was targeted. Different tactics, such as awareness, encouragement, and recognition, are needed if we want industry to eliminate pollution through continual review and improvement of their manufacturing processes.

After getting "beat up" by the press two days earlier ("Indiana is 'most polluted'--Two Elkhart plants named in region's 'dirty dozen'", The Elkhart Truth, July 12, 1998.), we in Elkhart County greatly appreciated IDEM Assistant Commissioner Tom Neltner (Office of Pollution Prevention & Technical Assistance) stepping forward to recognize the pollution prevention efforts that are being made by Elkhart County businesses ("Plants working to reduce pollution", The Elkhart Truth, July 14, 1998).

Neltner pointed out that the two companies spotlighted in the earlier article were diligently working with the Indiana Clean Manufacturing Technology and Safe Materials Institute to find a non-toxic, or at the least, less toxic alternative to the primary chemical currently used in their processes. As judged by the comments expressed by those participating in the next Environmental Council meeting at the Greater Elkhart Chamber of Commerce, and the thank you note to him that followed, Neltner's efforts symbolized, and strengthened, the productive and positive relationship that is being built by IDEM and Indiana industry.

At the risk of alienating myself from my colleagues, I will share a "secret" with you that I heretofore have only shared with a couple of peers: I believe that Toxic Release Inventory (TRI) reporting has been one of the most effective tools in encouraging pollution prevention that our government has promulgated. NOT because it embarrasses industry: It is effective because it brings about awareness. It is the only report that I cannot legally sign because it requires the signature of a senior manager.

Prior to TRI reporting, environmental matters at Crown were an operational concern, and only a few employees even knew we generated hazardous waste. In 1991, due to the absence of the senior manager in charge of manufacturing, I had to seek out the President for his signature. He was instantly alarmed: Why do ***I*** need to sign this? What does it mean? What does ***my*** signature mean for me personally?

The result was that he became much more informed, made environmental matters a corporate, rather than operational concern, and gave his full support to eliminating hazardous and toxic chemicals from our workplace.

Paradigm Shift #4: "State-funded pollution prevention assistance is nothing more than 'corporate welfare' ".

As just noted, I had a commitment from the top to eliminate hazardous and toxic chemicals from our workplace. So I waved my magic wand and "presto", we became a clean manufacturing facility. Not! We needed to set priorities. Determine available options for process improvement. Find vendors.

Review costs. Justify final selection. Etc., etc. And still get all our other work done.

This is the point where a small group at Purdue University became invaluable. Now known as the Clean Manufacturing Technology and Safe Materials Institute (CMTI), this group of engineers reviewed our processes, reviewed alternative "clean" processes and costs, and made recommendations.

With CMTI's recommendations in hand, and further research on our part, we eventually were able to eliminate the key hazardous and toxic chemicals 1,1,1-Trichloroethane and Methyl Ethyl Ketone from our manufacturing processes.

Methyl Ethyl Ketone was eliminated by replacing a solvent-based coating process with a "solvent-less" powder coating process. From our experience at Crown, here are some figures for powder coating versus wet coating for your consideration:

Quality improvement. 1% defect rate for powdercoat, vs. 4% for wet coat.
Decreased lead times and inventory, and increased cash flow. All of the parts previously finished by vendors have been brought back in-house, thus substantially reducing our costs and decreasing the lead times of 66% of our parts from 20 days to 3 days.
Increased throughput. 300 powder coated parts/hour vs. 60/hour for wet coat.
Decreased waste. Less than 1% of powder is wasted; more than 64% of wet coat paint was wasted, with 71% of that waste being hazardous.
Decreased raw material costs. Comparing equivalent coverages, powder is 1/3 the cost of the previously used wet coat paint.

These figures are much better than what we expected. Although the final figures aren't in yet, my understanding is that the investment payback time for the powder coat system was much less than the 18 months originally projected.

Although I didn't major in business, to me the above facts spell "increased profitability" for Crown, "increased tax revenue" for the state, and "investment" --not corporate welfare.

Paradigm Shift #5: "Industry only does what the government forces them to do."

There are many pollution prevention success stories beyond that just provided. For several years our Chamber of Commerce has awarded an environmental "Eartha Award" to "deserving entities". I jumped at the opportunity to participate in the selection committee last year because I had very strong feelings about the selection process. It bothered me that many of the past recipients weren't Chamber members, and those that were members weren't from the manufacturing sector, and few, if any, of the projects selected had any significant environmental impact. The many pollution prevention efforts of the manufacturing community weren't being recognized.

So there I was at my first meeting, primed to initiate change. My first suggestion was to target local manufacturers, many of which were implementing pollution prevention projects that had significant positive environmental impacts. The suggestion was quickly dismissed because "they [local manufacturers] aren't doing anything except what they're forced to do by the government." Keep in mind that these were fellow businessmen--not the stereotypical environmental activist!

I had some paradigms to change. Needless to say, I am now the chairperson of the Eartha Award Committee, and five very deserving manufacturers-- who have gone beyond what is required of them in their pollution prevention efforts-- have received the award since. In fact, let's talk about one of them, as their partnership with local regulators is quite a success story.

Paradigm Shift #6: "To adequately protect the environment, environmental decisionmaking must be made by State and federal regulatory agencies, and backed by a threat of punishment. "

Utilimaster, which is located in Wakarusa, Indiana, manufactures the "step-vans" that are used by FED-EX, the U.S. Postal Service, and many others. They are rugged vehicles that require an equally rugged finish.

Up until last year Utilimaster used a phosphate-based conversion coating process prior to painting. The coating worked wonderfully and certainly didn't need "fixing". That is, until the Town of Wakarusa approached them about a dilemma the Wastewater Treatment Utility was facing.

Due to continued growth, Utilimaster's discharge had increased-- up to 61% of the Wastewater Treatment Utility's capacity. As designed, Wakarusa's wastewater treatment plant could not keep up with the increased phosphorus load placed on it, and thus not meet their National Pollutant Discharge Elimination System (NPDES) permit limits for phosphorus. The town would need to invest in a new phosphorus-removal system, at a $110,000 capital cost and annual operating costs of $150,000. Not financially feasible for a small town the size of Wakarusa.

Utilimaster responded by launching an investigation into process modifications and material substitution to eliminate the problem now and for the future. The result: After much effort, Utilimaster was able to modify the process and replace the conversion coating, which eliminated phosphorus from the process and thus their discharge. The winners: The Town of Wakarusa, which is able to meet their permit limits without any additional costs, **and** Utilimaster-- in addition to the environmental benefits, the new process also provides quality and cost advantages-- indeed, a 12% decrease in the cost of painting vehicles!

Another example of partnering at the local level is the City of Elkhart. All new and renewed discharge permits have as the very first page "the pledge". It is a voluntary agreement between the City and each permittee, and if signed by the permittee, will also be signed by the Mayor. It is a mutual commitment to both support economic development and foster environmental stewardship, whereby pollution prevention considerations guide decisionmaking to best protect the environment and preserve our natural resources. While on the outside the pledge may seem to be merely "fluff", there was a very firm foundation built over the past few years by both parties to make it a reality.

For its part, the City has sponsored seminars, held roundtables to facilitate a good flow of communications, and partnered with the University of Notre Dame School of Civil Engineering to provide pollution prevention assistance to permittees. For its part, industry has responded positively and has actively participated in these offerings.

Win-Win-Win is the best description of the results. The City wins by having the full support of industry in its efforts to be in compliance with ***its*** NPDES permit, today and in the future. The Notre Dame students win with practical hands on pollution prevention experience. And industry wins by being better informed, and gaining the many benefits of pollution prevention projects implemented.

Probably the best example of the effectiveness of local environmental decisionmaking is provided by Elkhart County's Solid Waste Management District. To date, we have achieved the State solid waste reduction goal of 35% (on time) and are on track to meet the 50% goal that is the ultimate target. What makes this record impressive is the complexity of our waste stream-- there was not a single solution to the problem.

The majority of our waste is generated by industry-- a very diverse industry. Elkhart County is not Indiana's #2 manufacturing powerhouse solely due to several large companies or industrial sectors; we are #2 due to thousands of manufacturing entities, small to large, representing nearly every imaginable sector, ranging from manufactured homes to composite plastics fabrication, recreational vehicles to molded foam products, band instruments to electronic components, utility trailers to metal finishing, pharmaceutical-- you name it, we got it!

Being a community built by entrepreneurs, we made the decision early on to keep our fingers out of the recycling and pollution prevention business and let the private sector do what it does best-- make money by satisfying needs. The District's focus is thus education and tracking progress toward meeting the goal. Our Administrator has been to more businesses than he can count to conduct waste audits to help companies identify recycling and reduction opportunities.

Of course, the private sector didn't disappoint us-- we have recyclers taking care of nearly every waste stream you can think of-- from wood to gypsum board to the commonly recycled residential materials (newspaper, glass, plastic, etc.). Have we reached everyone? Are we recycling everything that can be recycled? Not yet. But we sure do have a good start on it!

Another benefit of the District: I believe it has provided all of us with a different perspective than that which we had prior to our involvement. I have developed a deep appreciation for the quality of our local government officials (not politicians!). A member of a local environmental group now has an awareness of the pollution prevention efforts industry is making. We all have a much better understanding of the many issues that haulers and landfill operators face.

Paradigm Shift #7: "The best way to determine if environmental improvements are being made is to review enforcement actions."

Where there is a lack of knowledge to facilitate environmental decisionmaking and priority setting at the local level, the state's job-- and challenge-- is to provide assistance to make it happen. Where there is a lack of action at the local level, the state's challenge is to make it happen. The "stick" should only be brought to bear when these efforts fail. The same logic applies to the EPA: Reveal the stick only after efforts at providing assistance and motivation have failed.

Environmental professionals have questioned the measurement methods used by regulatory agencies for a long time. IDEM has also recognized the inadequacy of these methods and, as noted earlier, published the "Indiana State of the Environment Report" for the first time this year. The 51-page report reviews all aspects of Indiana's environment: Air quality, watershed quality ratings, and landfill loading. All are quantified to provide a realistic picture of where we are, and where we most need improvement. It will take much convincing on someone's part to get me to believe that a review of enforcement actions can provide the same picture.

So what else has IDEM been doing? In this spirit, a review of IDEM's current efforts is warranted.

Paradigm Shift #8: "We're from the government and we're here to help."

One day this past summer I received a telephone call from our receptionist announcing that "John and Carol from IDEM are in the lobby to see you."

Her call brought back a memory that is as strong today as the actual event years ago, when the receptionist called me and said "Jack and Donna from IDEM are in the lobby to see you **OR** a member of Senior Management."

That day was my first RCRA inspection with representatives from the Indiana Department of Environmental Management. The results of the inspection would indicate not only whether or not Crown was in compliance, but also whether or not I was doing my job correctly. A very intense day that, while not particularly unpleasant, was not something I wanted to go through very often.

I shared that story with you to illustrate an important point: "John and Carol from IDEM" were John Hamilton, the Commissioner of IDEM and Carol Brubaker, one of his Deputy Commissioners. While planning a trip to Elkhart for other business, the Commissioner wanted to stop by Crown for a tour of one of the past recipients of the Governor's Award for Excellence in Pollution Prevention.

Now this was the type of regulatory visit that I like to host! The Commissioner was intensely curious and had a wonderful ability to quickly grasp concepts and take them to the next level. The most eye-opening part of the visit, however, was for me when he jokingly noted that if Crown blew up that night, he'd have mud on his face for not seeing the potential for it while he was here. It later occurred to me that in some respects he was putting himself on the line in his quest to see the view from our side of the table and, in the larger scope of things, to bridge the gap between "them" and "us".

From involving industry in regulation development, to encouraging the development of industry environmental management systems which include involvement by the public and local government, providing outreach activities such as regional seminars, and recognizing achievement through the Governor's Award for Excellence in Pollution Prevention, I laud IDEM's efforts, particularly in the past year, to build partnerships with Indiana's business community in the mutual quest to protect Indiana's environment.

Paradigm Shift #9: "I can't afford the time nor money to pursue pollution prevention projects."

In the new global economy, with global competition, you can't afford NOT to pursue pollution prevention projects.

The commercial audio business that Crown is primarily involved in is a very competitive and tight margin business. As we do not have the luxury of raising prices, as our competitors are lowering theirs, reducing the cost of manufacturing the product is necessary to survive.

You can only cut so much overhead. You can only squeeze vendors so tight. Eventually you must look to your manufacturing processes to achieve the reductions needed.

As I mentioned earlier, Crown is a past recipient of the Governor's Award for Excellence in Pollution Prevention (1996). The projects that led to the award involved changes, known as product substitution, that required investment in a $135,000 aqueous cleaning system that replaced a vapor degreaser, and a $1.1 million powdercoating facility that replaced a solvent-based coating process.

These projects enabled us to totally eliminate our use of 1,1,1-Trichloroethane and Methyl Ethyl Ketone, which were the primary hazardous chemicals used in our processes. In addition to eliminating the potential for employee exposure, our generation of hazardous waste was reduced by more than 50% and our air emissions reduced by more than 65%. We are now a small-quantity generator (vs. LQG)--that's right, I no longer have that Biennial Report to contend with, we are exempt from Title V air permitting requirements, and we no longer are subject to Toxic Release Inventory reporting for 1,1,1-Trichloroethane and Methyl Ethyl Ketone.

To give you a brief background of Crown, we manufacture commercial audio equipment, FM broadcast transmitters, and industrial power supplies (such as those that power magnetic resonance imaging systems-- MRI). Currently employing 750 people, the company was founded 51 years ago by Christian missionaries whose objective was to manufacture audio equipment that would survive the rigors of the South American mission field. The fledgling business was guided by the same principles proclaimed today: Honor God, Serve People, Develop Excellence, and Grow Profitably.

To achieve the balance our principles require, products and manufacturing processes are continuously under scrutiny and are improved, replaced, or eliminated to minimize waste and non-value added activities. Pollution Prevention is our commitment to good stewardship of the resources provided to us. Customers, Crown, and the environment benefit.

Is pollution prevention compatible with serving your customer and profitability? We at Crown sincerely believe so. As noted earlier, the resulting quality improvement, decreased lead times and inventory, increased cash flow, increased throughput, decreased waste, and decreased raw material costs were even better than what we expected.

Is pollution prevention "easy"? Probably not very often. It takes a commitment to excellence--product, service, and stewardship--and continuously seeking to improve your processes. It requires networking and benchmarking--what are others doing to achieve success?

Equally important, you need partnerships, such as with IDEM, the Clean Manufacturing Technology and Safe Materials Institute, and local regulatory agencies. All it takes is for us to change our paradigms.

ACKNOWLEDGMENT

The author would like to thank the following mentors and colleagues for their inspiration and encouragement: Clyde Moore, Chairman, Crown International, Inc.; Kurt Anderson, Environmental & Safety Manager, Monaco Coach Corp.; Jim Noonan, Assistant Director, Indiana Clean Manufacturing Technology and Safe Materials Institute; Claudio Ternieden, Section Chief, Office of Water Management, and Tom Neltner, Assistant Commissioner, Office of Pollution Prevention and Technical Assistance, Indiana Department of Environmental Management.

Robert P. Briggs/Roger L. Price

STV Inc.

"An Employee Driven Waste Minimization P2 Study at a Specialty Chemicals Plant"

Robert P. Briggs

Robert P. Briggs, II, P.G. is an Environmental Scientist with STV Incorporated. He received his Bachelor's Degree in Earth Science from The Pennsylvania State University in 1979 and his Master's Degree in Geology from Millersville University in 1993. Mr. Briggs has over 18 years experience in supervising and performing environmental studies, hydrogeologic and groundwater contamination investigations, regulatory compliance activities, health and safety programs and regulatory permitting efforts. He has extensive experience in waste management studies and audits, including site selection and evaluation, needs assessment, regulatory coordination and permit acquisition. Prior to joining STV Incorporated, Mr. Briggs was the Plant Engineer at a 500 ton per day office waste paper recycle pulp mill.

James Carlson

DaimlerChrysler

JAMES A. CARLSON

DIRECTOR OF POLLUTION PREVENTION AND REMEDIATION

Education

Wayne State University

BS Electrical Engineering, 1969

Cornell University, S. C. Johnson Graduate School of Management

Executive Development Program, 1990

Professional

Registered Professional Engineer: Michigan, Ohio, Indiana & Wisconsin

Diplomate - American Academy of Environmental Engineers

Member: Michigan Association of Environmental Professionals, ESD - The Engineering Society

Employment History

Mr. Carlson has 29 years of environmental engineering and regulatory affairs experience in the automobile and pharmaceutical industries. Since 1976, he has held a series of management positions with responsibilities related to plant and product regulatory issues.

In 1994, Mr. Carlson assumed the position of Director, Pollution Prevention and Remediation with Chrysler Corporation. In this position, he is responsible for the Corporation's environmental management system, pollution prevention, life cycle management, remediation and Superfund programs, as well as the deactivation and management of surplus real estate. Prior to this assignment, he held a number of plant and product regulatory affairs management positions with Chrysler and American Motors Corporation.

Previously, he managed regulatory affairs programs for Parke-Davis and Co. in the pharmaceutical industry.

He started his career with Ford Motor Company in 1969, where he held environmental engineering and regulatory affairs positions.

Chrysler Corporate Service Date: January, 1981

Kathy Carney

Battelle Memorial Institute

"Winning P2 Strategies for Laboratories"

BIOGRAPHY

Kathy Carney

Ms. Carney is a Certified Hazardous Materials Manager (CHMM) and received her Masters of Science from the University of Findlay in Environmental Management in 1997. Employed with Battelle Memorial Institute since 1990, Ms. Carney has held a variety of positions involving hazardous and radioactive waste management and hazardous materials transportation. Currently Manager of the Hazardous Waste Operations, she also coordinates the Responsible Care program for Battelle. Prior to her employment with Battelle, she has worked for Chemical Waste Management, Inc. and Westinghouse Materials Company of Ohio managing hazardous and radioactive waste management and transportation related projects.

Winning P2 Strategies for Laboratories

by

Kathy Carney

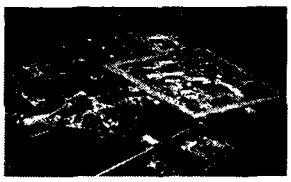
Battelle
. . Putting Technology To Work

Major Technology Centers

Corporate Headquarters
Columbus, Ohio

Pacific Northwest National Laboratory
Richland, Washington

Brookhaven National Laboratory
Long Island, New York



Pantex
Amarillo, Texas

Battelle Europe
Geneva, Switzerland

Battelle

2

Key Battelle Statistics

- Over 7,000 employees worldwide
- 5,276 projects
- 1,393 industrial and government clients
- Over 2,000 employees at Columbus-based facility
- Over 400 projects at Columbus-based facility

Battelle

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Key Industrial Markets

- Agrochemicals
- Automotive
- Chemicals
- Environment
- Consumer Products
- Digital Transactions
- Energy
- Medical Products
- Pharmaceuticals

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4

Key Government Markets

- Department of Energy
- Health and Public Policy
- NASA Technology
- National Security
- Environment
- Transportation

Battelle

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Putting Technology to Work

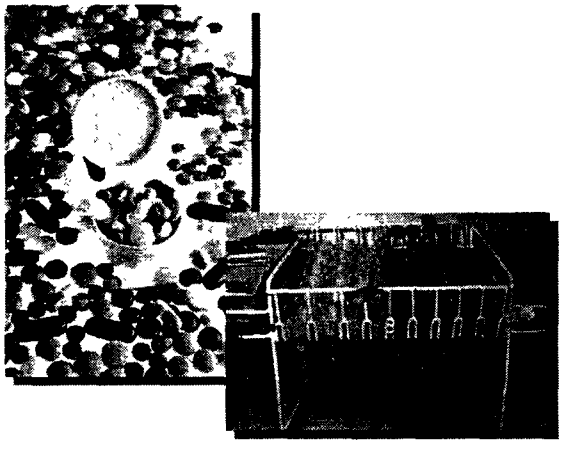
. . . for the Medical Products Industry

Battelle

6

Putting Technology to Work

. . . for the Pharmaceutical Industry



Battelle

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Putting Technology to Work

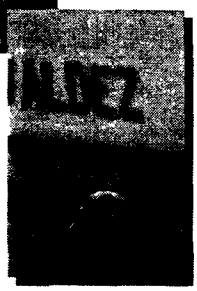
. . . for Health & Human Services

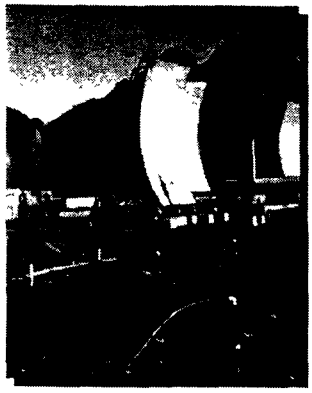
Battelle

8

Putting Technology to Work

. . . for the Environment





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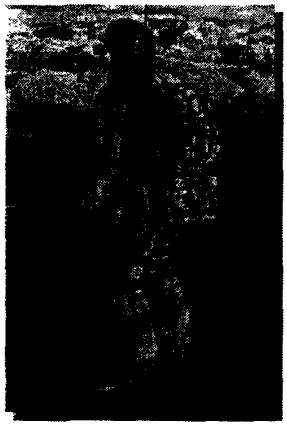
Putting Technology to Work

. . . for the National Security Community



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Putting Technology to Work

. . . for the Energy Industry

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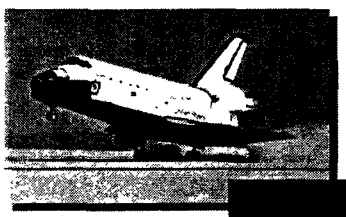
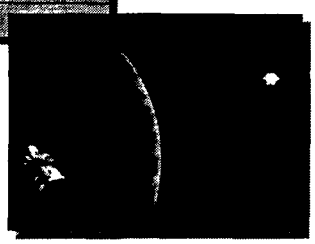
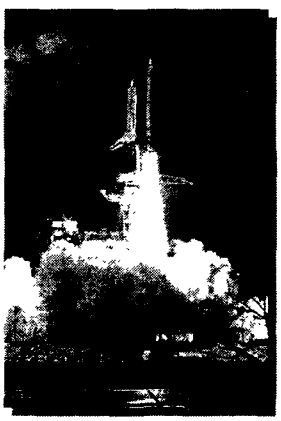
Putting Technology to Work

. . . for NASA







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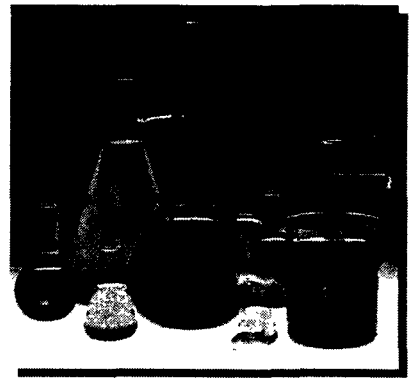
Putting Technology to Work

. . . for the Chemical Industry



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Putting Technology to Work

. . . for the Agrochemical Industry

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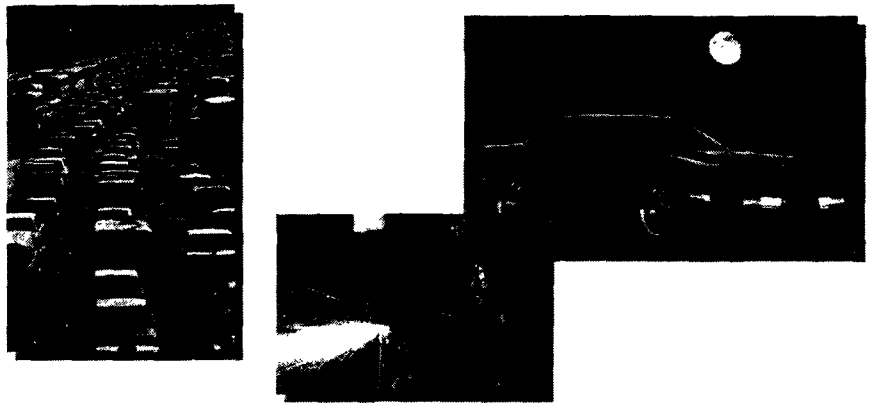
Putting Technology to Work

. . . for the Automotive Industry



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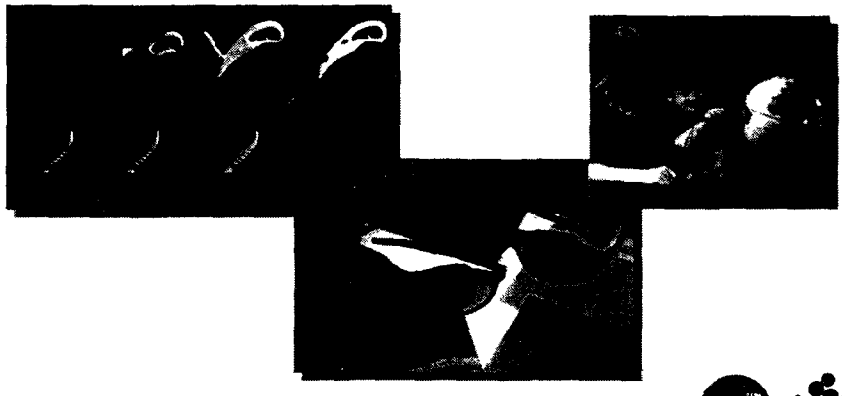
Putting Technology to Work

. . . for the Consumer Products Industry



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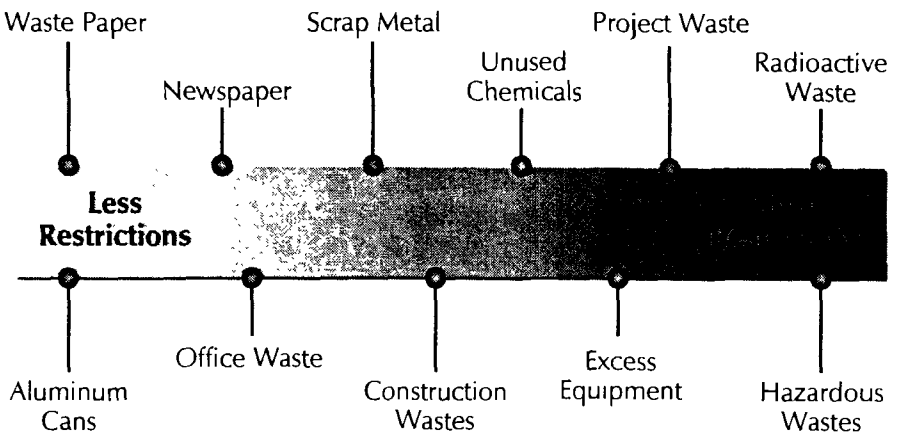
Wide Range of Wastes Generated at Battelle



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R&D Waste Options

R Reduce, Reuse, Recycle

& and

D Dispose

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Laboratory Dilemma

- High number of projects
- Small volume of waste streams
- Decentralized organization
- Creative work environment
- High technology
- Highly educated staff

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Battelle's Initial Approach to Success

- Build program on P2 basics (P2-101)
- Focus on non-technical
- Develop corporate policy
- Get organized – develop a basic program plan
- Build a support structure of management and staff

Battelle

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P2-101

- Make it easy
- Focus initially on non-technical opportunities for P2
- Identify existing P2 initiatives
- Document existing P2 and recycling activities
- Report and promote successes internally
- Educate staff

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Factors Contributing to Success in 1997-98

- Networking
- Improved documentation
- Improved management commitment
- Employee involvement
- Improved communication

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Getting Involved

- Ohio Governor's Initiative: "Ohio Prevention First"
- Ohio EPA Office of Pollution Prevention
- U.S. EPA Region 5 Voluntary P2 Program
- Local – Solid Waste Authority of Central Ohio
- U.S. EPA's WasteWise Initiative
- CMA's Responsible Care Initiative

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Improved Documentation

- Convinces management and staff of value of P2 program
- Tool for communicating P2 successes

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Management Support

- Which comes first, "the chicken or the egg"
- What do you ask for?
- Report success to management
- Communicate success to staff
- Seek external recognition

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Employee Involvement

- Communication – make it interesting
- Training – make it fun
- Activities and special events
  - Environmental fairs
  - Earth Day activities
  - Household hazardous waste collection days
- Incentives – recognition, cash awards, and trinkets
- Special initiatives
  - Hg Waste reduction initiative

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Netscape - [Battelle Waste Management]

http://www.battelle.org/wastemgmt/

Battelle's Waste Management Program

Because of the nature of Battelle's business we generate a wide range of wastes. We generate some of the same waste streams common to all businesses and industries such as office paper, scrap metal, and office waste. However, due to our unique R&D and project activities, we also generate waste streams requiring more restrictions such as unused laboratory chemicals, spent solvents, construction wastes, hazardous wastes, and radioactive wastes.

No matter what your position is here at Battelle--office staff, laboratory staff, researcher, manager, or subcontractor--you have the potential to generate waste. As a waste generator, you are the most important person in the disposal process! Only you know what the waste material is and how it was generated. You are in the best position to make the proper arrangements for its disposal.

This web page is designed to give you, as a waste generator, the

Chemical Redistribution Warehouse

- Planning for waste generation
- Generating waste and managing waste accumulation areas
- Wastes requiring special handling
- Managing unknown wastes
- Offering chemical and radioactive waste for disposal

Battelle

WASTE WISE

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Netscape - [Battelle Waste Management]

http://www.battelle.org/wastemgmt/

review your operations to prevent the generation of waste. To ensure the proper management of wastes in your laboratory, see Generating Waste and Managing Satellite Accumulation Areas. To learn more about disposing of chemical or radioactive waste, see Offering Waste for Disposal. These documents cover most of the prevailing waste streams generated at Battelle. For information regarding the disposal requirements for a specific waste stream not covered in the standard documents cited above, see the summary list at right.

Chemical Warehouse

Do you have chemicals that are available for re-use? Would you like to save your organization potential disposal costs for your un-used chemicals? Would you like to obtain chemicals without going through the procurement process at no cost to your organization? Then visit our internal chemical redistribution warehouse.

Hazardous Waste Generator Training on the Net

Click here to go through an interactive intranet-based training program for waste generators. Upon completion of the course please forward copies of your training certificate to your ES&H representative and Kathy Carney in HWO so you can be credited

- Other helpful links

Battelle's Paper Recycling Program

Battelle's Pollution Prevention Program

ES&H

Battelle's ES&H Documents site

Battelle's WasteWise Program

Responsible Care Initiative

Battelle

WASTE WISE

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Netscape - [What should i do with . . .]

http://www.battelle.org/wastemgmt/what.htm

What should I do with . . .

Wondering what the proper disposal method is for a particular waste? The list below will link you to the information you need.

- Acids
- Aerosol Cans
- Aluminum Cans
- Asbestos Containing Materials
- Batteries
- Broken Glass
- Caustic Wastes
- Chemicals
- Circuit Boards
- Computers and Related Equipment
- Construction Wastes
- Contaminated Media
- Controlled Substances
- Corrosive Wastes
- Corrugated Cardboard
- Cylinders
- Electrical Equipment
- Empty Containers

Glossary

Battelle

WASTE WISE

Netscape - [What should i do with . . .]

http://www.battelle.org/wastemgmt/what.htm#battery

Batteries

There are several different types of batteries including, but not limited to, alkaline, nickel-cadmium (Ni-Cad), lead-acid, and other batteries that contain reactive or heavy metals. Discharged batteries of all types (AA, AAA, D, C cells), computer batteries, Ni-Cads, and rechargeables can be disposed of in the Office Waste bucket or taken to the Instrument Lab. The Instrument Lab, located in 6A-0-28 also collects all other waste batteries. Take all your used batteries (other than alkaline batteries) to the Instrument Lab or offer them to HWO for proper management. For batteries managed through HWO directly, see Offering Chemical and Radioactive Waste for Disposal on how to arrange for the proper disposal of this waste stream. Since HWO manages all battery waste for the Instrument Lab, there is no charge for battery disposal, even if the batteries are directly offered to HWO.

Broken Glass

To protect janitorial and waste handling staff from injury, please place glass, whether broken or intact, into rigid outer containers (such as plastic jugs, buckets, or cardboard boxes) marked with the word "glass." This procedure includes glass waste, such as drink bottles, generated in office areas. Glass packaged in this manner can then be placed into regular trash receptacles. If the waste glassware was used to store a chemical, see Empty Containers for proper guidance on disposal.

Caustic Wastes

This waste stream can be managed in accordance with our general waste management procedure. Please follow the instructions given in Offering Chemical and Radioactive Waste for Disposal for more

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WASTE WISE

Netscape - [What should I do with ...]

http://www.battelle.org/wastemgmt/what.htm#lighting

Lighting Equipment and Wastes

Lighting equipment may contain fluorescent light tubes and metal vapor bulbs that contain mercury. Fluorescent tubes and mercury vapor bulbs of all sizes are collected for recycling by the janitors. The janitors then transport the lighting tubes to Shipping and Receiving where they are accumulated for recycling. Broken light tubes and vapor bulbs should be collected in rigid containers and offered for recycling through HWO. Contact Larry Dickson or Jim Audet of S&R or Kathy Carney of HWO for more information.

Older light ballasts may contain PCBs and therefore are collected for proper waste management by HWO. See Offering Chemicals and Radioactive Waste for Disposal for more information on how to arrange for the proper disposal of this waste stream.

Magazines

See Battelle's Paper Recycling Program for more information on paper recycling.

Newspapers

See Battelle's Paper Recycling Program for more information on paper recycling.

Battelle

WASTE WISE

PPT Carney 3-31 31

Netscape - [What should I do with ...]

http://www.battelle.org/wastemgmt/what.htm#officewaste

Office Waste

In order to encourage recycling and proper management of office waste, office waste collection areas have been established in each copier room at King Avenue and West Jefferson. Office waste collection areas consist of a 5-gallon bucket for "office waste" and a 1-gallon bucket for batteries. Office waste can be any of the following:

- Empty aerosol cans of "Old Smoky" cleaner, glass cleaners, furniture cleaner/polish, deodorants, hair spray, and air fresheners
- Leftover or empty correction fluid ("White-Out") and correction fluid thinner
- Pens, markers, and bottles containing liquid inks. Ballpoint pens would not be considered containing "liquid" inks
- Liquid cleaners, such as wipe board cleaner
- Empty photocopier toner containers (printer toner cartridges should be recycled)
- Empty cigarette lighters

Discharged batteries of all types (AA, AAA, D, C cells), computer batteries, Ni-Cad and rechargeables shall be placed separately into the 1-gallon bucket. Wet type batteries, such as lead acid batteries, shall be given to the Instrument Lab.

Laboratory-type waste, such as WD-40, aerosol spray paint, sponges, metal samples, X-ray films, electronic devices, etc., must be disposed of or recycled as lab waste, and must not be placed in the Office Waste Collection Areas or the regular trash.

Battelle

WASTE WISE

PPT Carney 3-32 32

Netscape - [What should I do with . . .]

http://www.battelle.org/wastemgmt/planning.htm

Planning for waste generation

In many circumstances, the cost for management and disposal of a waste can be very high and sometimes unexpected. Planning for waste disposal before your project begins can help save you money, valuable resources, and time - not to mention keeping you in compliance with all the regulatory requirements for handling and managing hazardous materials and wastes.

▶ STEP 1. Identify the process or source

First, you need to identify those activities and projects that have the potential to generate waste. Recognizing projects and activities that generate waste may not always be straightforward. Activities and projects that typically generate wastes are listed below as examples.

- Lab turnovers: lab clean-outs and chemical inventory reductions - expired, unwanted or unused chemicals and wastes need to be addressed
- Project completion - leftover, unused chemicals and wastes need to be addressed
- Employee turnovers: promotions - same as lab turnovers and project completion
- Research and development (R&D) processes producing waste - waste generated during R&D activities are varied and need to be addressed on a case-by-case basis
- Construction and demolition projects - building materials (such as asbestos and lead joints/seals) and other waste generated during demolition projects can be hazardous wastes when disposed of

Glossary

Battelle

WASTE WISE

PPT/Conway 3-33 33

Netscape - [What should I do with . . .]

http://www.battelle.org/wastemgmt/planning.htm

- Decontamination activities - can generate a wide variety of wastes, such as waste/spent decontamination solutions and contaminated soil and sludge
- Maintenance related activities - degreasers, strippers, used oils and antifreeze are typical maintenance related waste streams that need to be managed properly
- Painting operations and activities - operations involving spray paint booths, facility painting, and even aerosol spray paint cans may generate wastes requiring proper management and disposal
- Cleaning of laboratory facilities: equipment, cages and glassware - decontamination solutions generated during cleaning operations may contain regulated levels of contaminants that need to be collected and managed properly
- Evaluation and disposal of archived samples - environmental and other samples may contain various levels of hazardous constituents that must be managed properly
- Inorganic chemical analysis - can generate corrosive waste streams containing heavy metals

▶ STEP 2. Identify the waste

Identify the waste streams anticipated from your project

- Identify the type of waste to be generated (such as unused chemicals, spent solvents, acid waste containing metals, contaminated soil, etc.)
- Identify the characteristics of the waste to be generated (such as ignitable, reactive, corrosive, toxic, radioactive, etc.)
- Identify the anticipated volume or weight of waste to be generated

Battelle

WASTE WISE

PPT/Conway 3-34 34

Netscape - [What should I do with ...]

http://www.battelle.org/wastemgmt/planning.htm

▶ **STEP 3.** Determine a disposal pathway

Ensure that a disposal pathway for your waste exists. Most wastes are common and can be managed easily through normal means. Waste streams having more exotic, toxic, or hazardous properties may have limited disposal options and may involve more planning and cost to ensure proper management. A related page, Wastes Requiring Special Handling, can give you an idea if you will have a waste stream that is difficult to manage in the course of your project. You may also contact your ES&H representative or Hazardous Waste Operations staff for more assistance.

▶ **STEP 4.** Decide on an accumulation area

Determine the type of accumulation area needed. Wastes must be accumulated in a Satellite Accumulation Area (SAAs). These SAAs will differ in size and type, based on the needs of the project generating the waste. See Generating Wastes and Managing Satellite Accumulation Areas for more information.

▶ **STEP 5.** Prepare a budget

Budget space, staff time, and money for waste management and disposal. Handling, transportation, and disposal costs are provided in Current Waste Costs.

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WASTE WISE

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Netscape - [What should I do with ...]

http://www.battelle.org/wastemgmt/planning.htm

▶ **STEP 6.** Reduce, reduce, reduce!

Plan to minimize waste at every step of the generation process.

- Substitute less-hazardous material for more-hazardous material
- Use the smallest possible amounts of a hazardous material
- Even if you can receive a bulk discount, do not order hazardous materials in quantities greater than you need
- Identify products that are reusable
- Identify products that are safe for drain disposal
- Review Battelle's Pollution Prevention Program and the BCO WasteWise Program for more ideas on how to recycle, minimize, and avoid the generation of waste

▶ **STEP 7.** Review your plans as work scopes change

Review and re-evaluate plans for waste management and disposal whenever the work scope changes.

Waste Management Home Page • Generating Wastes and Managing Accumulation Areas
Wastes Requiring Special Handling • Managing Unknown Wastes
Offering Chemical and Radioactive Waste for Disposal • Current Waste Costs
What Should I Do With ... • Contacts • Hazardous Waste Generator Training
Chemical Redistribution Warehouse • Glossary • Links

Battelle

WASTE WISE

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Netscape - [Battelle's Pollution Prevention Program]

http://www.battelle.org/wastemgmt/poll_pre.htm

Battelle's Pollution Prevention Program

- 1998 P2 Program
- 1998 P2 Goals
- 1998 P2 Progress Report
- List of current P2 Committee members
- Get involved with P2! Send an email to the P2 Coordinator to see how you can get involved.

Chemical Redistribution Warehouse

Waste Management Home Page • Planning for Waste Generation
Generating Wastes and Managing Accumulation Areas • Wastes Requiring Special Handling
Managing Unknown Wastes • Offering Chemical and Radioactive Waste for Disposal • Current Waste Costs
What Should I Do With ... • Contacts • Hazardous Waste Management Training
Glossary • Links

Battelle

WASTE WISE

PPT/Conway 3-37 37

Netscape - [Chemical Redistribution Warehouse]

http://www.battelle.org/wastemgmt/chemicals.HTM

Chemical Redistribution Warehouse

Do you have chemicals that are available for re-use? Would you like to save your organization potential disposal costs for your un-used chemicals? Would you like to obtain chemicals without going through the procurement process at no cost to your organization? Then visit our internal chemical redistribution warehouse.

Reduce Reuse Recycle

If you have chemicals that are available for re-use send an e-mail to Kathy Carney listing the following information.

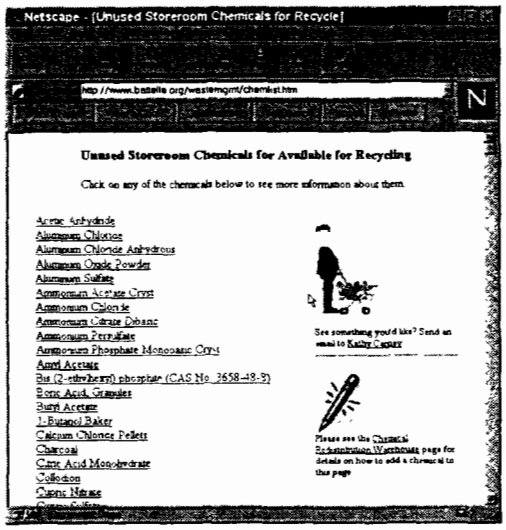
- Description of the chemical for reuse
- Numbers of containers available for reuse
- Volume or weight of the container(s)
- Indicate if container is an original, unopened, virgin form
- Indicate the volume remaining in the container if previously opened or partially used
- Name of person making the chemicals available for redistribution
- Telephone number of the above person
- Storage location of the chemicals by lab or room number
- Date made available for redistribution
- Other comments

If you are interested in obtaining one of the chemicals on the list, please send an e-mail to Kathy

Battelle

WASTE WISE

PPT/Conway 3-38 38



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Employee Activities

- P2 week activities
- Environmental fairs
- America Recycles Day activities
- Earth Day activities
- Household hazardous waste management and P2
- Incentives program

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Communication – Make it Interesting

- Internal web site – big winner at Battelle
- Company paper – communicate successes
- Daily bulletins – announce upcoming events and P2 tidbits
- Internal ES&H newsletters
- Committees
- TV messages
- Promotions

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Selecting Annual Goals

- High disposal costs
- High volume
- Toxicity/hazard
- Limited national treatment capacity
- Most common waste streams to all labs
- Spill/environmental clean up projects
- Exposure records
- Unplanned events
- Pollution prevention opportunity assessments
- Ideas from staff

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Pollution Prevention Opportunity Assessments (PPOA's)

- Engage your regulators
- Identify a project, product line or common activity
- Focus on hazardous and non-hazardous waste
- Involve the staff
- Document findings
- Promote findings
- Use as training tool

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Pollution Prevention Week

- Heavy advertising – daily messages
- Free posters from Pollution Prevention Roundtable
- Environmental Fair during lunch hours
- Free Hg Waste Recycling Day

Battelle

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Mercury Waste Reduction Initiative

- Advertise free recycling of Hg waste
- Elemental Hg and instrumentation
- Submit generator information and items for recycling
- Investigate substitutes for generator
- Communicate substitute methods to generator
- Reward generator for making changes

Battelle

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P2 Success Story: Instrument Laboratory

- Spill initiated P2 initiative
- Investigate substitutes for Hg as corrective action
- Silicon oil + change in procedure
- Pass the information to other labs using same process
- Acknowledge instrument lab staff through incentives program

Battelle

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Specific P2 Initiatives at Battelle

- Waste charge-back system
- Virtual chemical warehouse
- Hg waste reduction initiatives
- Solvent waste reduction initiatives
- Educational/communication initiatives
- PPOA's
- Investigating chemical inventory tracking

Battelle

WASTE WISE

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Stanley Childs

U.S. Army Environmental Center

"Hazardous Substance Management System (HSMS)"

HAZARDOUS SUBSTANCE MANAGEMENT SYSTEM (HSMS)

PURPOSE

- Provide Overview of the U.S. Army Hazardous Substance Management System (HSMS)

PROGRAM DRIVERS

HAZARDOUS MATERIALS | **HAZARDOUS WASTES**

ENVIRONMENTAL

CWA
EPCRA
PPA
CAA
RCRA

LOGISTICS

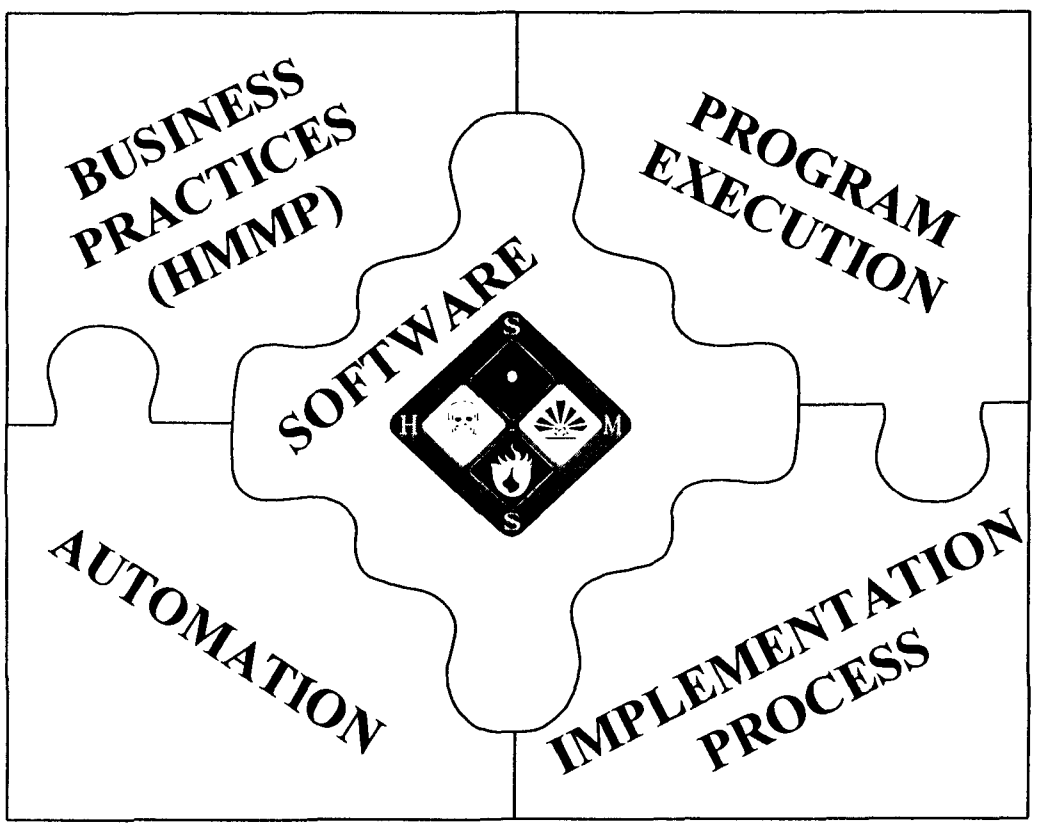
INVENTORY TRACKING
LABELING
SHELF LIFE MANAGEMENT
STORAGE
PROCUREMENT

HEALTH & SAFETY

REPORTING
HAZ COM
TOXIC SUBSTANCES
TRAINING
PPE
40-HOUR
LAB STANDARD

HMMP
BUSINESS
PRACTICES

HSMS PROGRAM



IMPACTS OF EXISTING BUSINESS PRACTICES

BUSINESS PRACTICES

Expired Shelf Life Items Constitute 40-80% of HW at Army installations

DoD Spends $8 in HW Disposal for Every $1 Spent on HM Procurement

Over 40% of Army ECAS findings since 1991 are tied to RCRA-C

160 fines and penalties totaling $14,204,125 as of 1 Jan 98

89 RCRA fines account for 74% or $10,554,272 as of 1 Jan 98

BUSINESS PRACTICE INITIATIVES

- Establish Reuse Procedures
- Order/Dispense by Unit of Use vs. Unit of Issue
- Establish Centralized Issue / Storage Points
- Establish Centralized HM Management Cell
- Establish Authorized User / Use List
- Implement a Tracking System (HSMS)
- Establish Inventory Levels at User / Operator Level
- Implement a HM Training / Awareness Program

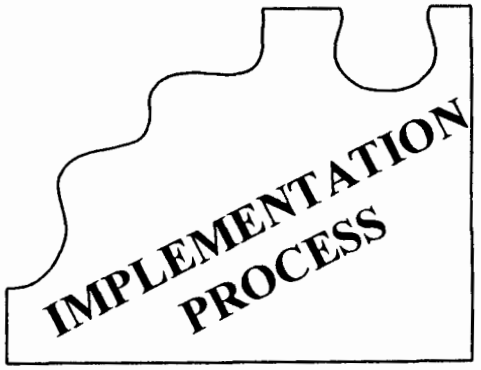
BENEFITS

- Increases Compliance with Federal, State, DoD, and Army Regulations
- Reduces Procurement Costs Through Improved Materials Management
- Improves Shelf Life Management
- Avoids Disposal Costs Through Reduced Ordering and Material Re-use
- Increases Substitution of Less Hazardous or Non-Hazardous Materials
- Improves Personnel Health and Safety

HSMS SOFTWARE

- Ties HM to HW Through Defined Processes
- Provides Visibility of HM Inventories
- Tracks HW from Generation to Final Disposition
- Supports P2 Initiatives
- Enhances OSHA Compliance
- Generates Environmental Reports

IMPLEMENTATION APPROACH



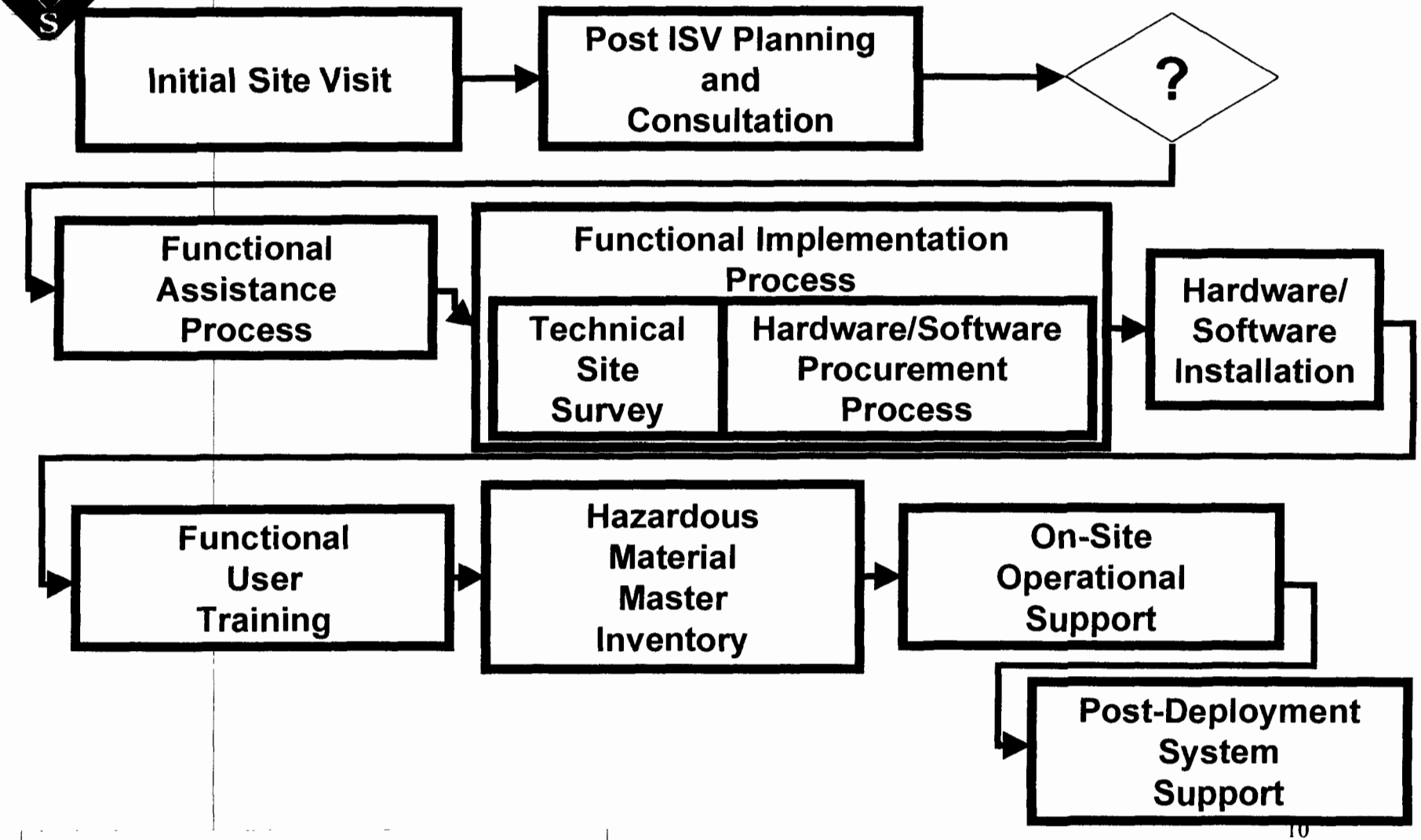
Initial Operational Capability (IOC)

- Selected Activities
- Selected Product Lines
- HSMS Functional
- Limited Reporting
- Defined by Installation

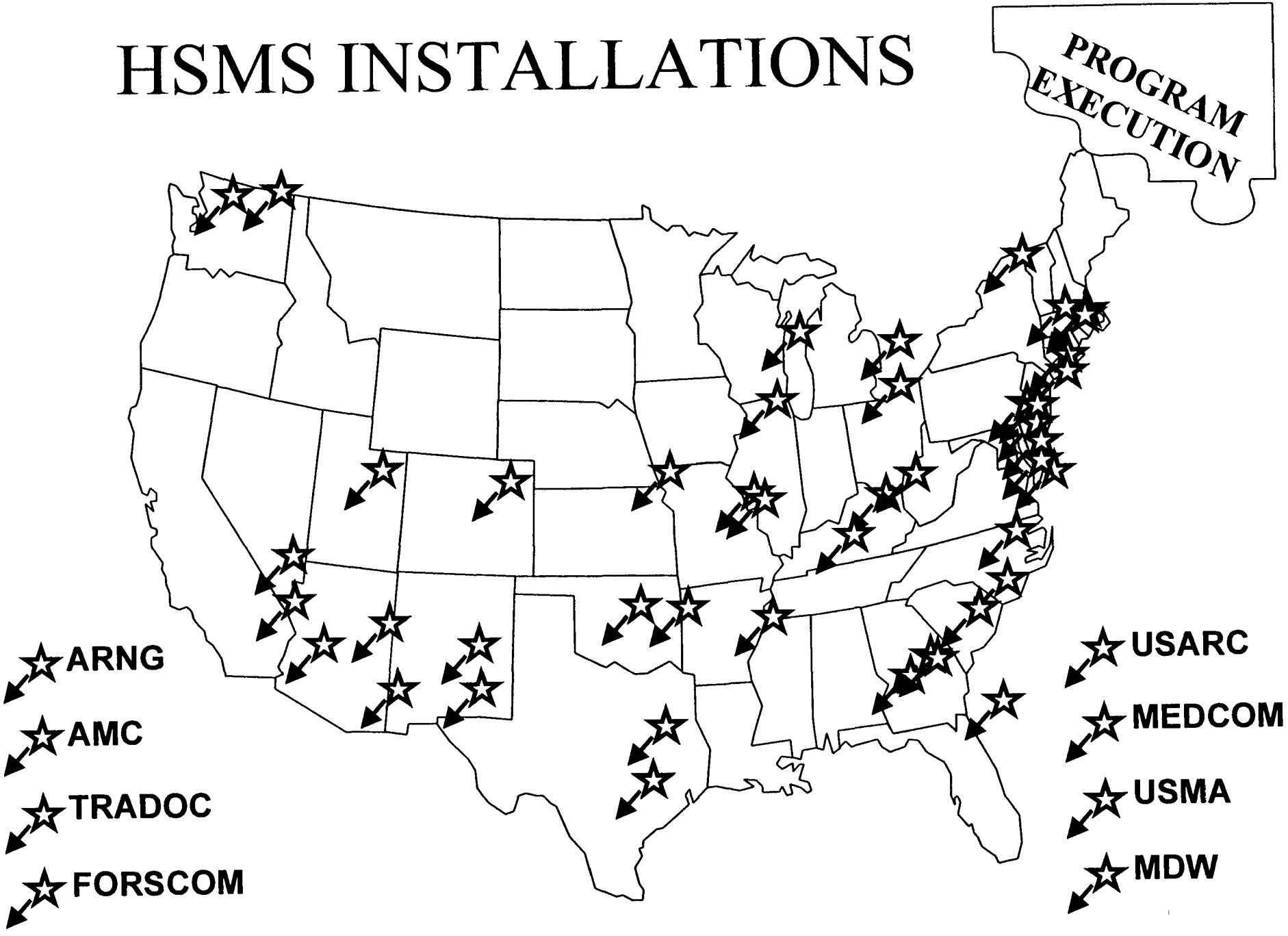
Full Operational Capability (FOC)

- Entire Installation
- All Hazardous Materials
- More Customers Not Users
- Installation Responsibility

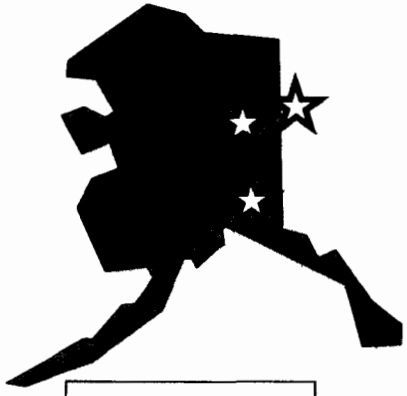
IMPLEMENTATION PROCESS



HSMS INSTALLATIONS



HSMS INSTALLATIONS



ALASKA

KOREA

JAPAN

HAWAII

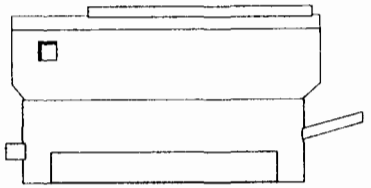
GERMANY

KWAJALEIN

HSMS ARCHITECTURE

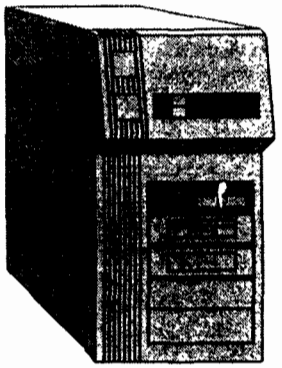
AUTOMATION

- Server - Dual Pentium 266 MHz Server
  - Operating System - Windows NT Server 4.0
  - DBMS - Oracle Workgroup Server 7.3.3



- Workstation - Pentium 166 MHz Workstation
  - OS - Windows NT WS 4.0
  - DBMS Access - ORACLE SQL*NET

- Printers
  - Laser Printers - Report Generation
  - Dot Matrix - Printing Multi-Part Forms (DD 1348)



- Bar Coding Equipment - Printer/Scanner

- Utility Software
  - Report Writer - Crystal Reports
  - Bar Code Printing - Bar Tender

SUPPORT MECHANISMS

- HSMS Customer Assistance Office (CAO)
  (888)800-7242/ (520)452-6679,
  email: hsms@saic.hqisec.army.mil
- AEC Web Page -
  - **http://aec-www.apgea.army.mil:8080/prod/usace/et/p2/hsms_01.htm**
- Resource Library - **CAO**
- Bi-Weekly Status Update- **CAO**
- Orientation Training ("HSMS 101")- CAO
- User's Group Conference Calls

Chad Cliburn

U.S. EPA

"Waste Minimization Projects within Region on PBT Initiatives for EPA"

Chad Cliburn

Chad Cliburn is an Environmental Protection Specialist with U.S. EPA Region 5's Waste Pesticides and Toxics Division. Chad works on waste minimization, pollution prevention, illegal dumping and universal waste projects for the Region. Prior to working for U.S. EPA 5, Chad directed a North Texas Small Business Development Center program that delivered training and compliance and waste reduction assistance to small and medium sized businesses. Chad also worked as a RCRA inspector and in the Pollution Prevention Program for the Oklahoma Department of Environmental Quality.

Chad has a Bachelors Degree from Oklahoma City University and a Masters Degree in Environmental Management from the University of Oklahoma.

Liz Cunningham

Tenneco Packaging

ELIZABETH (LIZ) A. CUNNINGHAM
TENNECO PACKAGING
SPECIALTY AND CONSUMER PRODUCTS, INC.

Liz is the Director of Environmental Health and Safety (EHS) for the Specialty and Consumer Products division of Tenneco Packaging. As such, she has overall responsibility for EHS programs in approximately 32 manufacturing plants, plus a number of engineering, research and development centers, and distribution centers

Liz has over 15 years experience in the environment, health and safety arena. She began her EHS career with the Connecticut Clean Water Act Section 208 Program (identification and quantification of surface and ground water impacts from area wide sources). This included looking at disposal of hazardous and non-hazardous wastes, urban runoff, agricultural runoff, identification and mapping of drinking water aquifers, and other varied activities. From this quasi-governmental position, she moved to environmental and safety management consulting and provided services to a diverse clientele including public schools, a national mortuary chain, and international oil and chemical companies. From consulting Liz took a job in private industry, and has worked for Tenneco for the past five years

Liz received Bachelor's and Master's degrees in environmental engineering from Rice University in Houston, Texas, and a Master of Public Health degree from the University of Texas Health Science Center in Houston. She holds certifications as a Certified Industrial Hygienist and a Certified Safety Professional, and is evaluating which environmental certification to pursue.

Chaitanya Daiya

Motorola Inc.

"P2 -- Make It Work"

Chaitanya Daiya

Chaitanya Daiya is a Director of Environmental, Safety & Industrial Hygiene (ESIH) at Motorola Inc. Mr. Daiya received Bachelor of Science degrees in Mechanical and Electrical Engineering from University of Poona, India and Master of Science degree in Industrial & Systems Engineering from Illinois Institute of Technology. Mr. Daiya's industrial experience covers Design, Manufacturing, Quality and ESIH. Mr. Daiya is also a senior member of American Society for Quality (ASQ).

POLLUTION PREVENTION—MAKE IT WORK

This article shares Motorola's exciting experience in pollution prevention endeavor, with highlights on the transformation of ideas to results in a business world. A detail case dissect provides an insightful look of how to turn an aggressive 10x reduction goal into impressive results. The article also discusses what works, why it works and how it can work for you. Motorola Schaumburg Manufacturing Facility is a 5-time winner of Illinois Governor's Pollution Prevention Award.

The Goal

The Company Culture

For many years, Motorola Schaumburg IL02 facility has been recognized as one of the best in ESIH compliance and beyond. This is evidenced by the first EHS CEO award for a site, the highest corporate audit score, VPP star site, to just name a few. Pollution prevention has been with the company for more than a decade. It has always been a challenge to make continuous improvement above the already high level.

Following are a few fundamentals practiced within Motorola that help set the directions for achievement and continuous improvement. All of these are encouraged throughout the corporation and all business units.

- One of the corporate key initiatives—Products, manufacturing and environmental leadership;
- Corporate EHS policy—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;
- Corporate EHS Vision—to be a recognized corporate leader for progressive and best-in-class environmental, health and safety practices;

- Corporate EHS Objectives—to assure continuing compliance with EHS requirements, promote Motorola's reputation as a global EHS leader and to fully integrate EHS values into Motorola's business operations, processes and products.

The Goals

Every achievement starts with a vision and a goal. In our pollution prevention effort, we set our goals according to these criteria:

1. Meaningful
2. Measurable
3. Aggressive
4. Achievable

The meaningfulness is the integration of EHS values with business operations. The compliance-oriented EHS function helped business to comply with all the regulations and avoided possible penalties. The new EHS values to the business include (1) minimize injury and risk; (2) minimize environmental impact; (3) reduce cost; and (4) enhance products and market share. The Motorola Schaumburg facility uses the Total EHS Management (TEM) approach to integrate these values with business. The TEM metric is measured against the goal of 10x reduction in 5 years in:

1. hazardous material use
2. process waste generation
3. landfill waste generation
4. accidents and injuries

This equates to an average reduction of 37% each successive year.

The Motivation

These are no easy goals. The Motorola culture of "Do what you never thought possible" has always been the motivation to achieve the highest level. Now with "Wings", we want to fly and see no limits.

Program Implementation

Success & Selling

Achieving the goals will totally depend on the teamwork among all the business units and every employee. Getting collaboration and commitment is the key to success. We have a good product – TEM. We need to show success even minor ones to help us be a good salesperson and do everything possible to sell the good product. Selling is a process of getting people to do what you want to do. Once people have the desire, there will be collaboration, there will be resources, and there will be commitment and energy.

Focus on Immediate Success

The sale does not end when management and everyone have agreed to the goal. Making initial success is critical to carry on the program. This initial success does not need to be large. When people see an immediate impact they are more inclined to listen to you and continue with the program. Success is infectious. Use the success to create more successes. An early success will help the team recognize that results are achievable and are worthwhile. It creates a great sense of accomplishment and bolsters confidence.

Bilingual

Management needs to listen and support you and we need to talk to them in the language they understand. You can talk to them in engineering details and you will loose them -- but when you talk in money language and you will get their attention. You still need to discuss the engineering details within the team to achieve our goals.

Firm and Consistent

Set up a tracking system and place the progress report on all the appropriate meeting agenda. This is especially important if the goal is to last for any great period of time. In Motorola Schaumburg, we have been using one set of charts consistently to present the progress. We found these periodic updates helped to keep people informed of progress and reinforced the commitment to succeed. The progress report is also a great opportunity to give recognition to other members. This creates a greater sense of being part of the solution and ownership.

Tactics found useful

We found the following tools useful:

- Set the goal and get buy-in early
- Communicate the goal
- Build and support the team
- Use bilingual approach (Show the value)
- Work on issues with immediate success
- Be firm and consistent

Obtaining Results

The people involved and the methods used are the two critical factors in determining the ability to obtain the results. Examples below will further explain how the two factors helped us in obtaining the results.

The People

The people factor can never be over emphasized. After all, people are the backbone of the industry. People are as important as the management support. Once the TEM goals are established, we need the collaboration of people and

the management within the business units. To ensure that the collaborative efforts are put together, a project team of volunteers was assembled for each of the goals. Each of the project teams consisted of members from different departments depending on the scope of the project and job function. Although a team leader was assigned, the person was a coach not any one as a real boss. Managing a project under this environment certainly proved to be a different challenge. Our experience told us that motivating people and holding the individual accountable certainly worked out for us, especially in long-term projects. The motivation to contribute is a positive force on the team that leads to a better flow of ideas and higher desire to achieve.

The Method

Using the right method is another important factor in obtaining the results. In Motorola, we use the Six Steps to Problem Solving approach. This is not the only method for problem solving. However, this is the method deeply established and widely used within Motorola. Almost all Motorola employees attend an all-day special class discussing the Six Steps. With our Quality Heritage and Six Sigma programs, it is advantageous to use this existing structure and method, and we have found that this method is very effective.

In brief, the Six Steps are:

1. State the problem
2. Analyze the facts and determine your goal
3. Identify and evaluate all alternatives
4. Make decisions on the best alternative
5. Implement the solution
6. Evaluate the results and institutionalize the solution.

Example—Water Conservation

This example will detail how the Motorola IL02 facility used the six steps to problem solving method in pollution prevention project.

In stating the problem, we realized that we were using and discharging over 120 million gallons of water each year. The cost for this water, in user and discharge fees, was over $500,000 per year. This was a huge use of natural resources.

In the analysis phase, we collected information where and how this water was being utilized. The fact was that 30% of the water was used in manufacturing processes, 30% for cooling water and 40% was utilized in other areas. We looked at water use in greater detail by examining which pieces of equipment used water and in what quantities. This information was put on a pareto chart so we could determine our heavy hitters, and main target. At the conclusion of the data analysis, we set a goal to reduce water consumption by 20%.

Step 3 is to identify and evaluate all reasonable alternatives. Nothing is sacred during this phase. Everything is subject to question and modification. Maybe a

very simple and economic solution exists which no one had ever considered. Maybe someone had considered a specific solution but figured that it had been rejected in the past. Brainstorming sessions provide the opportunity to mention, and record, all ideas. Each of the water-consuming units was studied in detail for any possible alternatives.

Step 4 is to decide the best solution out of all the alternatives. A set of criteria was used to compare alternatives and determine the best one. The criteria included potential water savings, implementation costs, dollar savings, the payback period, sustainability and time required for completion. One solution was chosen for each of the reduction targets.

Step 5 is to implement the solution. As the decisions were made on the best solutions for each unit, a team member and deadline were assigned to implement the solution. A progress chart was used to track the project and provide information on target completion and total savings. Team members gained confidence, as their project became more and more successful.

Step 6 is to evaluate the result. The project was a total success. As a result, we reduced water consumption by 50,000,000 gallons per year, which equates to reducing associated costs by over $200,000 per year. We doubled the original goal of a 20% reduction! The total investment of $8,600 was recovered with a payback period of just 16 DAYS.

Example—VOM Emission Reduction

In the early 1990's, we had an air permit to emit a maximum of 120 tons of VOM per year from over 200 emission units. The New Clean Air Act set a new emission limit of 25 tons per year. Engineering studies concluded we needed over $5 million dollars worth of pollution control equipment in order to meet the new 25-ton limit. We invited the consultants to help us. They concluded that the right thing for us to do was to go ahead with control and capture equipment and spend the $5 million dollars.

The cost was prohibitive and the challenge was formidable. We realized that it was a better option to reduce the emissions below the 25-ton maximum. This would help us avoid the $5 million dollar expense. And we set the 25-ton as the goal.

It was a very aggressive goal, not just the reduction amount with more than 200 emission units involved, but also the 2 years deadline for completion. In fact, none of the consultants we contacted said it could be done -- IT WAS IMPOSSIBLE!

We did have a tough time at the beginning of the project; very little progress was made. Part of the problem-solving process dealt with a change in nomenclature. We made a breakthrough when we referred to emissions as DEFECTS. Our

engineers and technicians know how to accept the challenge of defects and correct them. Engineers attacked the issue by changing to water-based chemicals wherever feasible. Every chemical process was examined and challenged. Nothing was accepted as "well, that's the way it has always been done." Everything was addressed as if the process was being designed from scratch.

From 1991 to 1993, our potential to emit VOM's was reduced from 120 tons to just under 25 tons per year. We believe in continuous improvements as part of our Quality Heritage. In the next four years, between 1993 and 1997, our VOM's were again reduced from 25 tons of potential emissions to just 7 tons per year of ACTUAL emissions. We did what the consultants said COULD NOT be done. This is a typical successful example of bilingual approach and building on existing culture.

The TEM—Total EHS Management

The same principles and approaches have been used on the TEM system -- 10x reduction in 5 years. Another IMPOSSIBLE? Yes indeed, the challenge has always been with us, and it will never go away. The tactic we applied was "Use the success of VOM reduction to create more successes". Success is infectious if you plan it.

Overall, we have achieved excellent results. Hazardous materials have been reduced at a rate better than the expected 10X reduction. Process wastes have also been reduced at a pace in excess of the 10X reduction. Landfill waste reduction met the average 37% per year reduction for the first two years. Our production volume has gone up and it has increased somewhat in 1998. Accidents have been reduced dramatically, and we have a challenge attaining the 10X-reduction goal. As stated earlier, the 10X reduction is a very aggressive goal.

The business impact of the TEM is obvious when we compare the cost of waste management and disposal to what could have been if there had been no reductions. In the case of accident reduction, we have achieved less than our intended goal. But the cost avoided, in millions of dollars, would not have been made if we hadn't made progress. In 1996 and 1997, we have saved 25% of ESIH budget (payroll & expenses) – a 25% return on investment. It adds to that corporate bottom line.

The Glories

We have received many awards over the past few years. Here is a list of some awards and status:

- 5 Illinois Governor's Pollution Prevention recognition/awards
- 2 CEO Environmental, Health and Safety awards
- VPP Star Award by OSHA
- 74% below industrial average for recordable injury rate

- No citations by EPA or OSHA
- Highest EHS audit score in the Corporation

Summary

The Motorola Schaumburg facility has had many successes in pollution prevention, and is making continuous improvement. The elements helping us in our success can be categorized into these areas:

The goals -- Integrate the pollution prevention goals with business objectives.
The people -- Give people the credit, show respect, motivate each member.
-- People are the most important resource.
The method -- Use the existing corporate cultures and structure.
-- The "6 Steps to Problem Solving" is a powerful tool.
The power -- Use positive thinking: "Do what you never thought possible."

Rudolph Dawson

United Technologies Electronics Controls

"Use of Silicone Conformal Coating on Circuit Boards at UT Electronic Controls"

BIOGRAPHICAL INFORMATION ON RUDOLPH DAWSON

Rudolph Dawson is presently the manager of Environmental, Health and Safety for UT Electronic Controls in Huntington Indiana. Responsible for all heath safety, and environmental activities: Occupational Health Monitoring, Fire Protection, Medical, Safety Permit Programs, Safety Audit, Safety Training, Environmental Audits, DOT, Workers Compensation, Emergency Response, Air, Solid Waste Disposal, Environmental Training, and Industrial Hygiene.

Rudolph Dawson has a BS degree in Agronomy, from Fort Valley State University, Fort Valley, Georgia; MS from Tuskegee University in Environmental Sciences, Tuskegee, Alabama; Candidate for Ph.D., Water Quality, University of Michigan, Ann Arbor, Michigan.

USE OF SILICONE CONFORMAL COATING ON CIRCUIT BOARDS AT UT ELECTRONIC CONTROLS

by Rudolph Dawson

Abstract

UT Electronic Control reduced its use of Volatile Organic Compounds (VOCs). UT Electronic Controls changed its use of an Acrylic-based Coating on circuit boards to a Silicone Conformal Coating. The change virtually eliminated the VOCs and hazardous air pollutants in the process. The Acrylic-based Coating contained sixty (60) percent toxic chemicals, containing forty (40) percent Xylene and twenty (20) percent Toluene.

UT Electronic Controls (UTEC) designs and assemble electronic controls for the heating, ventilation, air conditioning and refrigeration industry. As the manufacturing arm of Carrier Electronics, UTEC manufactured approximately 4,200,000 electronic circuit boards last year. The plant in Huntington, Indiana has approximately 850 employees.

Over the past three years, UTEC has reduced its toxic air emissions 99.8 percent (See Attachment A), total air emissions 66 percent (See Attachment B), and hazardous waste generation 92 percent. The plant improved its environmental performance through improved management processes, and the introduction of non-polluting processes and material to key manufacturing operations.

Introduction of a solvent-free coating process - A common feature of electronic circuit boards, especially those used in harsh or unfriendly environments, is the use of a conformal coating that seals out moisture and contaminants. These coatings are nearly always solvent-based; those used at UTEC consisted of approximately 60 percent toxic chemicals (toluene and xylene). Approximately forty percent of it was xylene and another twenty percent was toluene. Recognizing the environmental impact of these coatings, UTEC worked with the manufacturer to evaluate and develop a silicone-based, moisture-cure coating (which cured from the humidity in the air) that was favorable from an environmental and performance standpoint. The liquid coating has very low viscosity as supplied, and so does not require the additional solvents for use with various types of coating equipment. The cured coating is a flexible, transparent elastomer with excellent adhesion. It provides good dielectric properties and protects against severe humidity, thermal degradation, and other harsh environments. This new coating material virtually eliminated toxic air emissions and hazardous waste from coating operations. In 1996, UTEC was named winner of the Indiana Governor's Award for Excellence in

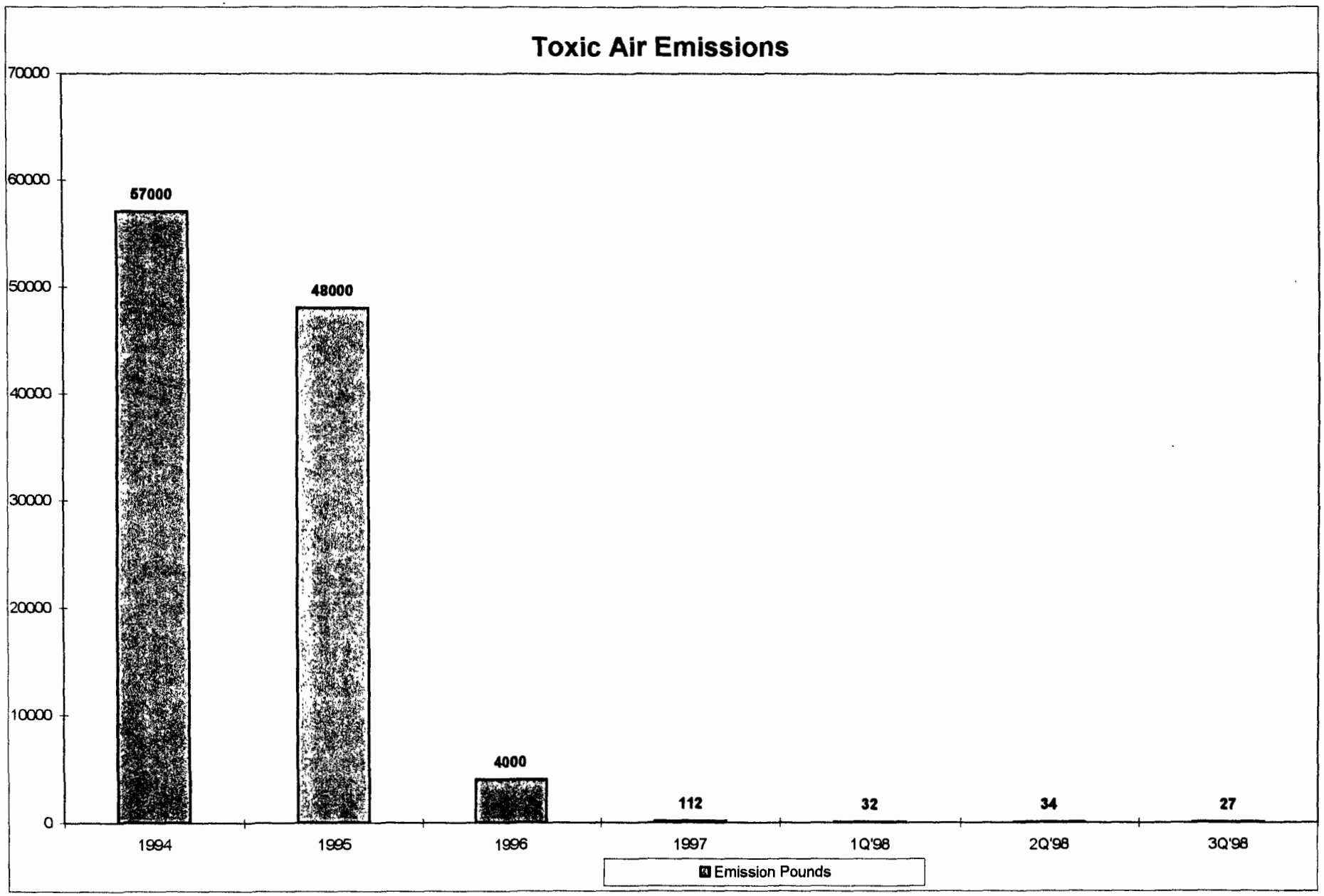
Pollution Prevention for developing and implementing this solvent-free coating process.

Conversion to spray fluxes - Integral to the soldering process is the application of a flux to promote wetting and the flow of liquid solder. For years the method of applying this flux, which is approximately 95 percent isopropyl alcohol, was to pass the undersides of the printed circuit board over a foaming vat of flux. This process caused a significant amount of alcohol evaporation, adding to total emissions. In addition, the vat had to be dumped due to flux contamination at least once a day, which further contributed to our hazardous waste stream. In an effort to reduce air pollution, hazardous waste generation and labor input while improving quality, UTEC converted all fluxing operations to a spray application. Only when boards are actually passing over small spray applicators does material get atomized, and then the material is always fresh.

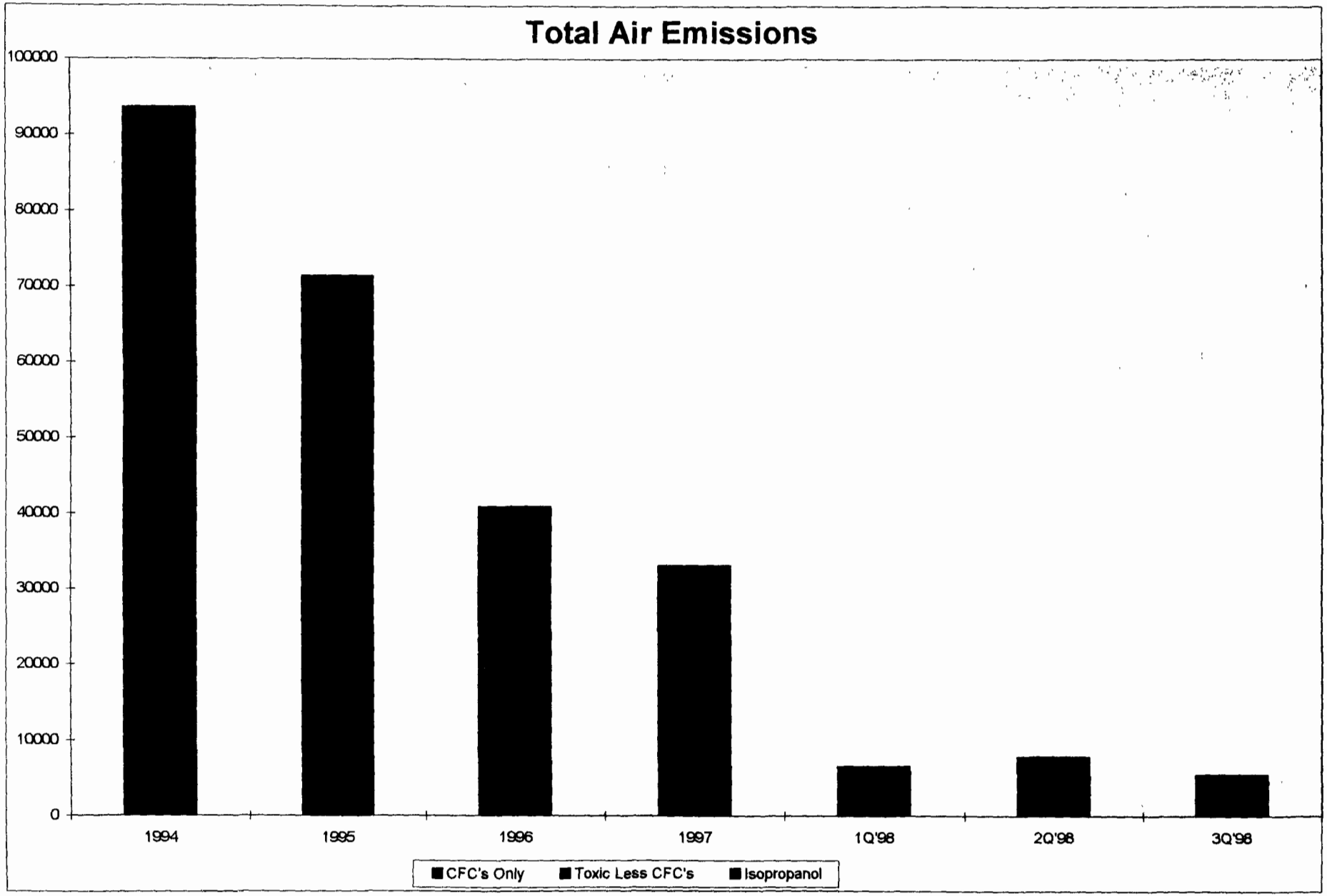
Robotic sprayers reduce toxic air emissions and hazardous waste - In the past, UTEC reclaimed vinyl masking devices by cleaning conformal coating from them with lacquer thinner. This operation yielded marginal results and contributed to toxic air emissions and hazardous waste. UTEC has purchased additional robotic sprayers for coatings which have dramatically reduced the need to mask components that should not be coated.

UT Electronic Controls has continuously improved it environmental performance during the past three years (See Attachments A & B), even during the period when production volumes increased 27 percent.

ATTACHMENT A



ATTACHMENT B



Mark Dhennin

Cummins Power Generation

"P2 Assessment of an Electrodeposition Coating System"

BIOGRAPHY

Mark Dhennin has 17 years of experience at Cummins Power Generation (formerly Onan Corporation), where he is responsible for environmental and materials engineering. Environmental duties include regulatory compliance and waste minimization activities. Cummins recently received the 1996 Minnesota Governor's Award for Excellence in Pollution Prevention, in part due to the implementation of the new E-Coat system. Mark's materials engineering responsibilities include production support, and the evaluation and analysis of fuels, lubricants, coatings, plastics, elastomers, and coolants. Mark received a B.Sc. in Biology and M.Sc. in Environmental Engineering from the University of Minnesota.

POLLUTION PREVENTION ASSESSMENT OF AN ELECTRODEPOSITION COATING SYSTEM

Mark Dhennin, Cummins Power Generation*
Patrick Brezonik, University of Minnesota

ABSTRACT

An in-depth pollution prevention study was conducted on an electrodeposition coating system (E-Coat) recently-installed at Cummins Power Generation (formerly Onan Corporation; Minneapolis, MN), a manufacturer of electrical generators and related components. Baseline discharges, emissions and wastes were identified, and a materials balance approach was used to determine the specific sources and sinks of pollutants and wastes generated by the system. Computer models were developed to improve understanding of process flows, and to evaluate potential waste reduction methods. Material balance analysis results confirm that the E-Coat system generates significantly lower air emissions than the conventional solvent-based spray paint process it replaced. A significant fraction of volatile co-solvents (glycol ether compounds) consumed by the system were discharged as wastewater, and appear to be at least moderately biodegradable. Concentrations of toxic metals in wastewater were very low, and wastewater treatment sludge was determined to be non-hazardous. Pollution prevention opportunities were identified, and ranked based upon potential environmental benefits, ease of implementation and process cost savings. Reductions in wastewater phosphorus and COD discharges were targeted as primary waste minimization objectives. Discharge reductions and relative cost savings are discussed.

INTRODUCTION

Since the commercial introduction of electrodeposition coating (E-Coat) in 1961, this technology has been widely used by the automotive, appliance and other industries to apply protective and decorative paint to metal parts. Materials and process improvements during the last 10 years have made E-Coat one of the leading alternatives to conventional solvent-borne spray painting. Volatile organic compound (VOC) air emissions are significantly lower (over 80% reduction per area coated), and transfer efficiencies are typically much higher than with conventional solvent-borne spray painting processes (95% versus 30%). Improved coating performance

(corrosion resistance, durability), higher productivity and reduced costs are also possible with current E-Coat technology (Oravitz, 1996; Loop, 1980).

Despite these benefits, additional pollution prevention opportunities exist, particularly in the areas of wastewater and solid waste. Wastewater contaminant loading of organic compounds, phosphorus, metals and dissolved and suspended solids can be significant from discharges from the water-borne E-Coat paint and aqueous pretreatment processes. Significant volumes of solid waste (as process and wastewater treatment sludge) are also generated (Fischer, 1996; Petschel, 1996). This paper describes the baseline emissions of an existing, state-of-the-art E-Coat paint and pretreatment system and evaluates potential methods to further minimize the system's overall environmental impact. Regulatory agencies are increasingly emphasizing pollution prevention efforts of this type (Bergeson, 1996; Bizzozero, 1996). Coating quality improvements and process cost reductions are potential side benefits of the approaches emphasized in this study.

E-Coat Discharges and Emissions

Wastes and emissions are generated at various points in a typical E-Coat system. A simplified schematic of a two-coat (primer and topcoat) E-Coat system and associated air, water and solid waste discharge/emissions is shown in Figure 1. Air emissions from the process consist primarily of glycol ethers, which function as cosolvents for the E-Coat paint; these emissions occur directly from coated parts during oven curing, and from the surface of the E-Coat paint and rinse baths. Certain glycol ethers, including several of the compounds commonly used for E-Coat, are listed as Hazardous Air Pollutants in the Clean Air Act Amendments of 1990 (Title III, Sec. 301), and as Toxic Chemicals under EPCRA (Title III, Sec. 313). Typical wastewater contaminants include organic material and soils from alkaline cleaning; phosphorus from cleaning, de-scaling and conversion coating processes; glycol ethers and organic acids from E-Coat paint discharges; metals, including zinc, chromium and mercury from conversion coating, de-scaling and cleaning processes; and dissolved and suspended solids from deionized (DI) water regeneration and other processes. The primary solid wastes are sludges from the wastewater treatment system and conversion coating process.

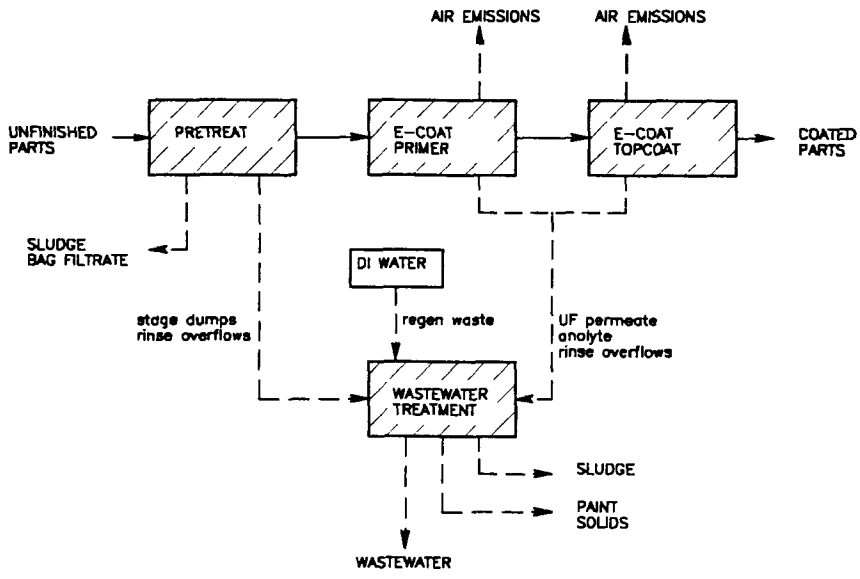


Figure 1. E-Coat discharge and emissions sources.

Objectives

Waste minimization analysis provides the opportunity to prevent pollution and conserve resources, with the potential for reducing production costs and future legal liabilities. This paper examines the pollution prevention potential for an existing, two-coat E-Coat painting and pretreatment system. Specific objectives were targeted:

1) Establish baseline emissions
   - Wastewater discharge volume and contaminant loading
   - Solid waste generation rates and composition
   - Air emissions
2) Identify specific sources and determine fates of pollutants
3) Analyze baseline emissions to identify waste minimization options

Site Description

This study was conducted at Cummins Power Generation (a manufacturer of electrical generators and related components). In October, 1994, installation of a state-of-the-art, two-coat E-Coat paint and pre-treatment system was completed at the Cummins Power Generation manufacturing facility in Fridley, Minnesota. A detailed description of the Cummins system and the rationale for selecting E-Coat was presented earlier (Knudtson, 1996).

Capacity of the system is approximately 10 million ft^2 coated per year. The system consists of the following components:

- 11-stage immersion cleaning and pre-treatment system with dry-off oven
- 4-stage cathodic epoxy primer E-Coat system with cure oven
- 4-stage cathodic acrylic top-coat E-Coat system with cure oven
- water treatment system (duplex deionization unit)
- zinc/iron phosphate stage sludge removal system
- wastewater treatment system

The pre-treatment system includes an alkaline cleaning process and a conversion coating process, which applies a crystalline phosphate surface coating for improved paint adhesion and corrosion resistance. The current system was designed to allow the use of either zinc phosphate/chrome seal or iron phosphate/non-chrome seal conversion coating processes. An iron phosphate/non-chrome seal process was chosen for initial operation of the system, because of lower generation rates of hazardous and non-hazardous sludge, and reduced zinc and chromium wastewater loading. A schematic flow diagram of the pretreatment system is shown in Figure 2.

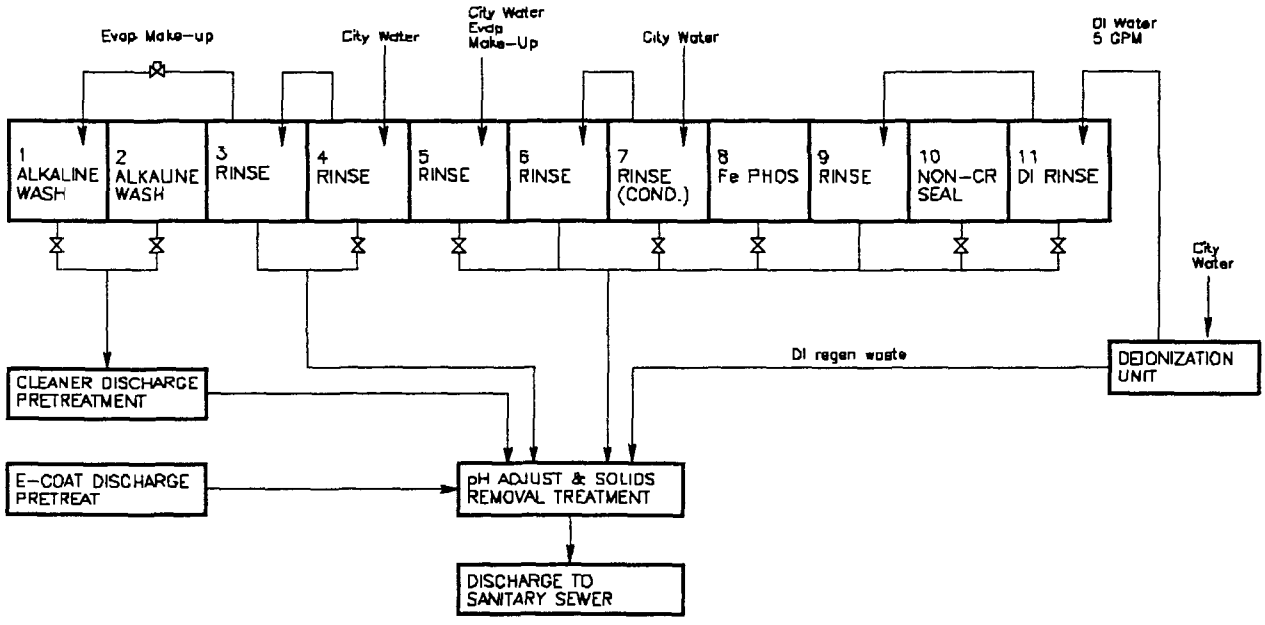


Figure 2. 11-Stage pretreatment flow diagram.

Several waste minimization measures were incorporated into the current system. Water conservation is achieved by utilizing multiple rinses with counterflows in both pre-treatment and E-Coat processes. Counterflowing returns excess paint solids from E-Coat rinse stages back to the paint stage for reuse. Soluble contaminants in the paint are removed via periodic discharge of ultrafilter (UF) permeate to the wastewater treatment system. Excess acids formed during the electrodeposition process are continuously removed by ion-selective membranes surrounding the anodes, and are discharged to wastewater treatment (as "anolyte"). The duplex deionization unit includes a dealkalizer (weak cation exchanger and an aerator for carbon dioxide removal) to reduce regeneration water and chemical usage rates. A schematic flow diagram of one of the two identical coating systems is shown in Figure 3.

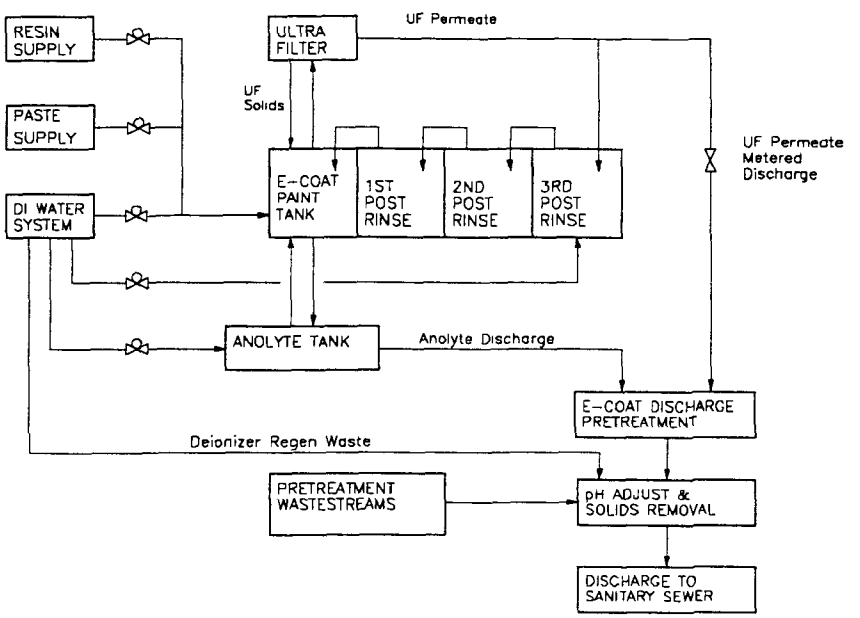


Figure 3. 4-Stage E-Coat system flow diagram.

All wastewater generated by the pretreatment, deionization and E-Coat processes is treated in a dedicated wastewater treatment system, which includes paint solids detackification and filtration, chromium VI reduction and metal precipitation (if zinc/chrome processes are used), solids and phosphorus removal, and pH adjustment systems. No additional treatment is performed before the flow leaves the facility and enters the municipal sanitary sewer system. All wastewater discharge from the facility (and most of the Minneapolis/Saint Paul metropolitan area) is

treated at the Metropolitan Council Environmental Services (MCES) Metro Treatment Plant, which discharges to the Mississippi River downstream of St. Paul.

MONITORING AND SAMPLING METHODS

A materials balance approach was used to analyze the inputs (materials, chemicals and water) and measurable outputs (wastewater volume, wastewater contaminant loading and solid waste volume and composition) from the E-Coat system. A database was created using Microsoft Access® software to store and manage measured and compiled data. Sampling methods, test procedures and data analysis for this project are presented in detail in the author's thesis (Dhennin, 1996).

Material Information and Usage Tracking

Over 20 materials and chemicals are used in the E-Coat system (in the pretreatment, paint, water and wastewater treatment subsystems). Physical and chemical information for each product was obtained from the manufacturer's Material Safety Data Sheets (MSDS). Daily usage quantities and destinations of each product were logged by system operators over an 8-month period. Rectifier output from the E-Coat primer system was used as a measure of system through-put (if system parameters are held constant, rectifier output is proportional to the square footage of substrate coated). Product data, usage quantities and rectifier outputs were entered into the Access® database.

Waste Discharge Monitoring and Sampling

Continuous wastewater flow monitoring and sampling was performed at the outlet of the E-Coat system to determine wastewater discharge characteristics, using an automatic, flow-proportional sampler. Wastewater sampling and monitoring was conducted over a three month period to allow for daily and weekly fluctuations in system operation and maintenance. In addition, several individual effluent sources that discharge to the E-Coat wastewater treatment system (UF permeate, anolyte and pretreatment stage dumps) also were monitored and sampled. Sludge generated from the wastewater treatment and conversion coating systems was monitored; grab samples of the sludge filter cakes were taken each time the filter presses were opened and cleaned. Air emissions

were not measured directly because of the difficulty of measuring oven exhaust stack emissions and ambient evaporative emissions. Instead, air emissions were estimated by difference [Measured Inputs - Measured Outputs = Air Emissions].

ANALYSIS

Samples were analyzed for the parameters listed in Table 1. Standard test methods were used when available (APHA, 1992); methods were developed or modified to determine glycol ethers (by gas chromatography) and organic acids (by ion chromatography and titration). Parameters and methods are briefly described in Table 2.

Table 1. Matrix of sample types and analysis parameters.

Sample:	Sample Type:	No. of Samples:	pH	P	COD	BOD	TDS	TSS	glycol ethers	organic acids	total acidity	metals	sludge solids	oil & grease
Wastewater	weekly composite	13	x	x	x		x	x	x	x		x		
Wastewater	daily composite	6	x	x	x		x	x	x	x		x		
Sludge	weekly composite	12		x								x	x	x
Cleaning Solution	grab	19		x	x			x				x		x
Primer Permeate	grab	10	x		x	x			x	x	x			
Topcoat Permeate	grab	10	x		x	x			x	x	x			
Primer Anolyte	grab	10	x		x	x			x	x	x			
Topcoat Anolyte	grab	10	x		x	x			x	x	x			

Table 2. Description of analysis parameters and test methods.

Parameter:	Description:	Method(s):
pH	measure of sample acidity (0-14 scale)	pH electrode
phosphorus (P)	total phosphorus content	ICP; digestion/ colorimetry
COD	Chemical Oxygen Demand: measure of organic matter content in a sample (oxygen equivalent)	chemical oxid./ colorimetry
BOD	Biochemical Oxygen Demand: measure of the content of biodegradable organic matter in a sample (oxygen equivalent)	biological oxid./ DO electrode
TDS	Total Dissolved Solids: non-volatile matter that passes through a filter (salts, other dissolved compounds)	filtration/ evaporation
TSS	Total Suspended Solids: non-volatile matter that is retained by a filter (particulates, precipitates, etc.)	filtration/ evaporation
glycol ethers	specific cosolvents used in E-Coat paint (ethylene glycol monobutyl ether, etc.)	GC
organic acids	specific organic acids used in E-Coat paint (acetic, lactic acids)	IC, titration; GC
total acidity	acidity from all acids used in E-Coat paint (organic & inorganic)	titration
metals	metals, cations & anions (K, Ca, Mg, Na, Al, Fe, Mn, Zn, Cu, B, Pb, Ni, Cr, Cd, Hg)	ICP-AES, cold vapor AAS (Hg)
total, fixed & volatile solids	measures of water and semi-volatiles content of sludge samples	evaporation
oil & grease	measure of oils, greases and other solvent-soluble matter in sludge and cleaning solution samples	solvent extraction

RESULTS

Results from the material balance analysis were examined to determine the sources and fates of phosphorus, COD, glycol ethers and metals in the Cummins E-Coat system.

Phosphorus

Phosphorus Sources. The primary sources of phosphorus are the cleaning agent and iron phosphate solution concentrates, which contain 10.1% and 6.4% wt P respectively (based on MSDS composition information). Phosphorus in the cleaning agent concentrate is in the form of sodium tripolyphosphate and trisodium phosphate, which function as detergents and sequestering agents to emulsify soils and soften water; they also add alkalinity and act as buffering agents (Murphy, 1982). The iron phosphate concentrate contains phosphoric acid and sodium phosphate. Another potential but unquantified source of phosphorus is contamination from incoming parts. Results for the monitoring period are shown in Table 3.

Phosphorus Fate. Four primary modes of phosphorus removal from the E-Coat system were identified. These include incorporation into the iron phosphate conversion coating; iron phosphate sludge; wastewater treatment sludge; and wastewater discharge to sewer. Phosphorus removal modes are summarized in Table 4.

Table 3. Phosphorus source summary.

Phosphorus Sources:	Source Material:	phosphorus lb/day:
Cleaning Stage Recharge	Cleaning Agent	3.8
Cleaning Stage Make-up	Cleaning Agent	1.3
Rinse Stage Additive	Cleaning Agent	4.8
Iron Phosphate Process	Iron Phosphate Sol'n	1.3
	Total:	11.2

Table 4. Phosphorus removal mode summary.

Phosphorus Sinks:	phosphorus lb/day:
Iron Phosphate Coating	0.4
Iron Phosphate Sludge	0.2
Wastewater Treatment Sludge	3.3
Wastewater Discharge	7.7
Total:	11.6

The total known phosphorus input is similar to the total quantity of phosphorus accounted for in the removal mode calculations. Of the 1.3 lb phosphorus per day used in the iron phosphate conversion coating process, approximately 0.35 lb/day appears to be incorporated into the coating, and 0.2 lb/day is removed as sludge from the process; the remainder (>50%) appears to be lost as drag-out. Over half of the total phosphorus input into

the system is discharged from the wastewater treatment system to the municipal sewer at a rate of 8 lb/day. A summary of phosphorus sources and sinks is shown in Figures 4 and 5.

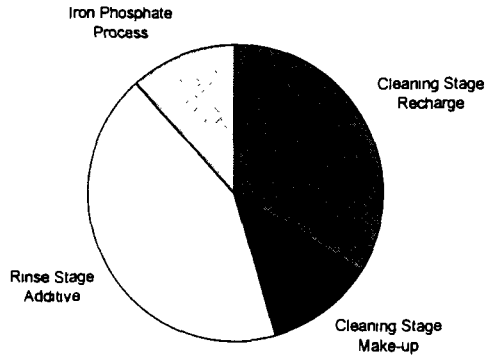


Figure 4. Phosphorus sources.

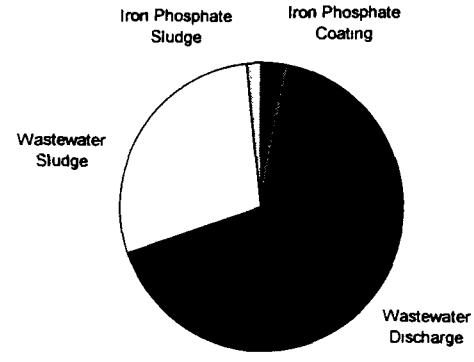


Figure 5. Phosphorus sinks.

Wastewater phosphorus loading fluctuated on a weekly basis from 20 to 160 lb/wk. Peaks in phosphorus loading generally coincided with batch discharges of spent cleaning stage contents to wastewater treatment.

Chemical Oxygen Demand (COD)

COD Sources. Potential sources of COD (organic compounds) in wastewater discharges were identified in both the pretreatment and E-Coat painting processes. The primary sources from pretreatment are soils removed from incoming parts during cleaning and the cleaning agent itself. Primer and topcoat permeate and anolyte are the primary COD sources from the painting process; paint solids are retained from the permeate and anolyte by ultrafiltration, and are not expected to be a significant COD source. A summary of the COD source inputs is shown in Table 5. This information suggests that about half of the total wastewater COD load is from permeate and anolyte, and the remainder is from the cleaning process (cleaning agent + soils).

COD Fate. Potential modes of COD removal from the E-Coat system include wastewater discharge, evaporation of volatile organic compounds, removal as sludge during wastewater treatment and as cleaning stage bag filtrate. E-Coat COD sinks are summarized in Table 6. The relative contributions of each COD source and sink are illustrated in Figures 6 and 7.

Table 5. Wastewater COD source summary.

Wastewater COD Source:	Average COD Load (lb/day):
Topcoat Permeate	44
Topcoat Anolyte	4
Primer Permeate	13
Primer Anolyte	3
Cleaning Stage Recharge	14
Cleaning Stage Make-up	5
Rinse Stage Make-up	17
Soils (by difference)	41
Total:	140

Table 6. Summary of E-Coat COD sinks.

Wastewater COD Sinks:	COD (lb/day):
Wastewater Discharge	129
Wastewater Treatment Sludge	7
Cleaning Stage Bag Filters	4
Total:	140

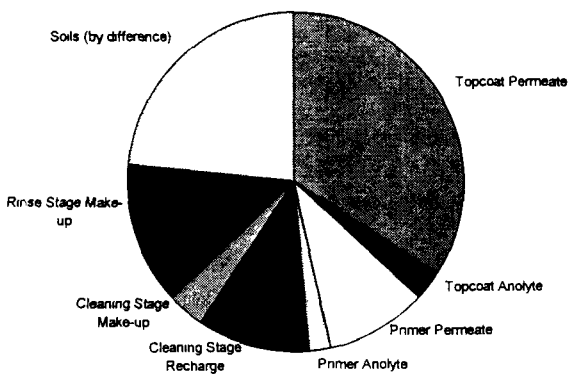


Figure 6. Summary of E-Coat COD sources.

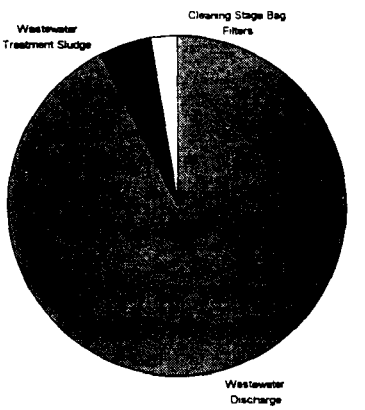


Figure 7. Summary of E-Coat COD sinks.

Glycol Ethers

Glycol Ether Sources. Glycol ethers are components of the E-Coat paint materials, and as such are present in the primer and topcoat immersion paint tanks, permeate rinse tanks, and permeate and anolyte discharges. Glycol ethers function as cosolvents to solubilize resins and pigments in the water-based E-Coat paint solution; these cosolvents are also commonly used in water-borne spray paints (Hussey, 1995). The concentrations of individual glycol ethers are carefully controlled in the paint and permeate rinse tanks to maintain consistent paint quality and performance. Contents of the paint and permeate rinse tanks are not intended to be discharged; instead, paint concentrates, glycol ether cosolvents, acetic acid and DI water are added as needed, and soluble contaminants are removed via permeate and anolyte discharges. During the monitoring period, glycol ether inputs were determined

using monitored consumption data of the make-up materials, and the concentration of glycol ethers in the materials (provided by the paint supplier). Total inputs are summarized in Table 7. Butyl Carbitol and Propasol B (propylene glycol butyl ether) are present in the paint concentrates but are not added as make-up to the system. Note that Propasol B is included in the table of inputs, but was not one of the glycol ether analytes.

Glycol Ether Fate. Potential fates of the glycol ethers are evaporation from the surface of paint and permeate tanks, evaporation from applied paint films during oven curing, and discharge as a wastewater contaminant. As the paint film is applied during the electrodeposition process, water and some glycol ethers are "squeezed out" of the film by a process called electroendosmosis (Wismer, 1995). It is likely that specific glycol ethers are retained in the wet paint film at varying degrees, based on differences in affinity for the adhered paint compounds. As a result, specific glycol ethers are expected to be consumed at different rates. All of the glycol ethers retained in the wet paint film are expected to evaporate during oven curing (>175°C). A significant fraction of the glycol ethers consumed during the E-Coat process are expected to be lost through permeate and anolyte discharges. Glycol ethers are permeable, but during the ultrafiltration process, specific glycol ethers may be retained to varying degrees reflecting differences in molecular characteristics (Gregor, 1995).

Glycol ether wastewater discharge loads were calculated based on the average measured concentrations and discharge volumes from each permeate and anolyte. Almost 90% of the glycol ethers was discharged as permeate and about 10% discharged as anolyte. Air emissions for each glycol ether were calculated by difference: [Total Input Quantity - Measured Wastewater Discharge = Air Emissions]. Wastewater discharges and calculated air emissions during the 3-month monitoring period are shown for each glycol ether in Table 7.

This data indicates that on average, 75% of the glycol ethers are lost by evaporation, and the remainder are discharged in wastewater. The relative quantities of Butyl Cellosolve, Hexyl Cellosolve and Dowanol PPH discharged as wastewater may reflect (in part) different affinities of these substances for the wet paint film; for example, Hexyl Cellosolve, which is less polar than Butyl Cellosolve and Dowanol PPH, is expected to have a higher affinity for paint film (and corresponding higher air emissions fraction). The high wastewater load measured for Butyl Carbitol (relative to the calculated input quantity) may be due to errors in the assumed paint concentrations, or errors in analysis; the relatively high polarity of Butyl Carbitol may also partially account for the high wastewater discharge percentage.

Table 7. Summary of glycol ether wastewater discharges and air emissions.

Glycol Ether (trade name):	Glycol Ether (chemical name):	Input Qty (lb/day):	Wastewater Disch. Load (lb/day):	Calculated Air Emissions (lb/day):	% Wastewater Discharge:	% Air Emissions:
Butyl Cellosolve	Ethylene glycol monobutyl ether	34	7	27	21%	79%
Hexyl Cellosolve	Ethylene glycol monohexyl ether	13	2	12	13%	87%
Dowanol PPH	Propylene glycol phenyl ether	10	2	8	24%	76%
Butyl Carbitol	Diethylene glycol monobutyl ether	4	4	0	100%	0%
Propasol B	Propylene glycol butyl ether	2	NA	NA	NA	NA
	Total:	63	15	46	24%	73%

Fate of Glycol Ethers in Wastewater Discharges. BOD test results and the literature indicate that glycol ethers are moderately biodegradable (NCMS, 1997; Pitter, 1990). Acetic and lactic acids are readily biodegradable. This data suggests that a significant fraction of the glycol ethers and most of the organic acids would be removed during secondary treatment at the POTW, rather than evaporating as air emissions. Consequently, it appears reasonable to exclude wastewater-discharged glycol ethers from the air emissions reported to state and federal agencies.

Comparison of E-Coat and Conventional Spray Paint Air Emissions. Air emissions of volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) from the E-Coat system were compared to the emissions from the conventional solvent-based spray paint process that it replaced. Air emissions data are summarized in Table 8. HAPs emitted by the spray paint process consisted primarily of xylene, ethylbenzene, toluene and methylethylketone (MEK). Spray paint VOCs consist of these HAPs and other organic compounds. HAPs from the Cummins E-Coat system are limited to three specific glycol ethers (Butyl Cellosolve, Hexyl Cellosolve and Butyl Carbitol); E-Coat VOCs include all of the glycol ethers, acetic and lactic acids, and other volatile organic compounds. Material VOC content data was obtained from the MSDS and other information reported by the manufacturer.

Air emissions from spray paint operations were extracted from existing databases used for facility regulatory reporting. Input quantities of specific HAPs for the spray paint process were calculated using the volumes of paints and solvents (for paint thinning and clean-up) and the materials' composition, as listed on the manufacturer's MSDS. The amount of volatile compounds recovered as hazardous waste (waste solvent and waste liquid paint) was estimated based on solids and composition analysis of the waste streams and subtracted from the total input quantities to determine air emissions from the spray paint process. Emissions are expressed on a per unit surface area-coated basis to allow direct comparisons of the two processes.

Table 8. Air emissions comparison for E-Coat and former spray paint processes.

Air Emission Parameter:	Spray Paint System:	E-Coat System:
VOC (lb/1000 ft^2)	53	3
HAPs (lb/1000 ft^2)	22	2
VOC (tons/yr*)	134	8
HAPs (tons/yr*)	54	6

* based on 5M ft^2/yr

The data show that significantly lower emissions (approximately 90%) are released with E-Coat for an equivalent surface area coated. E-Coat air emissions are relatively low due to lower VOC contents of the paint materials and to much higher material transfer efficiencies observed with E-Coat (~95%, compared to ~30% for conventional spray paints)(Oravitz, 1996). High E-Coat transfer efficiencies (defined as the percent paint materials incorporated into the finished coating) are achieved by recovery and reuse of paint solids and soluble materials in the permeate rinse tanks and ultrafiltration systems. In contrast, significant amounts of spray paint solids and solvents are lost as overspray or collected as waste.

Metals

Sources of Metals. Potential sources of major cations (K, Ca, Mg and Na) and other metals in wastewater and wastewater sludges can be grouped into three categories: ingredients of materials used in pretreatment, E-Coat paint, and water and wastewater treatment; soils and metal removed from incoming parts; and corrosion of metal

components from the E-Coat system itself. Sodium is a major component of the cleaning solution and the sodium hydroxide used for pH adjustment and regeneration of deionized water ion exchange columns. Calcium (as calcium chloride) is added as a wastewater treatment coagulant, and along with magnesium, was present in the incoming city water. Aluminum and iron were the only metals (aside from the major cations) consistently present at levels over 1 mg/L. The primary source of aluminum was the coagulant used in wastewater treatment; no aluminum parts were processed through the E-Coat system. Most of the iron probably originated from the reaction of phosphoric acid on ferrous parts during the conversion coating process. Nickel and chromium levels ranged from non-detectable to 0.1 mg/L; when measurable, both elements were typically found together. Minor corrosion of the stainless steel stage tanks, equipment and piping in the E-Coat system is the probable source of nickel, chromium and some iron. Information provided by the manufacturers indicates that no significant levels of mercury (>1 ppm) are contained in the paint or pretreatment materials or in the sodium hydroxide used for water and wastewater treatment.

Paint pigments often contain metal compounds, but no specific information was provided on the paint material MSDSs due to the proprietary nature of the formulations. Qualitative XRF analysis was performed on representative samples of each paint material to identify the elements present (above atomic number 12). The black primer materials contained no detectable metals (carbon black is assumed to be the primary pigment), but the green topcoat contained Ti, Fe, Cu, Br, and Zr (all at >0.1% wt). Calculated metal input quantities from pretreatment, water and wastewater treatment, and incoming city water are summarized in Table 9.

Table 9. Calculated metal input quantities.

	Total Quantity (3-month period)			
Source:	Na (lb):	Ca (lb):	Al (lb):	Mg (lb):
Cleaner	3095	0	0	0
NaOH	955	0	0	0
CaCl2	0	885	0	0
Coagulant	0	0	56	0
City Water	93	506	0	164
Total:	4142	1391	56	164

Metal Discharge Summary. The potential sinks of metals in the system include wastewater discharge, removal as wastewater and process sludge, and incorporation into the coated product. The total metal quantities removed as sludge were calculated using the average metal content and total sludge quantities removed during the monitoring period. Wastewater metal loads were calculated using the weekly wastewater discharge volumes and weekly wastewater metal concentrations. The fate of these metals are shown in Table 10, along with calculated input quantities.

These data indicate that a large fraction of the major cations are discharged in wastewater rather than removed in sludges. Calculated input and measured output quantities of Ca, Mg, Na and Al are relatively similar, suggesting that the material balance parameters are reasonable.

Table 10. Summary of metals sinks and known sources.

	Total Quantity (3-month period)				
Element:	WWT Sludge (lb):	FeP Sludge (lb):	Wastewater (lb):	Total Output (lb):	Total Input (lb):
K	2	1	181	184	
Ca	473	3	723	1198	1391
Mg	46	1	138	185	164
Na	14	8	3729	3751	4142
Al	49	0	99	148	56
Fe	37	1	21	59	
Mn	1.3	0.2	1.0	2.5	
Zn	0.3	0.1	1.4	1.7	
Cu	0.5	0.0	0.4	1.0	
B	0.0	0.0	1.5	1.5	
Pb	0.011	0.000	0.000	0.011	
Ni	0.09	0.03	0.16	0.27	
Cr	0.14	0.00	0.12	0.26	
Cd	0.0006	0.0000	0.0000	0.0006	
Hg	0.00018	NA	0.00004	0.00022	

POLLUTION PREVENTION ASSESSMENT

Information developed during this study was used to select areas for the pollution prevention assessment. As described below, reductions in wastewater phosphorus and organic matter contents were identified as the

primary targets, along with improved water conservation. A brief discussion of areas not selected for additional evaluation is also presented.

Wastewater Phosphorus Reduction

Phosphorus is an essential nutrient for algae and aquatic plants, and is often the limiting factor for their growth in aquatic systems. Excessive phosphorus levels have been associated with degraded water quality. The significance of wastewater phosphorus discharges from a particular source depends in part upon downstream wastewater treatment capabilities, watershed sensitivity and the total phosphorus load received by the watershed. In the case of the Cummins facility, all wastewater discharge is treated at the MCES Metro Treatment Plant, which discharges to the Mississippi River downstream of St. Paul. The Metro Plant processes wastewater with primary and secondary treatment systems; no tertiary phosphorus treatment currently exists at the facility.

Currently, phosphorus discharge is not limited under terms of the Cummins facility wastewater discharge permit, and no regulatory pressure or fees are associated with the phosphorus load. However, a review of the water quality literature indicated that local eutrophication (excessive algae growth) of the Mississippi River may be linked in part to phosphorus discharge from the Metro Plant. In light of these data, and the high cost of installing phosphorus removal systems at the Metro Plant (MWCC, 1993), future phosphorus restrictions are a possibility for MCES customers. Restrictions on phosphorus discharge exist in some other localities; for example, a typical phosphate limit for direct dischargers is 1.0 mg/L (daily max., as P). Indirect (POTW) dischargers may face surcharges if monthly averages exceed 10 mg/L phosphate (as P). Although Cummins' phosphorus load on the Metro Plant is relatively small (as indicated in Table 11), reductions in phosphorus discharge from the E-Coat system would contribute to improving downstream water quality. Voluntary efforts of this type are consistent with the company's environmental stewardship policy, and commitment to good corporate citizenship.

Table 11. Comparison of wastewater contaminant discharges and loads.

Parameter:	Average Load (lb/day)			Onan E-Coat (% of MCES Influent):
	MCES Influent:	MCES Effluent:	Onan E-Coat Discharge:	
COD	400,000	13,200	129	0.032%
TSS	437,000	18,800	18.1	0.004%
Phosphorus	11,300	5,100	7.7	0.068%

As discussed previously, over 80% of the phosphorus inputs to the E-Coat system are from the cleaning agent used in pretreatment. About half of the chemical is used in cleaning Stages 1 & 2, and about half is used as a rinse-aid in rinse Stages 3 & 4. A significant amount of phosphorus also appears to originate as drag-out from the iron phosphate conversion coating process. Of the total phosphorus input to the system, about half appears to pass untreated through the wastewater treatment system. Potential wastewater phosphorus reductions may be possible through the following activities:

1. Improve efficiency of wastewater treatment phosphorus removal
2. Use of phosphorus-free cleaning agent in Stages 1 & 2
3. Use of alternative rinse additives in Stages 3 & 4
4. Extending cleaning solution life via contaminant removal systems
5. Reducing rinse overflow rates in Stages 3 & 4
6. Reducing drag-out from cleaning and iron phosphate stages

Significant cost savings are also possible with these approaches. Discussion of these potential methods is provided below.

Reduction of Wastewater Organic Compounds

If discharged to rivers or lakes, organic compounds can degrade water quality by depleting dissolved oxygen needed by fish and other organisms. Most sewage treatment plants, or POTWs (publicly-owned treatment works) have treatment processes that remove much of the wastewater organic material. Cummins' E-Coat wastewater discharges exert a relatively small COD load on the Metro Plant, which on average removes over 95%

of the influent COD during treatment (as shown in Table 11 above). Currently, E-Coat system organic matter removal is limited to bag filtration and surface skimming of cleaning stages. Some of the organic matter in the discharge should be readily biodegraded during secondary wastewater treatment at the Metro Plant; this includes the organic acids and some "soils" removed from metal surfaces. Other organic compounds, such as the glycol ethers, appear to be moderately degradable. The discharge contributes a COD load to the MCES Metro Plant, which can assess surcharges to compensate for handling this load. The MCES currently assesses "strength surcharges" to *total facility* COD loads above 500 mg/L at a rate of $0.056/lb (Surbaugh, 1996). Historically, total facility wastewater volumes have been high enough to dilute E-Coat system COD discharges to levels below the 500 mg/L limit, and no strength surcharges have been assessed. However, as facility wastewater volumes continue to fall due to waste minimization activity, surcharges could become more significant in the future. If surcharges were assessed on the E-Coat system discharge alone, the fees would be approximately $2600/yr.

Results from this study indicate that about half of the organic compounds present in E-Coat wastewater are from permeate and anolyte discharges, with the remainder originating in the cleaning process (cleaning agent/rinse additives/soils). Most of the permeate COD (~75%) is in the form of glycol ethers. Routine permeate discharges are required to remove soluble contaminants from the E-Coat paint solutions, which otherwise lead to a variety of paint film defects. Unfortunately, permeate discharges also remove significant quantities of glycol ether cosolvents from the paint solution, and these must be replaced by additions of glycol ethers to the paint tanks. Because of the high cost of glycol ethers ($10 to $30 per gallon), replacement of the co-solvents discharged in wastewater represents a significant operating cost for the system (approximately $4300 per 5 million ft^2 coated). Recovery and reuse of glycol ethers from permeate would be desirable because it has the potential to reduce COD wastewater loads, wastewater strength surcharges and system operating costs. An alternative would be selective removal and disposal of contaminants from the paint solution.

Reductions in wastewater COD loads from cleaning processes are possible by extending cleaning stage life and reducing rinse stage chemical discharge, as discussed below.

Water Conservation

Water is used in the E-Coat system for pretreatment rinse stage overflows, deionizer regeneration, as make-up for evaporative loss and to recharge stages after disposal of tank contents. Results from this study show that rinse stage overflows make up over 80% of the total water usage, with overflow rates of about 3.5 gpm each at rinse Stage 3 and iron phosphate rinse Stage 9. Total water usage averaged 7.9 gpm, corresponding to 4.1 million gallons per year. At $2.20/1000 gallons for local water and sewer costs, this amounts to about $9000/year.

The addition of cascading rinses can reduce or eliminate wastewater discharge from a system. Counterflowing backwards carries drag-out contamination back to previous stages, maintaining low contaminant levels in later stages. If enough stages are used, the counterflowing can equal evaporative loss, and rinse stage cleanliness is maintained without wastewater discharge. Water savings also can be achieved by installing automatic monitoring and control systems designed to vary overflow rates and additive feeds in response to changes in stage contamination or additive concentrations.

Areas Not Considered for Waste Minimization

Areas not selected for in-depth review of waste minimization possibilities include air emissions, wastewater treatment sludge, and wastewater metals and solids. A brief discussion of each of these areas is presented in this section.

Air Emissions. As shown in Figure 8, air emissions from the E-Coat system are significantly lower than those of the conventional solvent-based spray paint process that the E-Coat system replaced. However, VOC and HAP emissions still occur, primarily from the glycol ethers and organic acids used as cosolvents and solubilizers for the paint components. Although stack controls could reduce these emissions, reductions are probably best accomplished at the source, in the form of alternative paint formulations and material processing methods. Significant work on these topics is underway within the paint industry, with the intent of minimizing or eliminating the need for toxic or volatile cosolvents (Austin, 1996; Oravitz, 1996). HAP-free E-Coat paint formulations are currently available (Oravitz, 1996; Tirado, 1996). It appears likely that alternative paint formulations will soon be available with reduced air emissions and acceptable performance characteristics. [The reader is referred to the above reports for details of this work.]

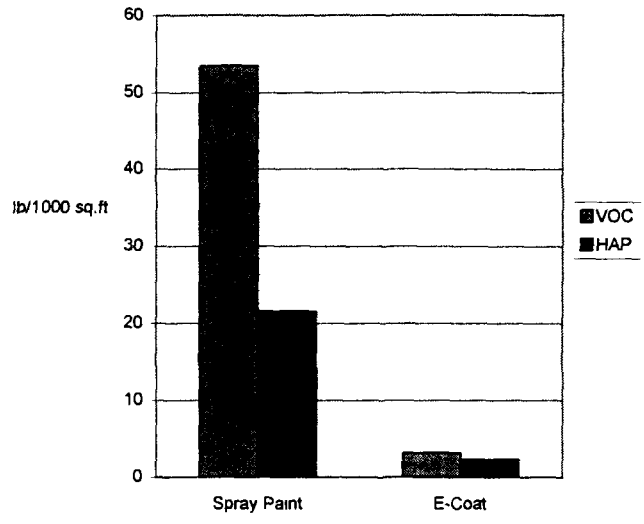


Figure 8. Air emissions comparison for E-Coat and former spray paint processes.

Sludge Generation. Results from compositional analysis of wastewater treatment and iron phosphate sludge ndicate that concentrations of toxic metals are low. These data are consistent with earlier testing performed at Cummins Power Generation in 1995 as part of profiling the sludge as a non-hazardous waste suitable for disposal at a local sanitary landfill. The "Toxic Characteristic Leachate Procedure" (TCLP) for metals, volatile organics and semi-volatile organics was performed, along with tests for free sulfide, free cyanide, and reactivity. Analysis of metals in the TCLP leachate detected low levels of barium (0.5 mg/L) and mercury (1.0 μg/L); and no detectable levels of the other elements (arsenic, cadmium, chromium, lead, selenium and silver). No semi-volatiles were detected in the leachate (<0.1 mg/L), and methylethylketone (at 0.26 mg/L) was the only volatile compound detected. Free sulfide and cyanide were not detectable (<5 ppm). The sludge was profiled as non-hazardous and was accepted for disposal at a local sanitary landfill. Disposal costs are low ($49/ton), and at the current sludge generation rate (74 lb/day), the impact on system operating costs is minimal ($1.81/day). No reuse or recovery of sludge components appears practical. The combination of low apparent environmental toxicity and low disposal cost rank sludge reductions low on the list of waste minimization opportunities.

Wastewater Metals and Solids. Analytical data indicate that wastewater metals concentrations are low -- well below permit discharge limits. Permit discharge limits for the E-Coat system are a combination of EPA

pretreatment standards and limits established by the MCES. A comparison of the discharge limits and measured wastewater concentrations is shown in Figure 9.

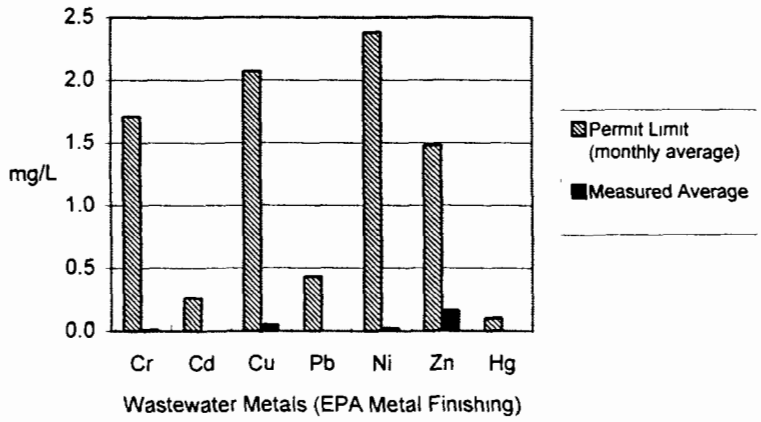


Figure 9. E-Coat wastewater discharge permit limits and measured concentrations for weekly composite samples.

The MCES currently assesses strength charges for total suspended solids (TSS) at a rate of $0.112/lb for total facility TSS loads above 250 mg/L (Surbaugh, 1996). Wastewater loading of TSS from the E-Coat system has not exceeded MCES strength charge limits for the total facility, and therefore no load charges have been assessed. If surcharges were assessed on the E-Coat system discharge alone, the fees would be relatively small (approximately $750/yr). Total dissolved solids levels are relatively high, but the loads are small relative to the total treated by the MCES, and they are not expected to be a problem in the local watershed. Similar systems located in sensitive watersheds may need to implement dissolved solids discharge controls, such as membrane filtration or evaporation of wastewater. The wastewater metals and solids do not appear to pose a significant water quality problem, nor do they violate wastewater permit limits or result in discharge fees. Accordingly, waste minimization is not considered a high priority in these areas.

E-COAT SYSTEM MODELING

In an attempt to gain better understanding of the E-Coat system, models were developed to simulate several portions of the system. The models were used to help optimize system processes and parameters (flow rates,

chemical dosages and contaminant removal rates) to minimize the potential for waste production. Detailed model descriptions, diagrams and outputs are given in Dhennin, 1996.

Model Construction

Stages of the E-Coat system were modeled singly or as a series of completely-mixed flow reactors (CMFR). By definition, in a CMFR, incoming substances are assumed to be instantly mixed throughout the container, or in this case, the stage. Although no real system could actually mix instantaneously, contents of each E-Coat system stage are continuously circulated through multiple, submerged eductor nozzles to achieve rapid mixing. Few obvious short-circuiting paths were observed, where a substance could exit a stage without significant mixing; one exception is with floating oils or "scum", which could overflow to successive stages without mixing. For most of the purposes described below, the CMFR appears to be a reasonable approximation.

The accumulation of substances (additives, contaminants, etc.) in a CMFR can be represented by the following:

$$\text{Accumulation} = \sum \text{inputs} - \sum \text{outputs} \pm \text{sinks/sources}$$

or by the following rate equation:

$$V\,(dC/dt) = Q_I C_O - QC \pm VkC$$

where V = volume of stage
t = time
C = concentration in the stage
C_O = influent concentration
Q_I = influent flow rate
Q = effluent flow rate
k = reaction rate constant

E-Coat system models based on this general equation were developed using STELLA II™ (© High Performance Systems, Inc) (other modeling software is commercially available, some specially designed for use with multiple-stage systems). STELLA II™ software provides the capability for setting up and solving complex differential equations such as these in a "user-friendly", visually explicit manner. A basic example of a system represented by STELLA II™ software is shown in the diagram in Figure 10.

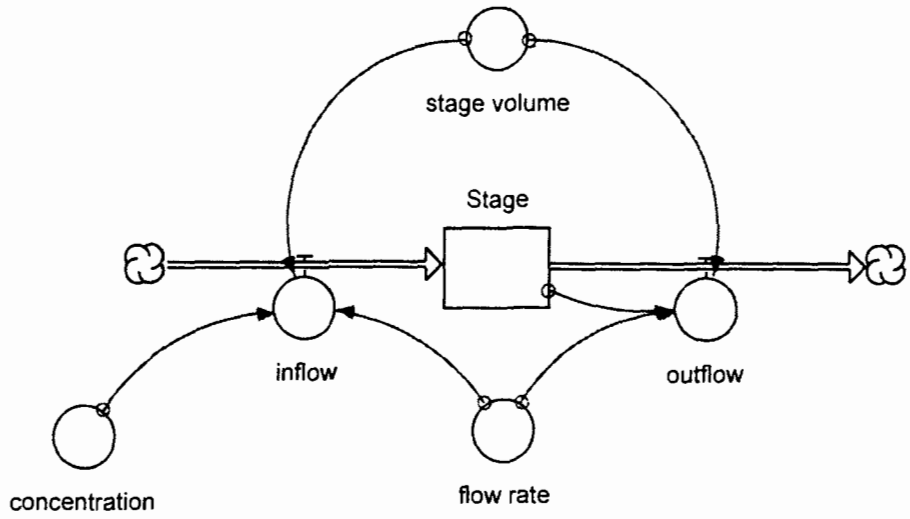


Figure 10. Simple flow model created with STELLA II™ software.

Figure 10 shows a simple model of the flow of a substance into and out of a container (such as a stage in the E-Coat system). "Flows" (shown as pipes with directional arrows and control valves) represent time derivatives into or out of a "stock". The "stock" (shown as a box) represents the integral of flows over time; in this model, the stock simulates the accumulation of a substance in a stage. "Converters" (shown as circles) contain the micro-logic of flows (High Performance Systems, 1994). Model boundaries are represented by clouds. To build a model, a diagram is constructed using simple "drag & drop" software tools; algebraic relationships are entered for each flow; and values for constants, variables and initial stock concentrations are entered. Figure 11 shows the resulting equations and parameters for the model.

```
Stage(t) = Stage(t - dt) + (inflow - outflow) * dt
INIT Stage = 0

inflow = (concentration*flow_rate)/stage_volume
outflow = (Stage*flow_rate)/stage_volume
concentration = 5
flow_rate = 10
stage_volume = 30
```

Figure 11. STELLA II™-generated equations and parameters for the flow model in Figure 10.

Separate models were constructed for the cleaning stages, rinse-after-cleaning stages, and final rinse stages in the E-Coat pretreatment system. A model also was built to simulate flows in the E-Coat paint and post-rinse system. The models are designed to simulate the flows, accumulations and fates of a substance through the system, one substance at a time (e.g. phosphorus, COD, Butyl Cellosolve, etc.). In general, use of the models begins with the input of system parameters (flow rates, concentrations, etc.), followed by the model parameters (simulation length, integration method, etc.). Variable inputs and flow rates can be used in the models. The simulation is then run, and results are generated in graphical or tabular form.

Several important parameters are needed for these models, including average drag-out rates and evaporation losses. These parameters have not yet been measured; instead, estimates of these values were used for the initial modeling, and methods for determining these parameters are discussed below.

Drag-Out Rate Determination. "Drag-out" is the material transferred from one stage to the stage immediately following by the parts and part carriers (racks, hooks, etc.) moving through the system. The drag-out rate in the E-Coat system is a function of several variables; most importantly, part configuration (size, shape, location and number of drain holes, etc.); part orientation on the carriers; holding time above the source stage (before moving over the successive stage); and system through-put. Drag-out is difficult to measure directly for several reasons. In the Cummins system, a wide variety of parts are processed at various rates, resulting in varying drag-out rates. Capturing and measuring the drippings from racks of parts is difficult in itself, but also neglects the material wetting part surfaces or trapped in confined spaces. An alternative is measurement of the accumulation of a unique, conservative tracer, input into one stage and measured in the following stage. For this study, a very rough

estimate of 6 gph drag-out was assumed, based on observed drip rates from typical parts carriers. Additional work is required to better understand drag-out in the E-Coat system.

Evaporation Rate Determination. Water is the only significant volatile material in the E-Coat pretreatment system; in the E-Coat paint and post-rinse stages, some evaporation of glycol ethers also could occur. Evaporative flux of materials from the system depends upon several variables, including solution temperature, air temperature and relative humidity, air movement over the surface (from system ventilation), and solution composition (Thomann, 1987). Some of these vary significantly over time (on a seasonal basis). One way to estimate evaporation is to float pans of the stage solution on the solution surface, and measure the loss of the component over time. Alternatively, evaporation rates could be measured by difference, if all other inputs and outputs from the stage were known. For this study, water evaporation rates were estimated by measuring the volume loss of city water from open containers of known surface area, placed in a laboratory fume hood. Rates were measured at room temperature in a shallow pan (without stirring), and at 120°F ($\pm$ 1°F) in a constant temperature bath (stirred continuously). Air flow across the surface was approximately 80 ft/minute (measured by a Vaneometer™); and ambient relative humidity was 21-26% (measured by psychrometer). Measured evaporation rates were 0.0042 gal/ft^2-hr at 68°F, and 0.039 gal/ft^2-hr at 120°F. The room temperature evaporation rate was used to approximate evaporation from unheated stages, and the elevated temperature rate was used for the heated cleaning stages. These rates may be reasonable estimates for winter operation at low ambient humidity levels.

E-Coat Model Descriptions

Cleaning Stage Models. Models were constructed for the existing 2-stage cleaning system and for an optional 3-stage system. The model can be used to track the following:

- cross-contamination between stages due to drag-out and stage overflows
- accumulation of soils and cleaning agent components
- cleaning chemical consumption rates
- accumulation of make-up water minerals, and the effects of using deionized or demineralized water in place of city water
- removal rates of contaminants and cleaning agent components by UF or other processes
- effects of evaporative concentration

Rinse-After-Cleaning Stage Models. Models were developed for the current rinse-after-cleaning stages (Stage 3 & 4) and for a 3-stage system under consideration. These models can be used to help determine the following:

- rinse stage additive and contaminant concentrations and wastewater loads
- optimum water flow rates (for water conservation and rinse performance)
- benefits of automatic controls for water flow and chemical additions
- potential benefits of a third rinse stage

E-Coat Paint and Post-Rinse Model. The permeate flow, overflows, drag-out, discharges and emissions from an E-Coat paint and post-rinse system were modeled. This model, which can be used for either the primer or topcoat E-Coat paint system, will assist in the evaluations of the following:

- glycol ether wastewater discharges and air emissions
- soluble contaminant flow and accumulation
- modifications to current glycol ether additions or permeate discharge practices

DISCUSSION

Several methods were identified as potential ways to meet the pollution prevention objectives. Specific methods and required development efforts are discussed below; projected environmental and operating cost benefits are discussed, along with potential risks of implementation.

Enhanced Wastewater Treatment Phosphorus Removal

Current wastewater treatment practice at Cummins involves the collection of rinse overflows, stage discharges and permeate/anolyte discharges into holding tanks, and then metering the contents into the wastewater treatment system. Phosphorus removal is accomplished by adjusting waste stream pH within a range of 6 to 9, then mixing in calcium chloride and flocculant to precipitate phosphorus as insoluble calcium phosphate. Precipitates are removed from the wastewater by clarification, thickening and filtration, and disposed of as filter cake sludge. Results from this study indicate that the phosphorus removal efficiency of the existing process was low (about

35%), especially during batch discharges of cleaning and cleaning rinse stages. Possible reasons for the low efficiency include inadequate treatment chemical dosing, and blending/diluting cleaning stage waste streams with other system discharges. Improved efficiency of this treatment could be accomplished by separately treating cleaning stage discharges in "batch" mode rather than combining cleaning stage discharges with other wastewater flows. Treatment procedures should be fine-tuned using laboratory "jar testing" to determine optimum $CaCl_2$ dosages and solution conditions. Monitoring equipment has been obtained to determine the residual phosphorus concentrations in treated wastewater as a measure of process efficiency.

Enhanced treatment procedures could be implemented without significant equipment or material cost. Operating costs include technician time for lab jar testing and the decreased flexibility inherent in batch treating as opposed to flow treating. Potential phosphorus reductions will depend upon actual stage phosphorus concentrations and the removal efficiency of the process. Assuming that cleaning stages are discharged at the current interval (once every 30 days) and that 90% phosphorus removal efficiency is achieved, average wastewater phosphorus discharges would be reduced by 3.7 lb/day. This amounts to reduction in the wastewater phosphorus load of approximately 50%; higher reductions are possible if enhanced treatment is used in conjunction with extended cleaning stage life, as discussed below.

Alternative Cleaning Agent Formulations

The cleaning agent formulation currently used in the E-Coat system was selected based on (1) the pretreatment system configuration (two heated immersion cleaning stages followed by two unheated immersion rinses), (2) the types of soils and substrates processed by the system, (3) required level of cleanliness, and (4) material cost. The cleaning solution and stage parameters (cleaning agent concentration, bath temperature, depletion indicators, etc.) were fine-tuned over several months of operation to reach the current, acceptable level of cleaning performance. Phosphorus-free alternatives are available, as are formulations with lower COD content. Unfortunately, these alternatives may compromise at least one of the performance properties of the current formulation; in an immersion system, phosphates are typically required to adequately disperse certain soils, sequester hard water minerals, and aid in rinsing and removal from the substrates (Petschel, 1996). However, acceptable cleaning performance may be achieved with alternative cleaning agents in conjunction with increased

physical action, such as that provided by spray cleaning stages (Leviten, 1996). Adding an additional cleaning stage may also provide the contact time necessary for a less-aggressive cleaning agent to provide acceptable cleaning performance. Modifying the pretreatment system by adding spray cleaning equipment and/or adding additional cleaning stages is currently under consideration. Use of demineralized water as make-up for cleaning stage evaporation may reduce the need for the sequestering properties of phosphates.

A significant amount of the current cleaning agent formulation is added to rinse Stages 3 & 4 to maintain acceptable alkalinity (for corrosion prevention) and rinsing performance. Rinse stage concentrations are relatively low (about 0.1% wt, compared to 3.3% wt in Stage 1), but the daily consumption is higher to compensate for losses from stage overflows to the wastewater treatment system. Replacement with a phosphorus-free rinse additive, such as an alkaline buffer used elsewhere in the pretreatment system, would provide residual alkalinity for corrosion prevention but may not provide adequate rinsing due to the lack of phosphates. The addition of a spray rinse stage would provide physical action to enhance rinsing.

Evaluation of alternative cleaning agents and rinse additives would require initial bench testing (to determine cleaning performance on typical soils and substrates) followed by full-scale testing in the pretreatment system during production. Potential risks include reduced paint quality and re-work of inadequately cleaned parts. Costs include equipment required for cleaning stage modification, and development costs (labor and materials). The potential reduction of wastewater phosphorus is significant, however, as the current cleaning agent represents about 88% of the phosphorus inputs to the E-Coat system. Implementation of phosphorus-free cleaning agent in Stages 1 & 2 would reduce phosphorus loading by 5.1 lb/day; eliminating rinse additives (or implementing phosphorus-free alternatives) would reduce loading by an additional 4.8 lb/day. Potential COD reductions are 19 lb/day for the cleaning stages, and 17 lb/day for the rinse stages. Implementing alternative cleaning agents and rinse additives could save significantly on operating costs. As an example, replacing the current rinse additive with an alkaline buffer could reduce rinse chemical costs by 70%, saving up to $14,000/year (based on equivalent alkalinity).

Rinse Stage Modifications

Pretreatment rinse stage modifications present an opportunity to reduce water consumption, rinse additive usage and wastewater loading of phosphorus and COD. Modifications considered are optimizing rinse additive dosage rates, the addition of cascading rinses after cleaning stages, and the use of automatic monitoring, chemical feed and overflow controls.

The model for the current rinse system (two stages after cleaning) was used to show rinse stage phosphorus concentrations and phosphorus output to waste treatment. Results indicate that phosphorus concentrations increase about 50% in Stage 3 (due to drag-in from Stage 2), and decrease about 50% in Stage 4. [Phosphorus concentrations are proportional to the concentration of cleaning agent additive in the stages; the cleaning agent is about 10% wt phosphorus.] These results suggest that additive dosing is excessive in Stage 3, assuming that adequate rinsing performance is achieved in Stage 3 at the initial additive concentration, and in Stage 4 at the current levels. The model suggests that reduced phosphorus discharge (>2 lb/day) and additive usage (>20 lb/day) could be achieved by eliminating the addition of cleaning agent to Stage 3. Cleaning agent levels in Stage 3 are maintained just above initial concentrations by drag-in from the preceding cleaning stage. Model results indicate that water usage could be reduced by 70% by adding a third rinse stage, with no reduction in final rinse quality. Reductions in water consumption could be achieved by automatic control of water flow rates into the rinse stages. In practice, contamination and drag-out rates will vary with time as a result of varying parts type and interruptions in system through-put rate (from weekends, holidays, etc.). Rinse water quality could be monitored continuously, using conductivity, pH or other methods; automatic flow controllers would then use this data to adjust water input into the rinse stage (Kelly, 1993; Zickgraf, 1993). Similar controls could be used to feed additives in response to stage concentrations.

Extending Cleaning Agent Life

Cleaning stage solutions gradually become contaminated by incoming soils, and cleaning agent ingredients (such as detergents and saponifiers) are gradually depleted by contact with soils. Several options exist for contaminant removal from aqueous cleaning solutions, including (in order of increasing complexity and cost): surface skimming; coalescence; centrifugation, and filtration. Surface skimmers are in place on the E-Coat system

cleaning stages, but remove negligible amounts of material; this suggests that free oil volumes are very low. Centrifugation has the potential to remove emulsions and solids in addition to free oils, without removal of active cleaning agent components. An approach considered for this system was cross-flow ultrafiltration to separate particulates, oils, and emulsions from the cleaning stages. Systems of this type have been reported to extend cleaning solution life by 5 to 10 times (Fischer, 1996), with associated reductions in cleaning solution disposal, system down-time and labor costs. Selection of membrane type and construction depends upon a number of factors, including cleaning agent composition, soil types and concentrations, fouling characteristics, operating parameters, and capital and operating costs (Fischer, 1996). Active cleaning agent surfactants can be removed during ultrafiltration, requiring replenishment of these components to the cleaning stage. Membranes can become fouled with oils and some components of the cleaning agents (such as sodium metasilicate) during operation, and this would require aggressive membrane cleaning procedures using highly alkaline or nitric/hydrofluoric acid solutions. Membrane design and composition must be resistant to fouling and cleaning chemicals. Preliminary selection of the filtration system parameters is best accomplished by reviewing cleaning agent formulations, followed by bench testing with actual contaminated cleaning solutions.

Implementing membrane filtration imparts several risks, including membrane fouling by incoming soils; excessive removal of active cleaning agent ingredients; high maintenance requirements; low flux rates; and inadequate membrane life. These risks can be minimized by coupling small-scale pilot system to the cleaning stages, and evaluating the performance of the best candidate membrane constructions. Capital costs of full-scale systems are relatively high, and payback depends upon contaminant removal efficiency, removal rate of desirable cleaning agent components, maintenance costs, cleaning solution filtrate disposal costs, and membrane life.

Permeate Glycol Ether Recovery/Retention

Ultrafilter permeate is discharged periodically from the E-Coat paints in order to remove soluble contaminants that accumulate in the paint solution. If allowed to accumulate, these contaminants are the apparent cause of several paint film defects, such as "pinholing" and film rupture. At this time, the exact nature of the contaminants are not known, but a potential list of contaminants includes degradation products from the electrodeposition of paint compounds; contaminants in make-up materials and DI water; and/or external

contaminants carried into the paint baths (from preceding stages). Permeate discharge has been the method used by the industry to remove these contaminants; but in the process, glycol ether co-solvents also are discharged and must be replenished to the system.

One possible alternative to the current permeate discharge process involves the selective removal of the specific contaminants responsible for paint defects, and retention of the glycol ethers in the paint system. A second option would be recovery and reuse of glycol ethers from the current permeate discharge. Both alternatives probably require better understanding of the nature of the contaminants to determine practical treatment methods. The residue observed after permeate samples are evaporated may contain these contaminants. Analysis of these residues may provide clues as to the identity of the contaminants, and bench-scale electrodeposition testing could be conducted to determine if specific contaminants result in the observed paint defects.

One potential method for selective removal of contaminants is membrane filtration of the current permeate, using membranes that retain species just larger than the glycol ethers, thus returning water and the ethers back to the paint system. Reverse osmosis of the permeate also could be performed, returning the water phase to the paint system, and recovering the glycol ethers from the filtrate via distillation. Significant development work would be required to identify specific contaminants and to evaluate the treatment options, but the effort may be justified due to potential cost savings associated with glycol ether recovery. Projected savings, based on measured glycol ether discharge rates and 80% recovery of glycol ethers, is about $6500/yr at a coating rate of 7.5 million ft^2/yr. This topic is recommended as a future research project with potentially significant, industry-wide benefits.

CONCLUSIONS

Baseline discharges and emissions were established for the E-Coat system over a 3-month monitoring period. Wastewater discharges of phosphorus, COD and glycol ether compounds were found to be relatively significant; metals and solids discharges were comparatively minor. Phosphorus and COD loading rates varied by an order of magnitude during the monitoring period. Air emissions, consisting primarily of glycol ether compounds, were 90% lower than the system it replaced (per area coated), confirming preliminary projections. Solid waste volumes (primarily from wastewater treatment sludge) were small; concentrations of toxic metals and organic compounds were very low, and the waste was determined to be non-hazardous.

Sinks and sources of the major constituents were determined using a mass balance approach. The cleaning agent compound used in pretreatment cleaning stages and as the rinse additive in rinse stages was a major source of phosphorus and COD. Drag-out from the iron-phosphate conversion coating process also was a significant phosphorus source. Most of these phosphorus and COD inputs were discharged in wastewater. A significant fraction of the COD wastewater load consisted of glycol ethers removed from the E-Coat process as permeate; this represents about 24% of the total quantity of glycol ethers consumed by the E-Coat process, the balance of which were released as air emissions.

Information generated during the study was used to identify and prioritize potential waste minimization opportunities. System models were developed, and proved useful in evaluating these options; the models also will serve as tools for future evaluations of the E-Coat system. Put into perspective, the phosphorus and COD wastewater loads from the E-Coat system are small compared to the quantity processed by the local POTW, and no permit compliance issues or fees currently exist. Glycol ethers discharged in wastewater probably biodegrade during secondary treatment at the POTW. However, reductions in these constituents would provide environmental benefits; reductions in phosphorus would be especially beneficial due to the sensitivity of the local receiving waters. Moreover, reductions in these areas may be further justified by savings in process costs. The following waste minimization activities are recommended, ranked according to potential environmental benefits, ease of implementation and process cost savings:

1. Modify rinse additive dosing to minimize phosphorus and COD discharge and additive cost.
2. Replace the current rinse additive with a phosphorus-free alternative to minimize phosphorus and COD discharge and reduce additive cost.
3. Improve efficiency of waste treatment phosphorus removal to reduce phosphorus discharge.
4. Add a third rinse stage after cleaning to reduce water consumption and associated costs.
5. Add a third cleaning stage (preferably spray) to allow alternative (phosphorus-free) cleaning agents, and reduce phosphorus and COD discharges.
6. Implement cleaning stage contaminant removal systems to extend cleaning solution life, thereby reducing phosphorus and COD discharges and chemical and operating costs.
7. Investigate reuse and recovery options for the glycol ethers discharged as permeate from the E-Coat paint tanks.

Results from this study illustrate how pollution prevention assessments can identify relatively simple alternatives to reduce both the environmental impact and the operating costs of an industrial process.

ACKNOWLEDGMENTS

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Mark Dorfman

INFORM, Inc.

"The Power of Right To Know Data to Track and Promote P2 of Persistent and Bioaccumulative Toxicants"

Dianne Dorland

Dept. of Chemical Engineering
University of Minnesota Duluth

"Mercury P2 at Potlatch Corporation's Cloquet Pulp and Paper Mills"

BIOGRAPHY

Dianne Dorland

Dianne Dorland is a professor in the Department of Chemical Engineering,University of Minnesota, Duluth. She is a licensed professional engineer and teaches hazardous waste processing for both practicing and undergraduate engineers. Dianne works on pollution prevention and hazardous waste management with companies in a wide range of industries. She received her BS and MS in chemical engineering from the South Dakota School of Mines and Technology in 1969 and worked for industry before receiving her PhD in 1985 from West Virginia University. She joined the faculty of University of Minnesota-Duluth (UMD) in 1986, and is head of the Department of Chemical Engineering.

MERCURY P2 AT POTLATCH CORPORATION'S CLOQUET PULP AND PAPER MILL

Eliminating mercury from ECF bleaching and other activities

Dianne Dorland, Kevin W. Kangas, and Tim Tuominen

Pollution prevention is often challenging, requiring careful consideration of unrecognized opportunities. After achieving pollution prevention, we may be able to clearly summarize our work. But when starting the process, it is often difficult to know what lies ahead.

This article describes a successful mercury pollution prevention project at a pulp and paper mill. It also reveals a surprising cause of mercury contamination at the mill: the facility's switch to elemental chlorine-free bleaching, a more environmentally friendly process.

Background

Mercury is a naturally occurring heavy metal. We are frequently unaware of its presence, although it is used in thermostats, fluorescent lamps, thermometers, switches, and gauges. The silvery metal evaporates easily, producing a colorless, odorless vapor that is highly toxic to the brain and nervous system, kidneys, liver, and developing fetuses. Estimates of the global mercury budget indicate that natural and anthropogenic sources are almost equally important contributors to the atmospheric mercury burden.[1]

As an airborne contaminant, it is a byproduct of garbage incineration and the combustion of coal, oil, natural gas, and wood. After deposition in lakes, rivers, and streams, it is converted to a highly toxic form, methylmercury, which accumulates in fish and wildlife. This is one reason that 94 percent of Minnesota's lakes have been posted with advisories from the Minnesota Department of Health restricting fish consumption.[2]

The International Joint Commission, an advisory group jointly representing EPA and Environment Canada, has targeted mercury for virtual elimination from human-related sources in the Great Lakes Basin.

The focus on mercury pollution prevention has brought a diverse group of people together. The team that worked on the project described in this article represented industry, academia, and a regional publicly owned treatment works (POTW). This article begins with a brief introduction to these players.

Western Lake Superior Sanitary District

The Western Lake Superior Sanitary District (WLSSD) in Duluth, Minnesota utilizes solid waste as refuse derived fuel (RDF) to incinerate wastewater treatment sludge, conserving energy resources while reducing landfill loading requirements. Mercury is commonly found in municipal garbage from items such as disposable batteries, paint and painted objects, inks, thermostat controls, and other electrical parts. WLSSD actively discourages disposal of these items in the solid waste stream through source separation and separate disposal, but mercury remains a concern in the stack gas and wastewater effluent.

The Potlatch Cloquet mill has replaced several mercury-containing products at its plant with mercury-free alternatives.

As mercury became a top priority for pollution prevention, WLSSD implemented process changes to reduce mercury in the wastewater effluent to meet National Pollutant Discharge Elimination System (NPDES) permit requirements. After identifying process points where mercury concentrated, operational changes were made that resulted in the removal of mercury as a solid waste.[3] This lowered the mercury concentration in the wastewater effluent, but further reduction was still desirable. WLSSD has continued to promote mercury pollution prevention, working with major industries as well as smaller dischargers such as dentists and laboratories.

The Potlatch Cloquet Mill

The pulp and paper industry is no stranger to the principles of pollution prevention. P2 has become a key design consideration in process modernization and expansion projects, as well as a part of day-to-day plant operations.

The mercury pollution prevention program implemented at Potlatch Corporation's bleached kraft pulp and paper mill in Cloquet, Minnesota has demonstrated that significant reductions in the use of mercury-containing products—and the potential for incidental releases—can be achieved using basic pollution prevention techniques.

Since 1992, the Potlatch Cloquet mill has replaced several mercury-containing products at its plant with mercury-free alternatives. In addition, the mill has developed mercury recycling programs for fluorescent light bulbs, pressure switches, batteries, and thermostats; these programs were initiated under the auspices of the Minnesota Pollution Control Agency's (MPCA's) special hazardous waste pilot project. The recycling programs have been coordinated with the mill personnel who work with each product. **Exhibit 1** lists the mercury-containing products that have been replaced or recycled since the mercury P2 program was begun.

Minnesota Pollution Control Agency

In the early 1990s, the MPCA established a Mercury Task Force and began promoting a "pollution prevention first" approach that departed from traditional regulatory "back-end" pollution control.

The Mercury Task Force is comprised of staff from the MPCA and the state's Office of Environmental Assistance. The group has assembled a comprehensive report summarizing what is known and not known about mercury contamination in Minnesota's environment.[4] The report also describes the steps that can be taken to reduce mercury.

The report points out that conventional regulations often emphasize pollution control over pollution prevention. Regulatory controls may help capture mercury from the air or water; however, ultimately this approach simply transfers the mercury to another medium. Thus, reducing mercury emission limits is not sufficient to solve the mercury pollution problem. Mercury must be reduced or eliminated at the point of entry in a process.

Exhibit 1. Mercury-Free Alternatives and Elemental Mercury Recycling

Mercury-Containing Product (Units recovered and recycled)	Area Where Used	Mercury-Free Alternative	Mercury Recovered and Recycled Since 1992 (lbs)
Parabolic Flow Meter Transmitters and Manometers[A] (10)	Boiler steam systems	Electronic or pneumatic	254
Miscellaneous Laboratory Uses	Process and analytical laboratories	—	10
Fluorescent Light Bulbs[B] (17,000)	Mill-wide	—	0.9
Old Alkaline Batteries[A] (2,100)	Mill-wide	No-mercury-added Rechargeable	0.9
Mercoid Pressure Switches[B] (5)	Boiler steam systems	Electronic or mechanical models	0.45
Non-Electric Thermostats[B](20)	Mill-wide	Electronic models	0.23
Silver Bulb Thermometers[A] (50)	Process and analytical laboratories	Red Bulb (alcohol) or Digital	0.23
Total		—	267

A—Indicates a mercury-containing product that has been completely replaced.
B—Indicates a mercury-containing product that has not been completely replaced. A recycling program is in place to ensure that the elemental mercury is recovered and recycled when taken out of service.

Chemical Engineering Department, University of Minnesota Duluth

The Chemical Engineering Department at the University of Minnesota Duluth (UMD) emphasizes hazardous waste processing and promotes undergraduate research in pollution prevention. In 1994, the MPCA provided funding for a team of four chemical engineering students in the department to inventory and identify sources of pollutants in wastewater effluent. The students' objective was to perform in-depth pollution prevention audits with industrial users of POTWs.

The focus of the students' efforts was on persistent toxic bio-accumulative substances, including mercury. Mercury pollution prevention was the common thread that brought WLSSD, Potlatch, and these chemical engineering students together on a task force.

Problem Identification

In mid-1994, the Potlatch Cloquet mill observed increased mercury concentrations in its wastewater effluent. There was no apparent direct cause for the increase. The only major process change that had taken place recently at the mill was a conversion to elemental chlorine-free (ECF) bleaching using chlorine dioxide. This change virtually eliminated the formation of pollutants such as dioxins and furans in the bleaching process.

Potlatch formed a Mercury Pollution Prevention Task Force comprised of personnel from Potlatch, WLSSD, and the UMD Chemical Engineering Department. The goal of the Task Force was to determine the source of the increased mercury contamination.

The Task Force began by focusing on the feedstocks used in the pulp and paper process. They first reviewed the available process flow diagrams that show product and waste flows and chemical entry points. These flow diagrams were later used to select strategic sample points for mercury monitoring.

Typically, a bleached kraft mill uses a number of feedstock chemicals in the manufacture of pulp and paper. These chemicals range from dispersants and defoamers to sodium hydroxide and sulfuric acid. Because of mercury's ubiquitous nature, many of these substances may contain a trace of mercury.

Suppliers provide limited information on the mercury content of feedstock chemicals. The incidental mercury content of a chemical is never disclosed on an MSDS. If a mill requests a "certificate

Exhibit 2. Mercury Background Search—Telephone Survey Template

1. Hello my name is _____ and I am conducting a raw materials analysis for (**company name**).

2. Because we are concerned with protecting the environment from mercury pollution, we are conducting a raw materials analysis with a special focus on mercury that may incidentally be in the (**product name**) you supply to us.

3. Is there a technical representative who could answer a few questions about (**product name**) for me?

4. If transferred, repeat questions 1 and 2. If not transferred, would you please answer a few questions about (**product name**) for me?

5. If the company is only a distributor ask for manufacturer's name and a contact person.

6. Do you know if (**product name**) contains any mercury?
   6a. What are the technical and sales specifications?
   6b. What method was used to measure the mercury content and what were the detection limits?
   6c. Do you have any mercury-free products or substitutes for (**product name**)?

7. Is elemental mercury used in your production process for (**product name**)?
   7a. If yes, how does this impact the mercury content in (**product name**)?

8. Have you changed your production process recently?
   8a. If yes, what did you used to do and what do you do now?
   8b. Have you investiagted whether or not this process change could have increased the mercury content of (**product name**)?
      8b1. If yes, would you share the results of your investigation with us?

9. Have you checked for mercury in your raw materials?
   9a. If yes, what raw materials contain mercury?
   9b. What are the technical and sales specifications?
   9c. What method was used to measure the mercury content and what were the detection limits?
   9d. Have you investigated finding a mercury-free supplier?

10. Have you changed raw material suppliers recently?
    10a. Have you investigated whether or not this change could have increased the mercury content of (**product name**)?
    10b. If yes, would you share the results of your investigation with us?

11. Could we get a schematic or flow chart of your production process and a list of the raw materials you use?

12. Would you like to be informed of any significant findings we may discover?

13. Could I please get an address and telephone number to contact you at?

14. This has been very helpful and is sincerely appreciated. Thank you for your time and cooperation!

of analysis" for a given chemical, mercury is seldom listed; buyers must specifically request that mercury content be included in the analysis.

To aid in the search for sources of mercury, the Task Force decided to conduct a survey of pulp mill chemical suppliers. Students and staff from the UMD Department of Chemical Engineering developed a questionnaire for surveying suppliers via telephone (see **Exhibit 2**). The questionnaire was designed to guide Task Force members through the process of asking suppliers about a chemical's production process and mercury concentration. By using the questionnaire, we could be assured that the same questions would be consistently asked. The interviewers also asked suppliers to provide process flow sheets and lists of raw materials used in producing their chemicals.

The Task Force members contacted suppliers' sales or technical representatives. Calling technical representatives at raw material suppliers turned out to be an excellent method for obtaining information. By talking directly to a

technical representative, more information was acquired. In addition, the representative had a chance to ask for clarification of any questions that were not understood. In some phone conversations, the technical representative was able to provide additional information relating to the Potlatch Cloquet problem that was not requested in the survey.

A few supplier representatives asked that the questionnaire be faxed to them because they did not have the information readily available. Only one company failed to return the completed survey form. However, none of the companies sent process flow sheets or lists of their raw materials.

Mercury Monitoring

Rather than analyzing every feedstock chemical for mercury, the Task Force used wastewater effluent analysis to locate mercury sources in specific areas of the pulp and paper manufacturing process. The Potlatch Cloquet mill operates two wastewater clarifiers (one for pulp mill effluent and one for paper mill effluent) that physically treat wastewater prior to discharge to WLSSD for secondary treatment.

The only mercury data that existed at the start of the project were from the mill wastewater effluent. Consequently, the process began with a mass balance focused on the mill's waste treatment plant in order to pinpoint the source of mercury at the mill. Clarifier sampling indicated that the mercury originated somewhere in the pulping process. The flow from the pulp mill was found to account for 96 percent of the mercury in the mill wastewater effluent.

To trace the mercury back to its source, a flow diagram of the pulp mill sewer system was used to identify strategic sample points. Grab samples of the major pulp mill wastewater effluent and feedstock chemicals were taken by the Potlatch environmental staff for analysis at WLSSD. The feedstock chemicals analyzed for mercury included sodium hydroxide, sulfuric acid, and chlorine dioxide.

Quality Assurance/Quality Control

WLSSD uses EPA method 245.1 for mercury analysis (cold vapor atomic adsorption) with "clean" techniques for low level detection at 0.05 µ/L. Adequate quality assurance/quality control (QA/QC) procedures are important when sampling and testing for mercury at levels below the standard EPA detection limit of 0.2 µg/L. To ensure that the WLSSD analytical laboratory was providing valid data, mill wastewater effluent samples were split between the WLSSD and four other EPA-certified laboratories for mercury analysis. All five analytical laboratories provided similar results at the standard EPA level of detection.

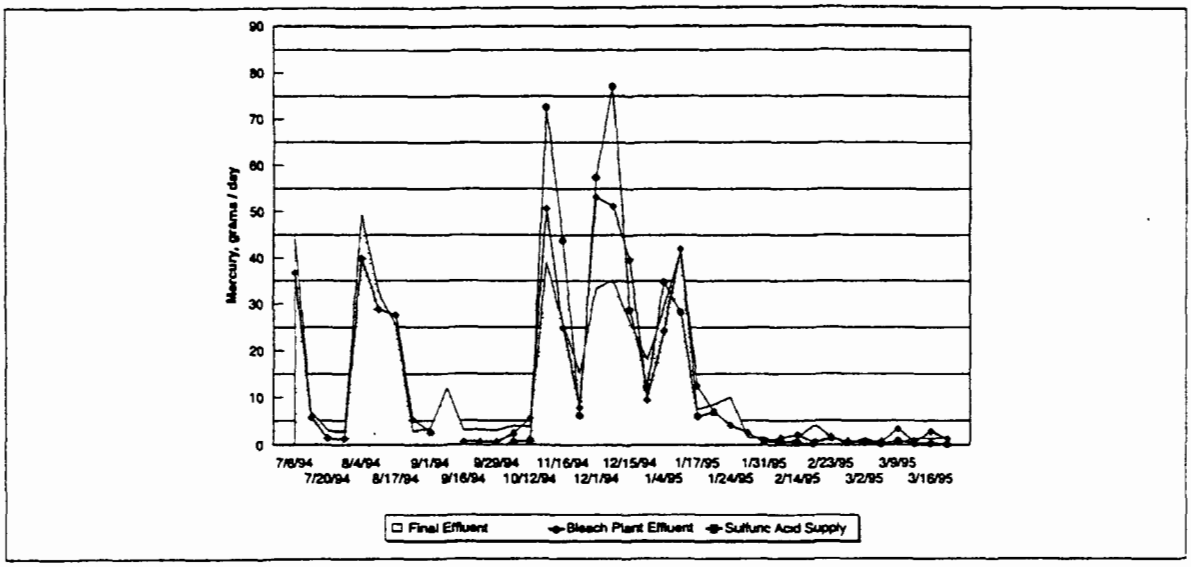
Process Sewer Investigation: Data Review and Correlation

Using the monitoring data, the Task Force narrowed the search for the mercury source to the bleach plant. The sampling frequency was then increased for the bleach plant, the mill wastewater effluent, and the feedstock chemicals used in the bleaching process. A mass balance approach was an essential tool for determining the chemicals' contribution to the mill wastewater effluent. Considering only mercury concentration may lead to the conclusion that a chemical is a significant component of wastewater effluent, but until the flow rate is considered, the true impact will not be known.

The highest mercury mass flows were 0.17 lb/day (0.077 kg/day) in the sulfuric acid, 0.0004 lb/day (0.00018 kg/day) in the caustic soda, and 0.0004 lb/day (0.00018 kg/day) in the chlorine dioxide. The mercury in the sulfuric acid was identified as the probable cause of the increased mer-

To trace the mercury back to its source, a flow diagram of the pulp mill sewer system was used to identify strategic sample points.

Exhibit 3. Mercury in Bleach Plant Effluent, Mill Effluent, & Sulfuric Acid Supply



cury in the wastewater effluent. When the data were graphed, the mass flow of mercury in sulfuric acid was shown to correlate strongly with the bleach plant and mill wastewater effluent mercury mass flow (see **Exhibit 3**).

Pinpointing the Supplier and Source

The next step was to pinpoint the sources of mercury in terms of suppliers and manufacturing plants. Through the mill purchasing department, it was learned that the conversion to ECF bleaching significantly increased sulfuric acid usage. With ECF bleaching, sulfuric acid addition is necessary to adjust pH prior to the first bleaching stage. Many North American bleached kraft pulp mills are converting to ECF or increasing the level of chlorine dioxide substitution to virtually eliminate the formation of pollutants such as dioxins and furans in the bleaching process.

The phone surveys were reviewed and sulfuric acid suppliers were contacted once again for more information about their manufacturing plants. During this round of phone calls, Potlatch environmental staff requested technical representatives rather than sales personnel.

It was learned that one particular supplier was sending the mill sulfuric acid from a new source—a secondary lead smelter. The technical representative for this facility indicated that his plant had a problem with mercury contamination in its sulfuric acid.

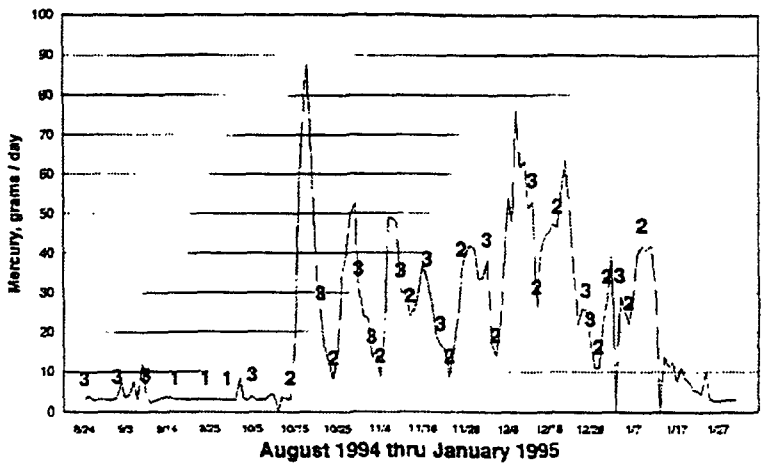
Potlatch was able to attribute the mercury in its wastewater to the secondary lead smelting source by correlating effluent mercury increases with chemical unloading documents. **Exhibit 4** shows that when sulfuric acid from the secondary lead smelter was unloaded, the bleach plant and mill wastewater effluent mercury mass flows increased sharply.

Sulfuric Acid Manufacturing Methods

Through this investigation, much was learned about the processes used to manufacture sulfuric acid. Although sulfuric acid can be made from raw sulfur, it is widely produced from byproduct sulfur dioxide that is captured to reduce air emissions in the petroleum and metal smelting industries. Mercury typically enters these processes with mined materials and is incidentally released with stripped sulfur dioxide gas.

Based on our investigation, the lowest mer-

Exhibit 4. Mercury Mass Flow in Mill Wastewater Effluent



cury concentrations are found in sulfuric acid produced by petroleum refineries, followed by secondary copper smelters, and lastly by secondary lead smelters (see **Exhibit 5**). During the feedstock sampling, sulfuric acid from the secondary lead smelting facility was found to contain as much as 10 mg/L mercury.

Eliminating the Source of Mercury

Once the Mercury Pollution Prevention Task Force identified the source of the mercury in the Potlatch Cloquet wastewater, the mill stopped accepting sulfuric acid shipments from the secondary lead smelter. Since this change was made in January 1995, effluent mercury concentrations have been reduced by over 90 percent; they are now at nondetectable levels of less than 0.05 µg/L as measured by the WLSSD. Analytical results from a recent sampling event using "ultra clean sampling techniques" and cold vapor atomic fluorescence (CVAFS) resulted in an average primary wastewater effluent concentration of 0.012 µg/L.

Mercury-Free Alternatives and Elemental Mercury Recycling

Concern over mercury pollution has fostered the development of many new mercury-free products. At Potlatch Cloquet, mercury pollution prevention efforts began in 1992 with the establishment of programs for replacing mercury-containing products with mercury-free alternatives. This reduced the likelihood that mercury could enter process wastewater or the solid waste stream.

In some cases, however, mercury-free alterna-

Exhibit 5. Sulfuric Acid Mercury Concentration from Various Suppliers to the Potlatch Cloquet Mill

Supplier	Manufacturing Process Byproduct of	Mercury Concentration (mg/L)
Supplier 1, Plant 1	Secondary Copper Smelter	0.01–0.1
Supplier 1, Plant 2	Secondary Lead Smelter	1–10
Supplier 2, Plant 3	Secondary Copper Smelter	0.01–0.1
Supplier 3, Plant 4	Petroleum Refinery	0.001

tives are not available or are uneconomical. In other instances, mercury may serve a valid environmental purpose; for example, mercury-containing fluorescent light bulbs conserve energy and fossil fuel usage. When mercury cannot be eliminated, the next best option is to establish a product-specific recycling program.

In 1992, the MPCA implemented a pilot project for "special hazardous waste" as part of an effort to simplify the process of properly handling and recycling mercury-containing products. The pilot project has successfully reduced the complexity and cost of recycling mercury-containing products by not requiring a hazardous waste manifest. These materials are recycled and do not count toward a facility's hazardous waste generator status. More recently, EPA promulgated a similar regulation called the Universal Waste Rule that applies to the handling of waste batteries and mercury-containing thermostats.

Conclusions

It is ironic that the increased mercury in Potlatch Cloquet's wastewater effluent resulted from a switch to a more "environmentally friendly" bleaching process. This is not meant to downplay the need to promote environmentally friendly processes, but simply emphasizes the challenge of pollution prevention.

The Potlatch Cloquet bleach kraft mill has shown that basic pollution prevention techniques are effective in reducing the use of mercury-containing products and the potential for incidental mercury releases. To date, the mill has recycled approximately 588 lbs of elemental mercury from mercury-containing products.

To have a significant impact on global mercury emissions, all stakeholders (government, industry, and environmental groups) must proactively work together to promote "front end" pollution prevention strategies. What is emerging is a new paradigm for mercury management—one that promotes knowledge of how mercury impacts the environment and emphasizes responsibility for reducing mercury releases across all phases of the mercury life cycle.

Recommendations

To ensure that mercury-free products and low mercury feedstock chemicals are purchased, we recommend the following pollution prevention steps:

- *Inform your chemical suppliers of your concern about mercury contamination in feedstock chemicals.* Ask suppliers to provide historical mercury data and technical specifications for their product's mercury content. Most mills require that a certificate of analysis be supplied with chemical shipments, but seldom does the analysis include mercury. Require that mercury be included in the certificate of analysis.
- *Implement a chemical management program that includes pre-purchase review and approval by environmental staff.* This program will provide mill personnel with the opportunity to question a given product's mercury content (as well as other constituents of concern) prior to authorizing purchase.
- *Require that all engineering projects be reviewed by environmental staff.* This will provide an opportunity to discuss the potential multi-media environmental impacts specific to mercury or other constituents of concern for all engineering projects.
- *Always remember and practice the basics for mercury pollution prevention:*

  - Know where mercury is found;
  - Use mercury-free alternatives; and
  - Properly recover and recycle elemental mercury and mercury-containing products.

Notes

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Dianne Dorland, Ph.D., P.E., is a professor in the Department of Chemical Engineering, University of Minnesota Duluth. She is a Licensed Professional Engineer and teaches hazardous waste processing for both practicing and undergraduate engineers. **Kevin W. Kangas** is an environmental/chemical engineer with Potlatch Corporation in Cloquet, Minnesota. **Tim Tuominen** is a pollution prevention chemist with the Western Lake Superior Sanitary District in Duluth, Minnesota.

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Curt G. Elliott

Procter & Gamble Cosmetic/Fragrance Products

"Waste Source & Cost Reduction at a Cosmetic Manufacturing Facility"

Curtis G. Elliott

Job History:	Plant Environmental Manger Procter & Gamble Manufacturing Co.	1988-present
	Engineering Services Foreman same as above	1983-1988
	Production Line Foreman same as above	1973-1983

Accomplishments: Waste Reduction Projects over the past 10 years have included all areas of Environmental Media (Air, Wastewater, and Solid Waste) and represent a 55%-60% yearly reduction in total tons/gallons generated and a cost savings of approximately 1.8 Million Dollars/year

Memberships:
Baltimore County Wastewater Coalition
Environmental Manager's of Maryland
Baltimore County LEPC
Harford County LEPC
Cosmetics Trade Association
Businesses for the Chesapeake Bay
Participant with the National Environmental Education and Training Foundation and Cattonsville Community College in the development of an Industrial Ecology course curriculum for community colleges around the country.

Awards:

P&G "Outstanding Environmental Management System" Award 1992.

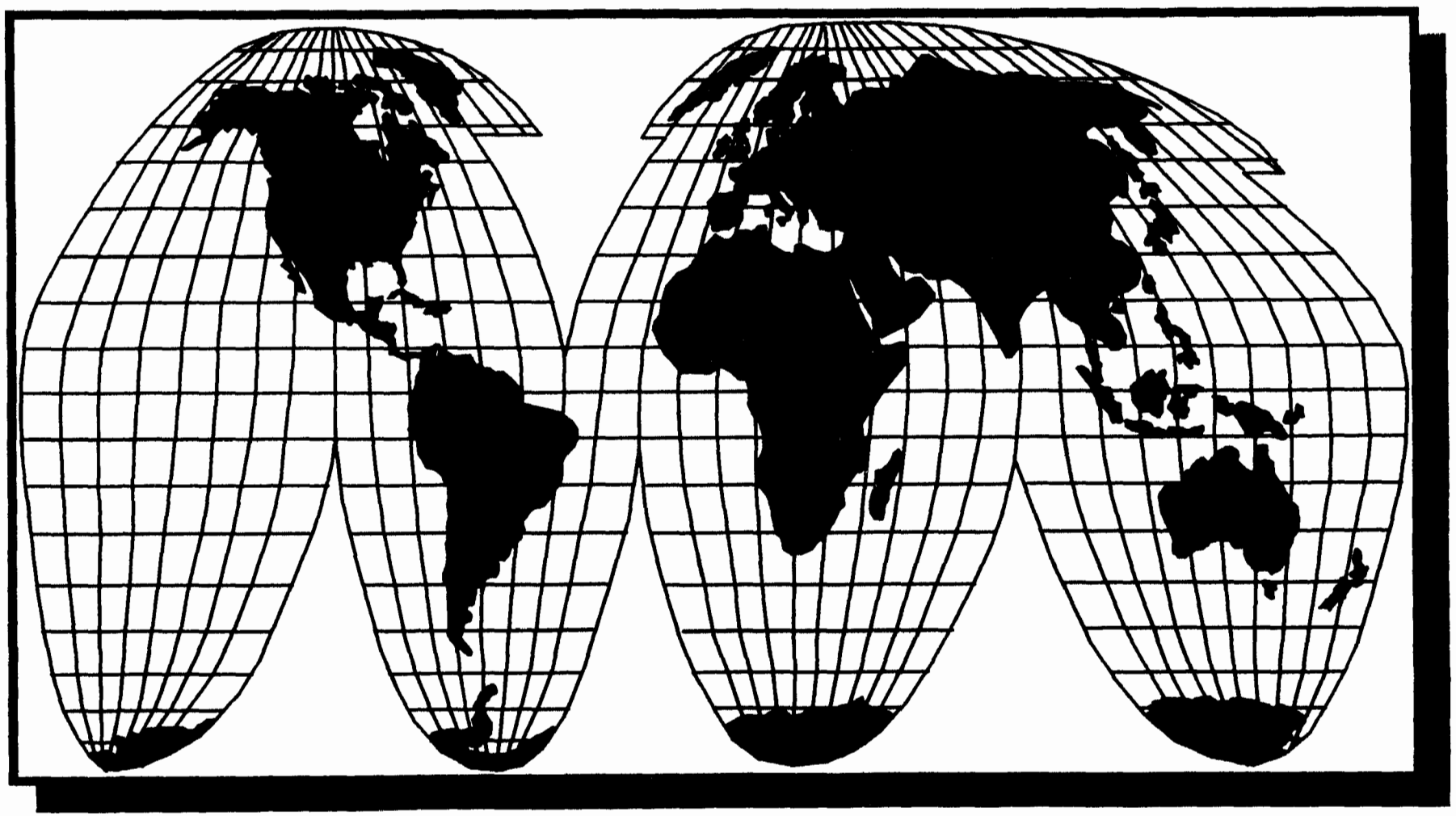
PA State Senate "Outstanding Environmental Achievement: Award 1992.

PA House of Representatives "Outstanding Environmental Achievement" Award 1992.

P&G "Outstanding Environmental Management System" Award 1993.

Baltimore County Bureau of Solid Waste Award for Recycling 1997

Procter and Gamble's Global Cosmetic's and Fragrance Division

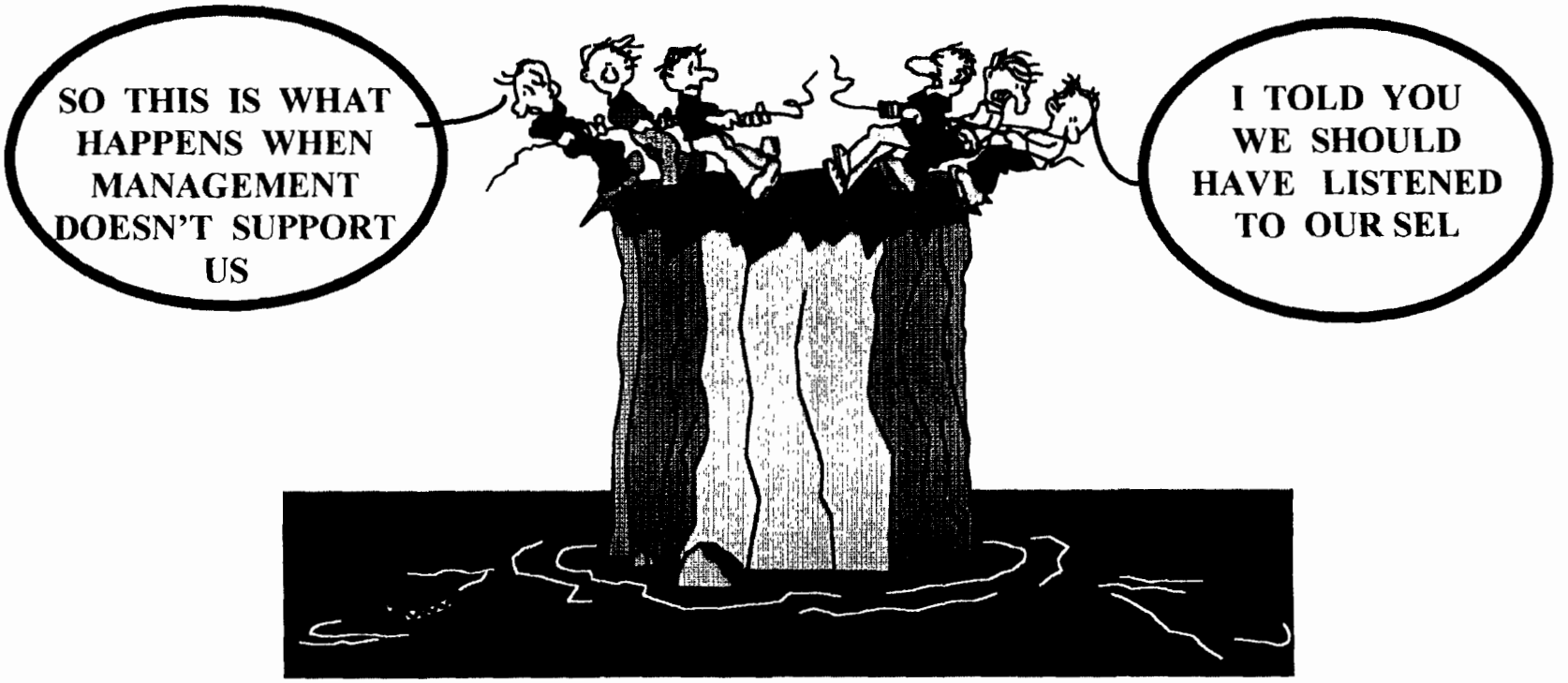


P & G's Global Environmental Policy

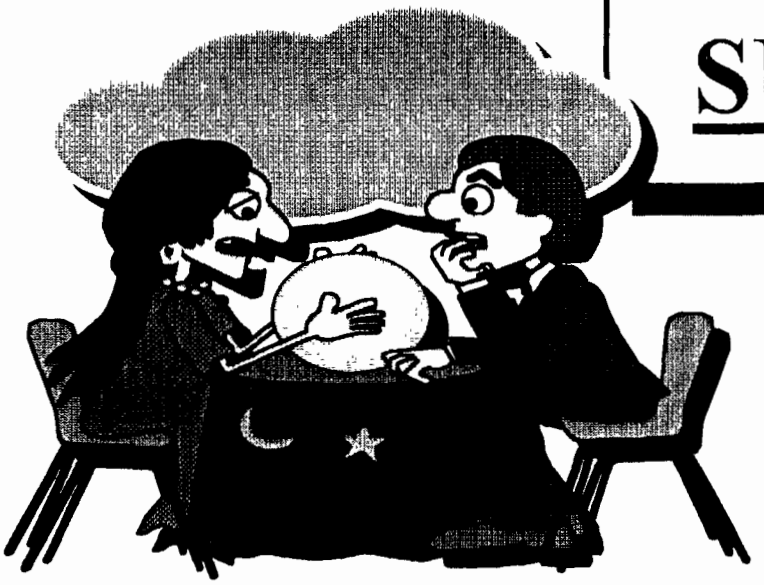
- Ensure our products, packaging and operations are safe for our employees, consumers and the environment.
- Reduce the environmental impact of our products and packaging in their design, manufacture, distribution, use and disposal whenever possible.
- Meet or exceed the requirements of all environmental laws and regulations.
- Continually assess our environmental technology and programs and monitor progress toward environmental goals.
- Provide our consumers, customers, employees, communities, public interest groups and others with relevant and appropriate factual information about the environmental quality of P&G products, packaging and operations.
- Ensure every employee understands and is responsible and accountable for incorporating environmental quality considerations in daily business activities.
- Have operating policies, programs and resources in place to implement our environmental quality policy.

WORK ITEM

CURRENT PROCESSES



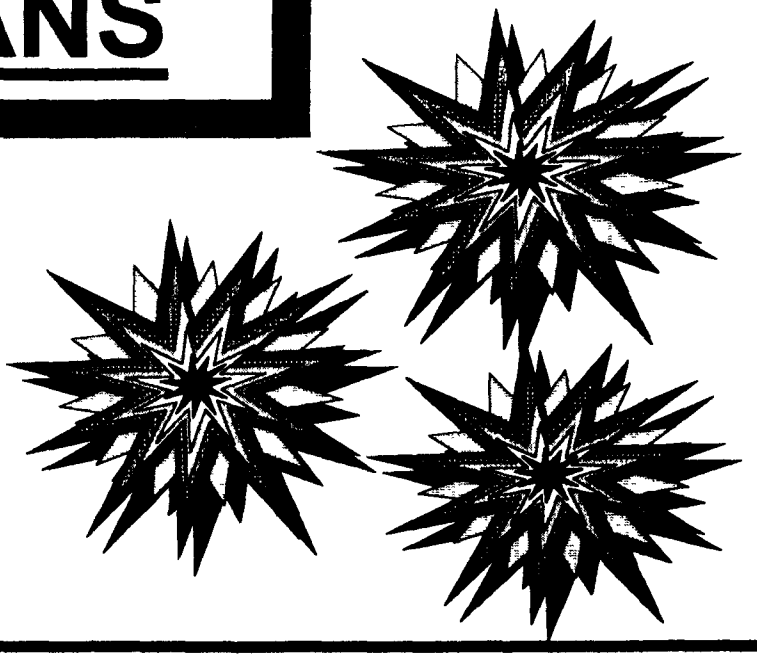
WASTE REDUCTION



SUCCESS CRITERIA

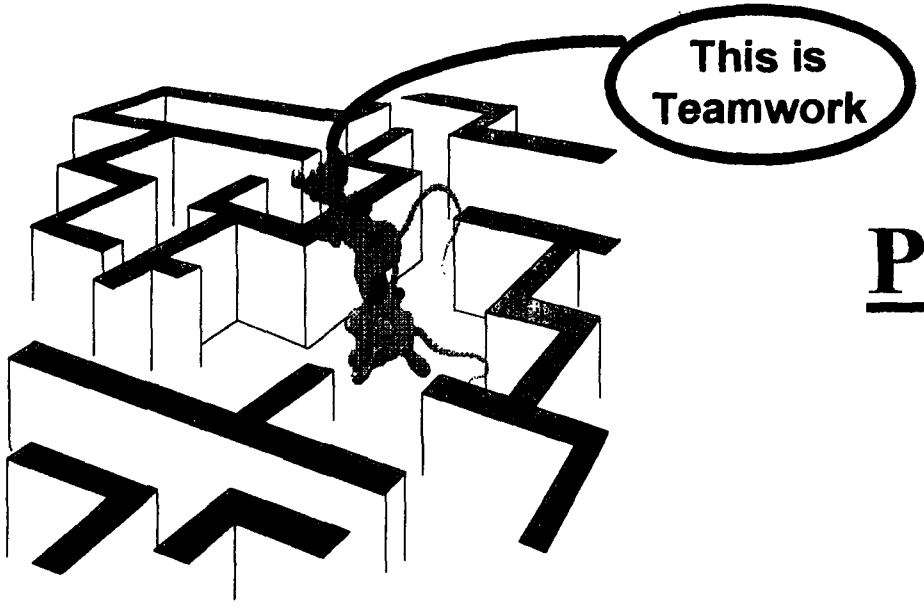
- REDUCE WASTE GENERATED FROM ALL MEDIA ON A POUND PER STAT BASIS
- REDUCE WASTE COST FROM ALL MEDIA ON A POUND PER STAT BASIS

ACTION PLANS



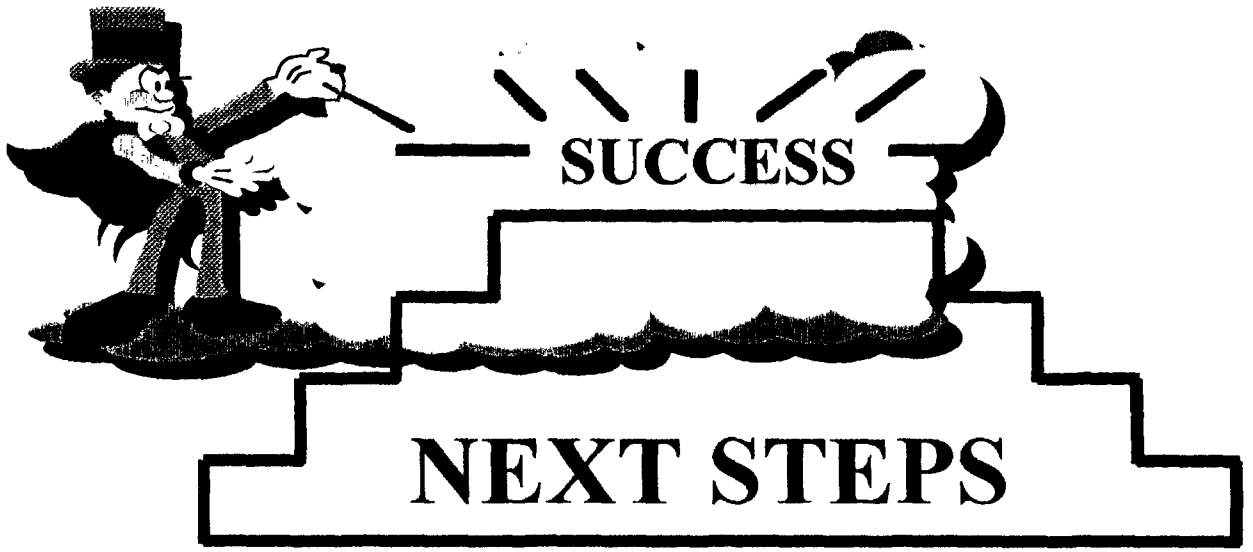
- EACH BUSINESS IN THE FACILITY SHOULD TARGET THEIR TOP THREE ITEMS TO WORK AGAINST, IN ORDER TO ACCOMPLISH SOURCE AND COST REDUCTION

- TAKE A COUPLE OF MINUTES TO THINK ABOUT WHAT THEY ARE, AND WRITE THEM DOWN



PROCESS TO FOLLOW

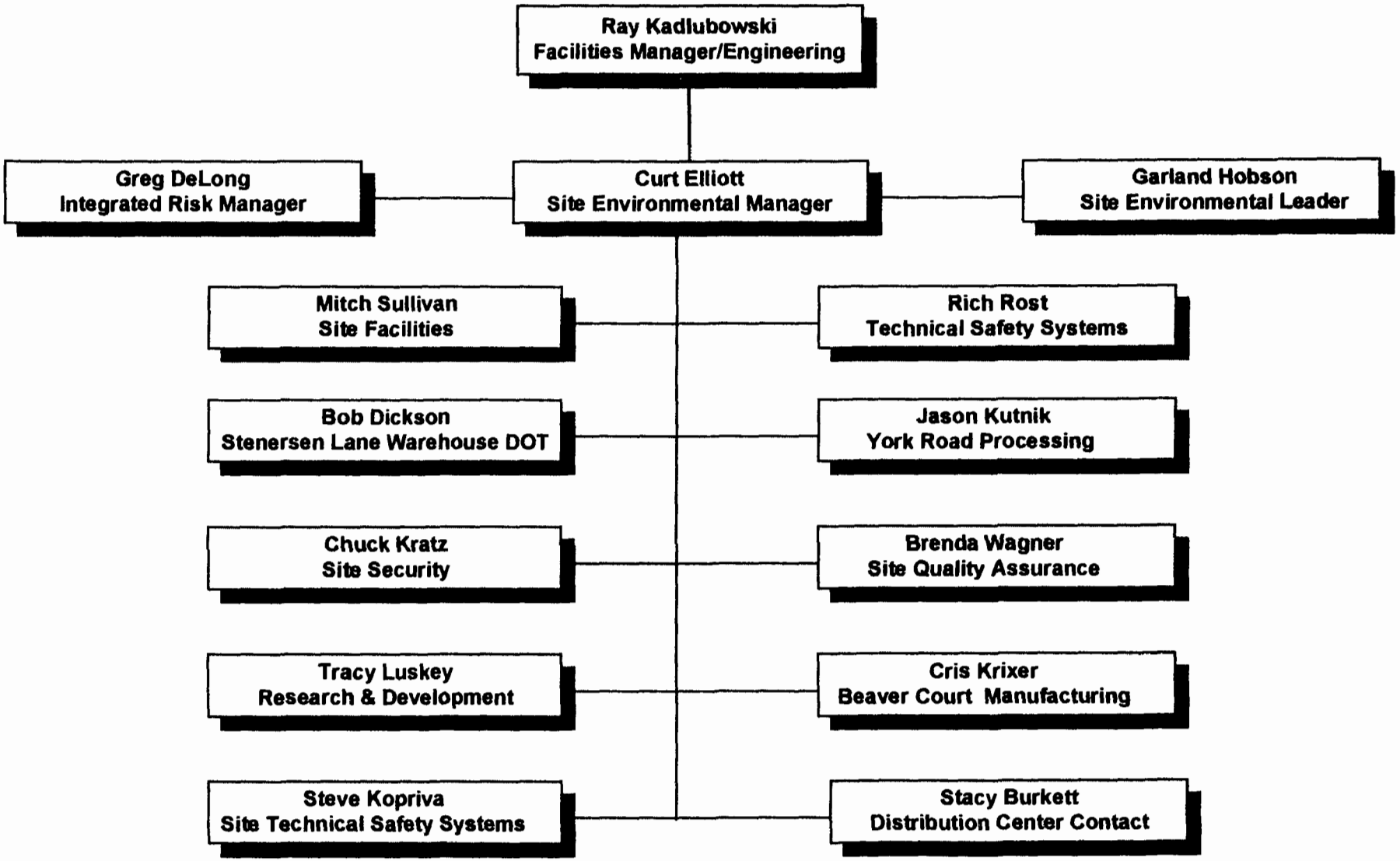
- DEVELOP A TOTAL QUALITY APPROACH - USING A TEAM COMPOSED OF ALL CONTRIBUTING DISCIPLINES IN ORDER TO ACHIEVE SUCCESS.
- TEAM SHOULD DEVELOP PLANS
- STRATEGIES AGAINST PLANS
- OBSTACLES TO ACHIEVING OBJECTIVES
- TRACK RESULTS AND COMMUNICATE THEM PLANT WIDE



NEXT STEPS

- DEVELOP A PLANT MINIMIZATION TEAM
- PICK 1, 2, OR 3 WORK ITEMS IDENTIFIED
- FORMALIZE AN ACTION PLAN
- DEVELOP STRATEGIES AGAINST PLAN
- CONSIDER OBSTACLES IN THE ACHIEVEMENT OF YOUR PLAN
- TRACK RESULTS AGAINST YOUR WORK ITEMS
- SHARE YOUR RESULTS PLANT WIDE

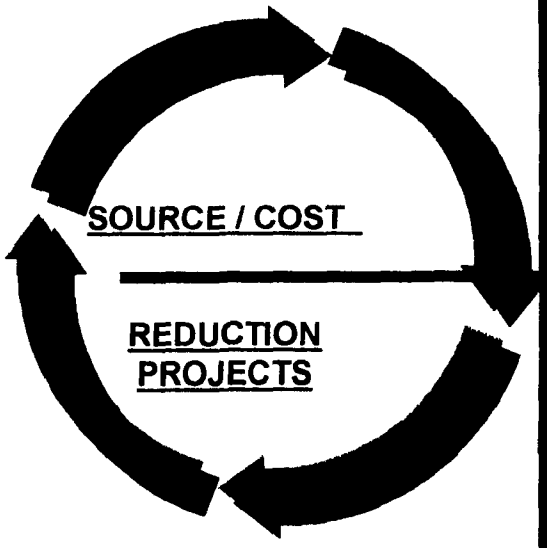
ENVIRONMENTAL CONTROL LEADERSHIP TEAM



HUNT VALLEY ECLT WORK PLAN FY 97/98

		ISSUE	ACTION PLAN	OWNER	DATE
PLANT	SYSTEM	ROBUSTNESS SOP 1501-1505	REVIEW ALL CURRENT ENV. CBA's	G. Hobson & ECLT	Continuous
			IDENTIFY ANY NEW CBA's NEEDED	G. Hobson & ECLT	Continuous
			CREATE AND UPDATE ALL ENV. PLANS	C. Elliott & G. Hobson	Continuous
			IMPROVE RECORD KEEPING SYSTEMS	C. Elliott & G. Hobson	12/97
	PLANT	TRAINING SOP 1502	EMPLOYEE TRAINING	ECLT	11/97
			TEMPORARY EMPLOYEE TRAINING	ECLT	9/97
			CONTRACTOR TRAINING	ECLT	12/97
ENVIRONMENTAL COMPLIANCE	COMPLIANCE	SOP 1501-1505	KEEP CURRENT - ALL REGULATIONS	C. Elliott & G. Hobson	Continuous
			MAINTAIN SITE ENV. CALENDAR	G. Hobson	1/98
			ALL REQUIRED REPORTS FILED ON TIME	C. Elliott	Continuous
	WASTE SOURCE	COST REDUCTION SOP 1505	IMPLEMENT WASTE TRACKING SYSTEMS	C. Elliott, G. Hobson & ECLT	11/97
			TRANSFER $$ OWNERSHIP TO GENERATOR	R. Kadlubowski	5/98
			SYSTEM FOR COST OF LOST MATERIAL	C. Elliott & Planner's	5/98
			SOURCE/ COST REDUCTION PROJECTS	G. Hobson & ECLT	Continuous

HUNT VALLEY SOURCE / COST REDUCTION PROJECTS



	SOURCE / COST REDUCTION KEY OPPORTUNITIES	% REDUCTION	POTENTIAL / ACTUAL $$ SAVED
WASTEWATER	VACUUM PUMP COOLING WATER	56%	ACTUAL $17.48 M
	AIR COMPRESSOR	8%	ACTUAL $2.5 M
	REDUCTION OF WET CIP's	77%	ACTUAL $0.6 M
REDUCTION IN VOLUME FROM 64 MM GAL TO 18 MM GAL IN ONE YEAR	AIR CONDITIONING COOLING	8%	ACTUAL $2.5 M
	BEAVER COURT PROJECTS	6%	ACTUAL $1.9 M
SOLID WASTE	CHANGE RECYCLE VENDORS	0%	POTENTIAL $ 6 M
	REDUCE THE # OF COMPACTOR PULLS	32%	POTENTIAL $ 13.8 M
	REPLACEMENT OF FIBER DRUM USE	18%	POTENTIAL $ 90.2 M
	REDUCTION OF HAZARDOUS WASTE	62%	ACTUAL $ 55.6 M
	SCRAP / OBSOLESCENCE		ACTUAL $1 MM
	BATCH YIELD IMPROVEMENTS	23%	ACTUAL $396.5 M
AIR	PRESENTLY NO PROJECTS IDENTIFIED		

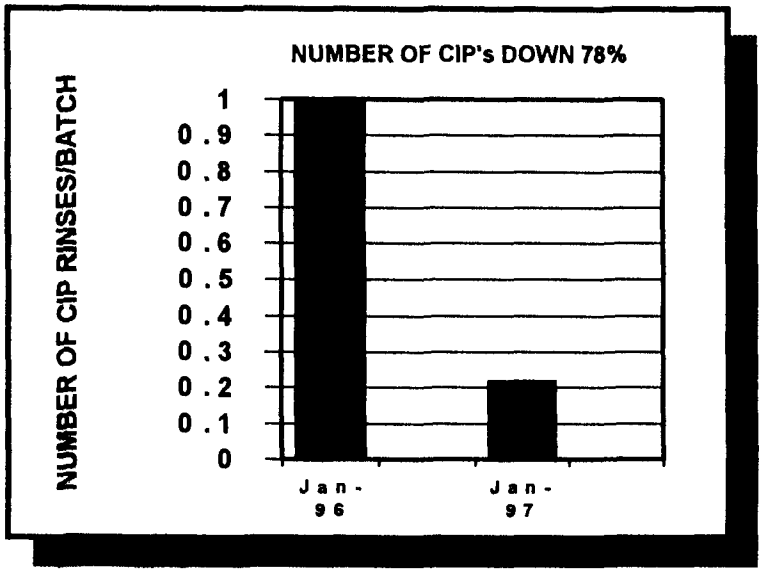
TOTAL ACTUAL SAVINGS = $1.48 MM

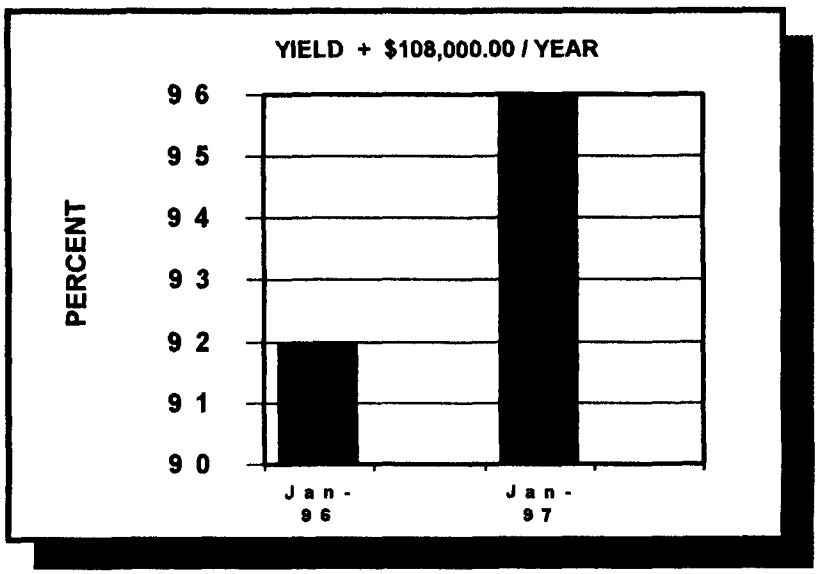
TOTAL POTENTIAL SAVINGS = $110 M

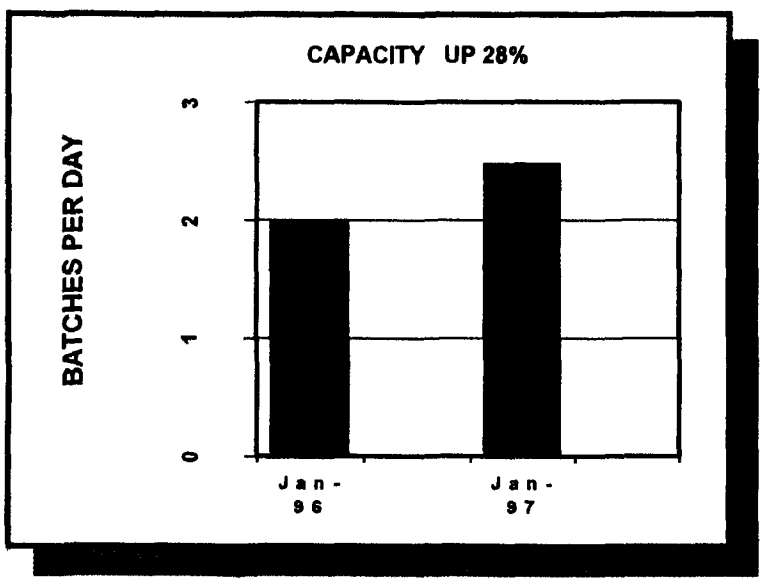
HUNT VALLEY WASTEWATER STRATEGY BUSINESS FOCUS

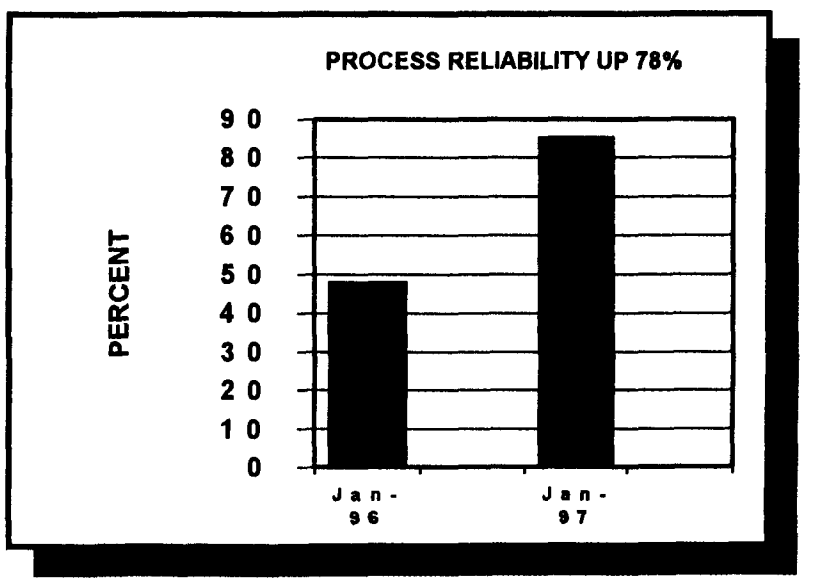
MODULE	AV. CIP/BATCH	STRATEGY
EYES	1.00	BREAKTHROUGH
LMU NORTH	1.00	BREAKTHROUGH
LMU SOUTH	1.00	BREAKTHROUGH
SKIN CREAM	0.04	CONTROL & MAINTAIN
LIPS	N/A	CONTROL & MAINTAIN

MASCARA

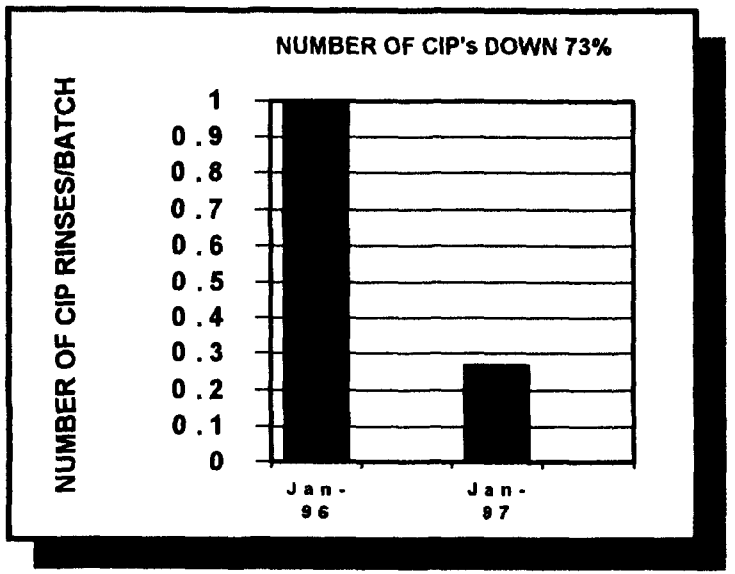

NUMBER OF CIP's DOWN 78%
NUMBER OF CIP RINSES/BATCH
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan-96
Jan-97

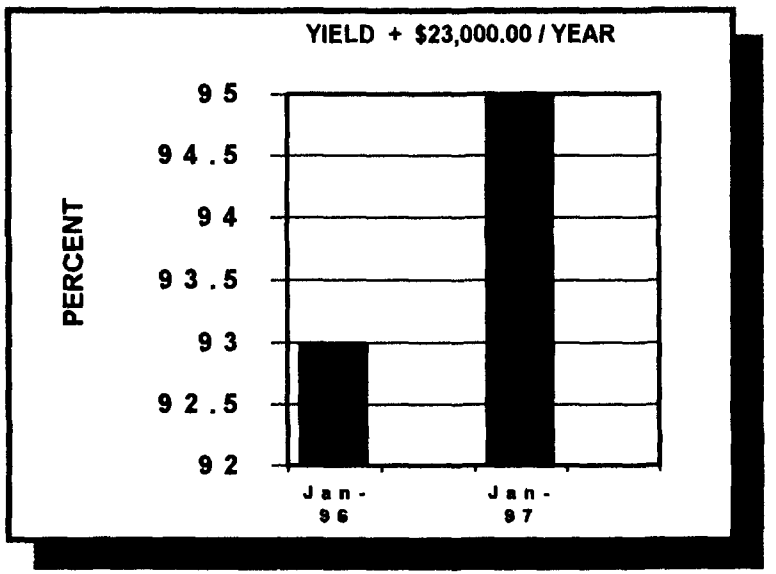

YIELD + $108,000.00 / YEAR
PERCENT
96
95
94
93
92
91
90
Jan-96
Jan-97

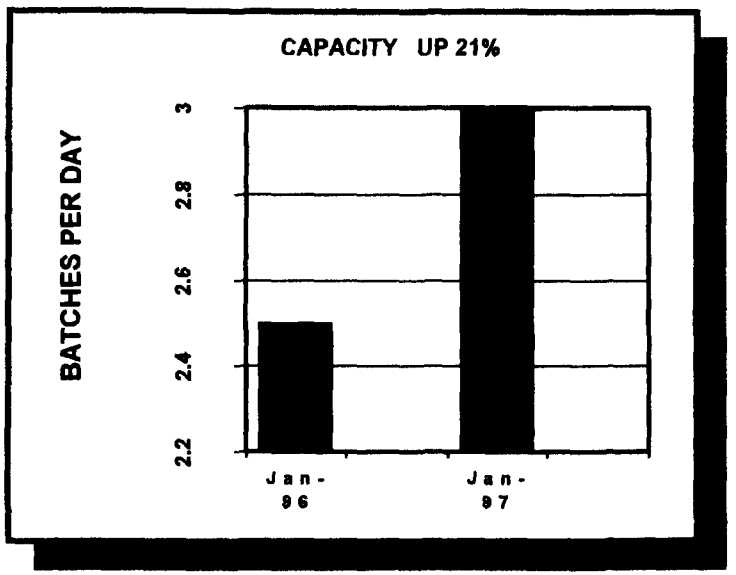

CAPACITY UP 28%
BATCHES PER DAY
3
2
1
0
Jan-96
Jan-97

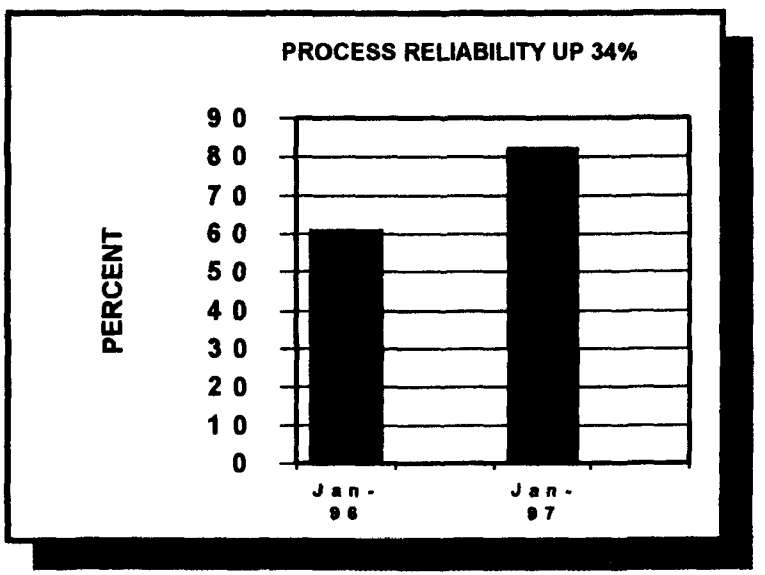

PROCESS RELIABILITY UP 78%
PERCENT
90
80
70
60
50
40
30
20
10
0
Jan-96
Jan-97

NORTH LMU

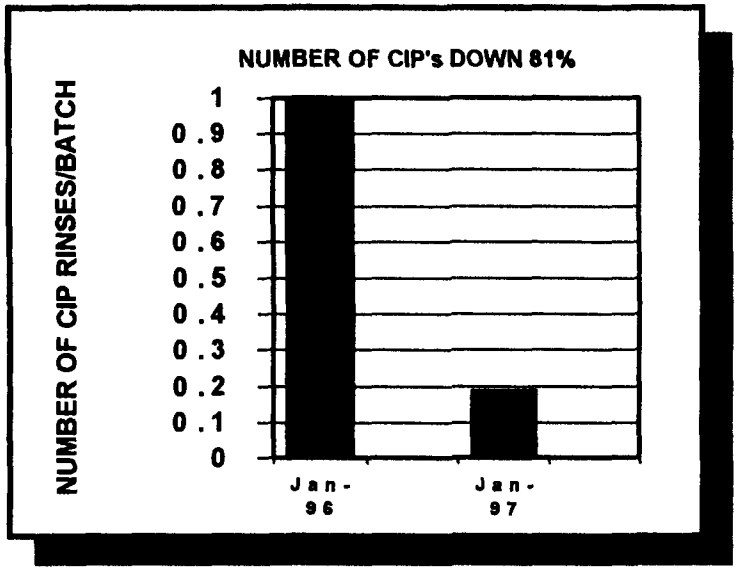

NUMBER OF CIP's DOWN 73%
NUMBER OF CIP RINSES/BATCH
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan-96
Jan-97

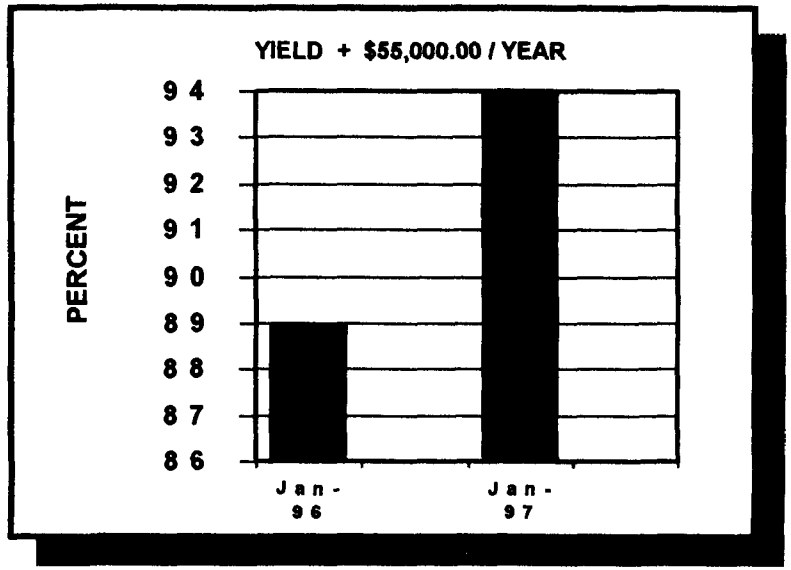

YIELD + $23,000.00 / YEAR
PERCENT
95
94.5
94
93.5
93
92.5
92
Jan-96
Jan-97

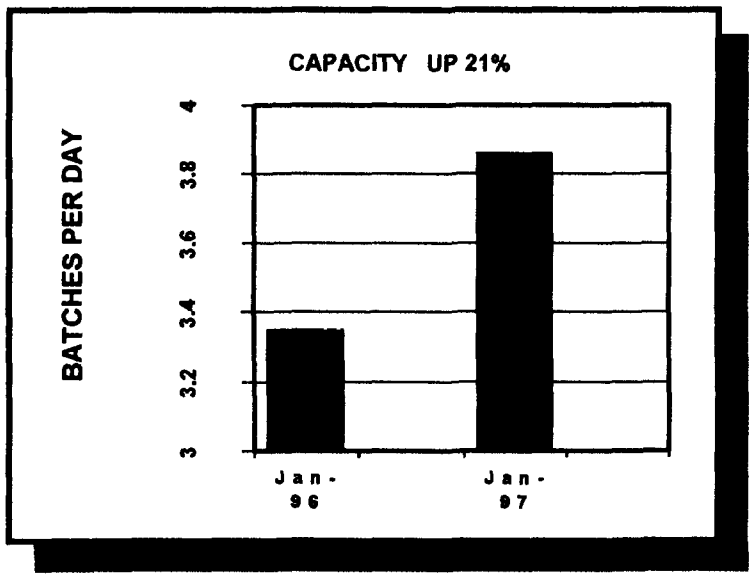

CAPACITY UP 21%
BATCHES PER DAY
3
2.8
2.6
2.4
2.2
Jan-96
Jan-97

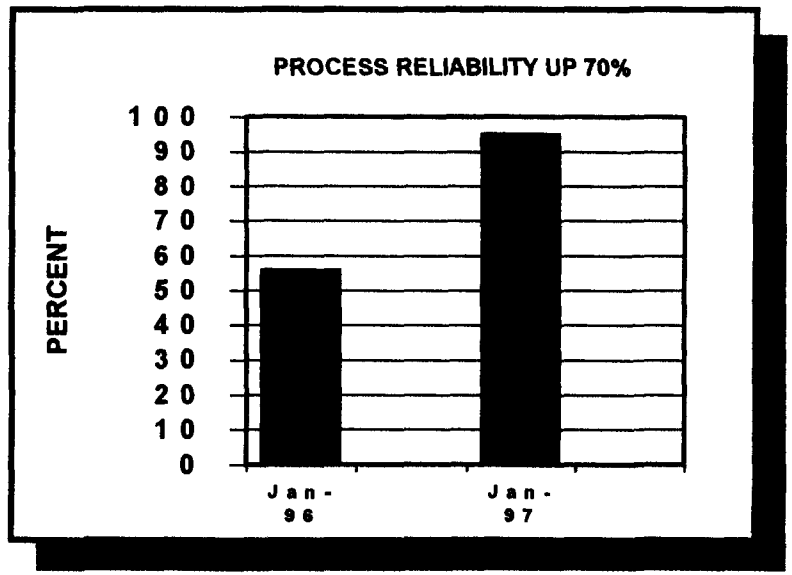

PROCESS RELIABILITY UP 34%
PERCENT
90
80
70
60
50
40
30
20
10
0
Jan-96
Jan-97

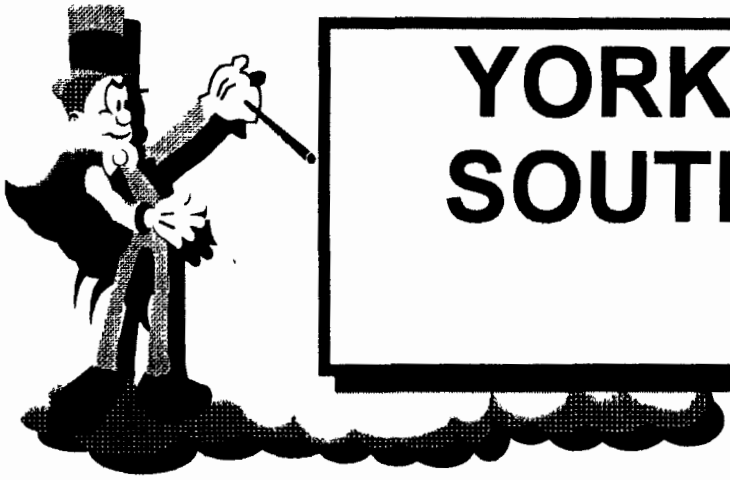
SOUTH LMU


NUMBER OF CIP's DOWN 81%
NUMBER OF CIP RINSES/BATCH
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan-96
Jan-97


YIELD + $55,000.00 / YEAR
PERCENT
94
93
92
91
90
89
88
87
86
Jan-96
Jan-97


CAPACITY UP 21%
BATCHES PER DAY
4
3.8
3.6
3.4
3.2
3
Jan-96
Jan-97

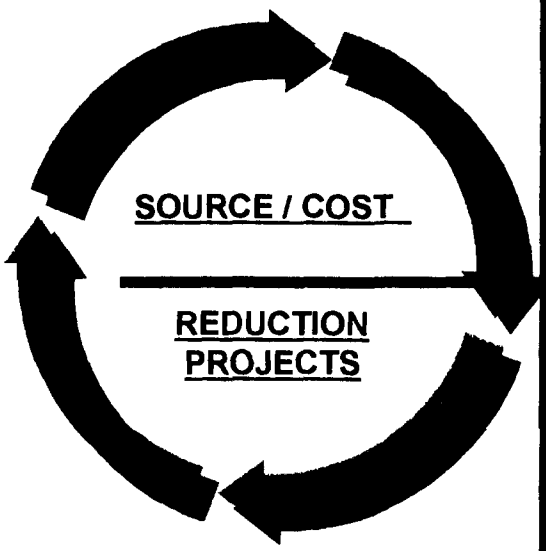

PROCESS RELIABILITY UP 70%
PERCENT
100
90
80
70
60
50
40
30
20
10
0
Jan-96
Jan-97



YORK ROAD LMU NORTH & SOUTH WASTE REDUCTION SUMMARY

• Product yield improvement	$	78,000.00 / year
• Detergent & Sanitizer savings	$	28,000.00 / year
• Waste cost avoidance	$	3,900.00 / year
• Water & Energy savings	$	3,071.00 / year
TOTAL SAVINGS	$	112,791.00 / year
• CAPITAL COST AVOIDANCE	$	1,200,000.00 / year
• AVERAGE CAPACITY INCREASE		21%
• AVERAGE CIP REDUCTIONS		77 %
• AVERAGE PROCESS RELIABILITY INCREASE		52%

HUNT VALLEY SOURCE / COST REDUCTION PROJECTS



	SOURCE / COST REDUCTION KEY OPPORTUNITIES	% REDUCTION	POTENTIAL / ACTUAL $$ SAVED
WASTEWATER	VACUUM PUMP COOLING WATER	56%	ACTUAL $17.48 M
	AIR COMPRESSOR	8%	ACTUAL $2.5 M
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REDUCTION IN VOLUME FROM 64 MM GAL TO 18 MM GAL IN ONE YEAR	AIR CONDITIONING COOLING	8%	ACTUAL $2.5 M
	BEAVER COURT PROJECTS	6%	ACTUAL $1.9 M
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	REDUCE THE # OF COMPACTOR PULLS	32%	POTENTIAL $ 13.8 M
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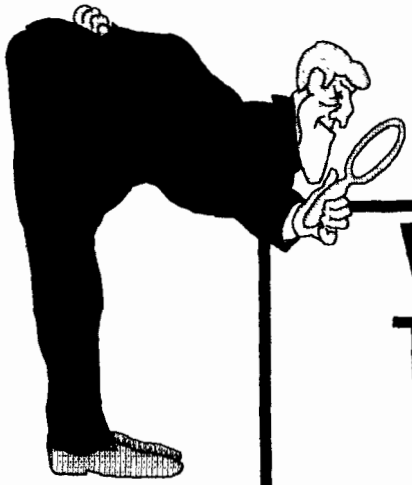
AIR	PRESENTLY NO PROJECTS IDENTIFIED		

TOTAL ACTUAL SAVINGS = $1.48 MM

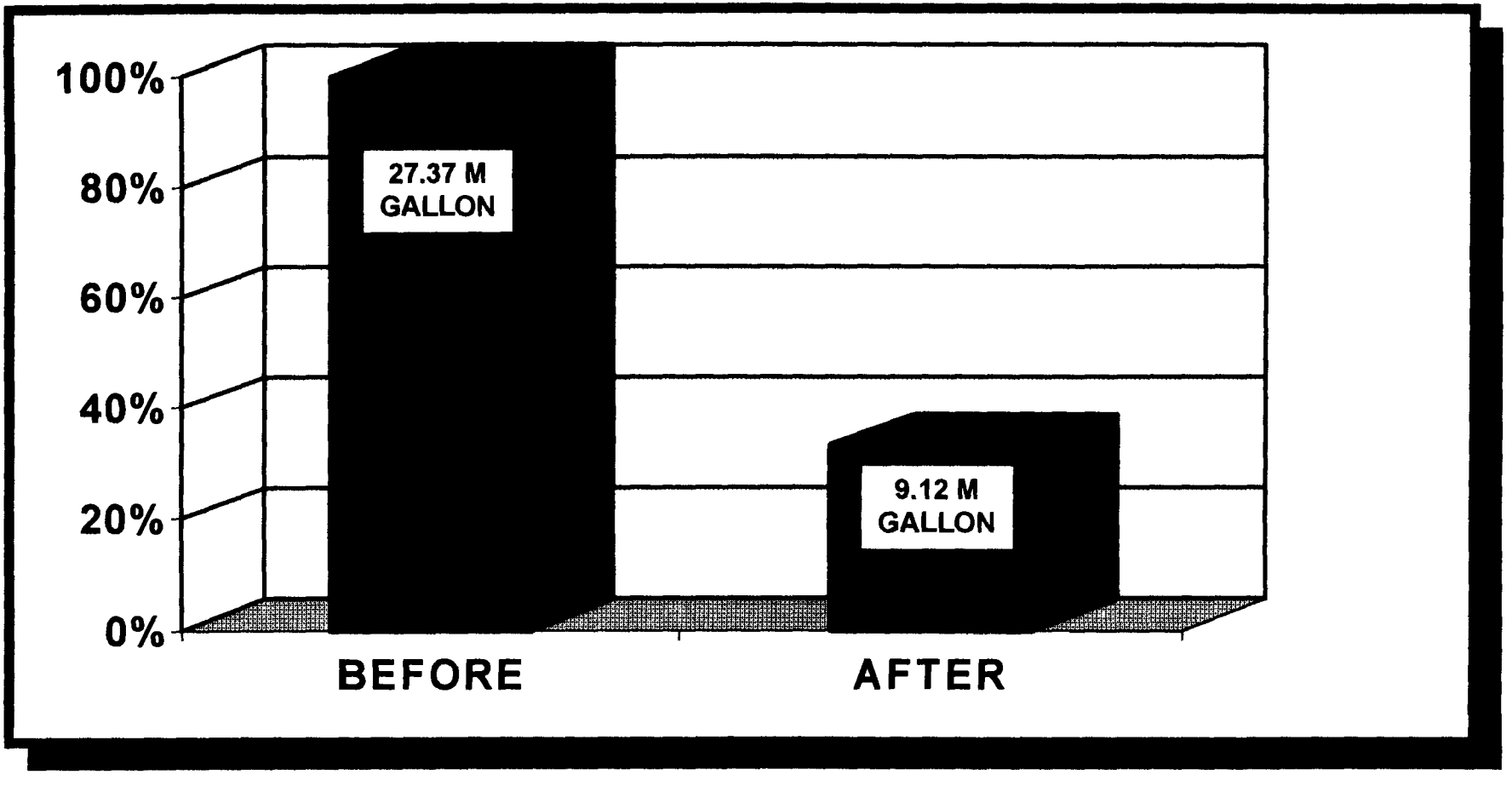
TOTAL POTENTIAL SAVINGS = $110 M



WORK ITEMS IDENTIFIED TO REDUCE HAZARDOUS WASTE

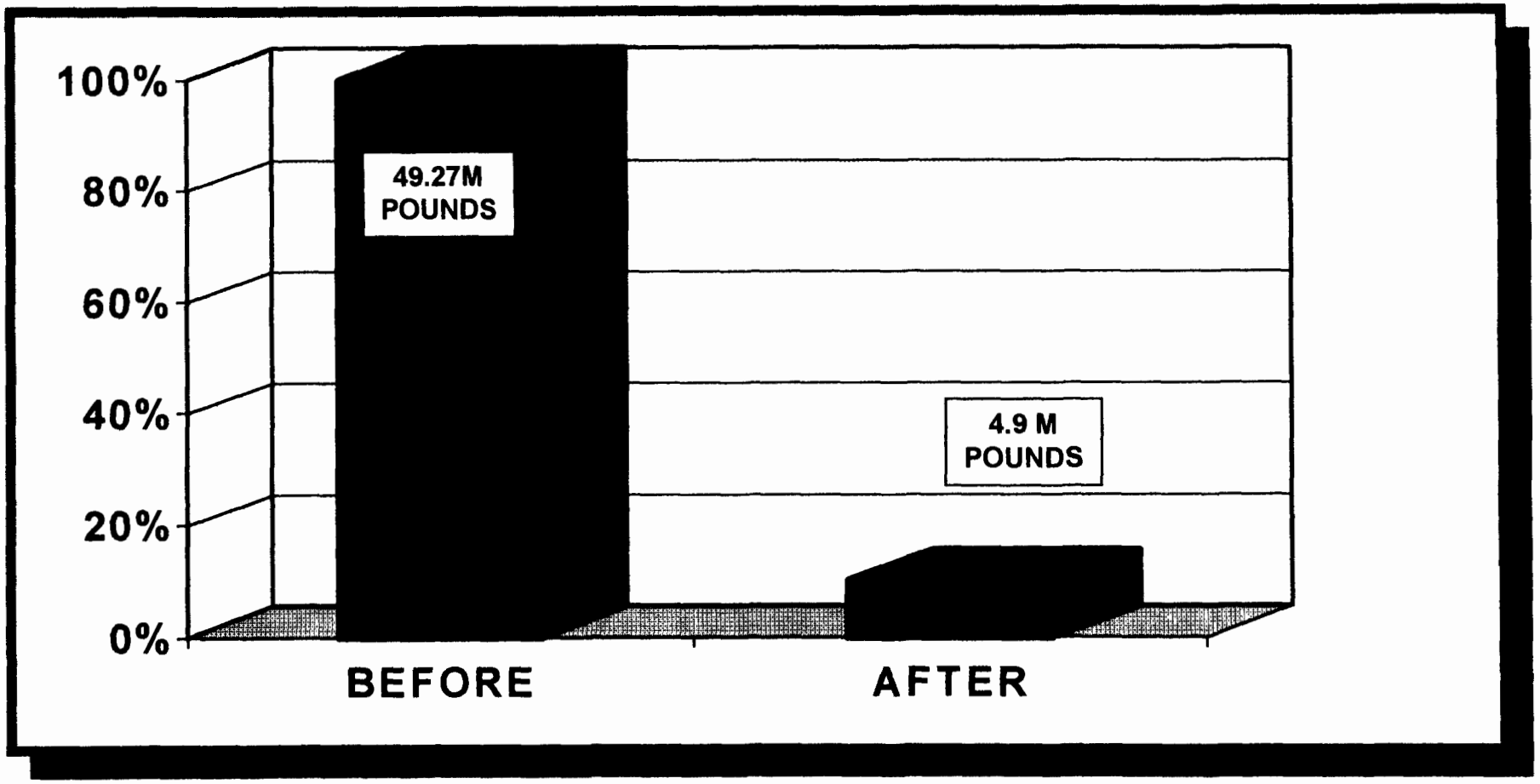
- EQUIPMENT REPLACEMENT
- EQUIPMENT MODIFICATION (CENTERLINING)
- QUALITY VERIFICATION AND CERTIFICATION (QVC)
- EMPLOYEE TRAINING AND CERTIFICATION
- CONTINUOUS IMPROVEMENT

LINE 76 ACETONE WASTE
33% REDUCTION
HAZARDOUS WASTE GENERATION



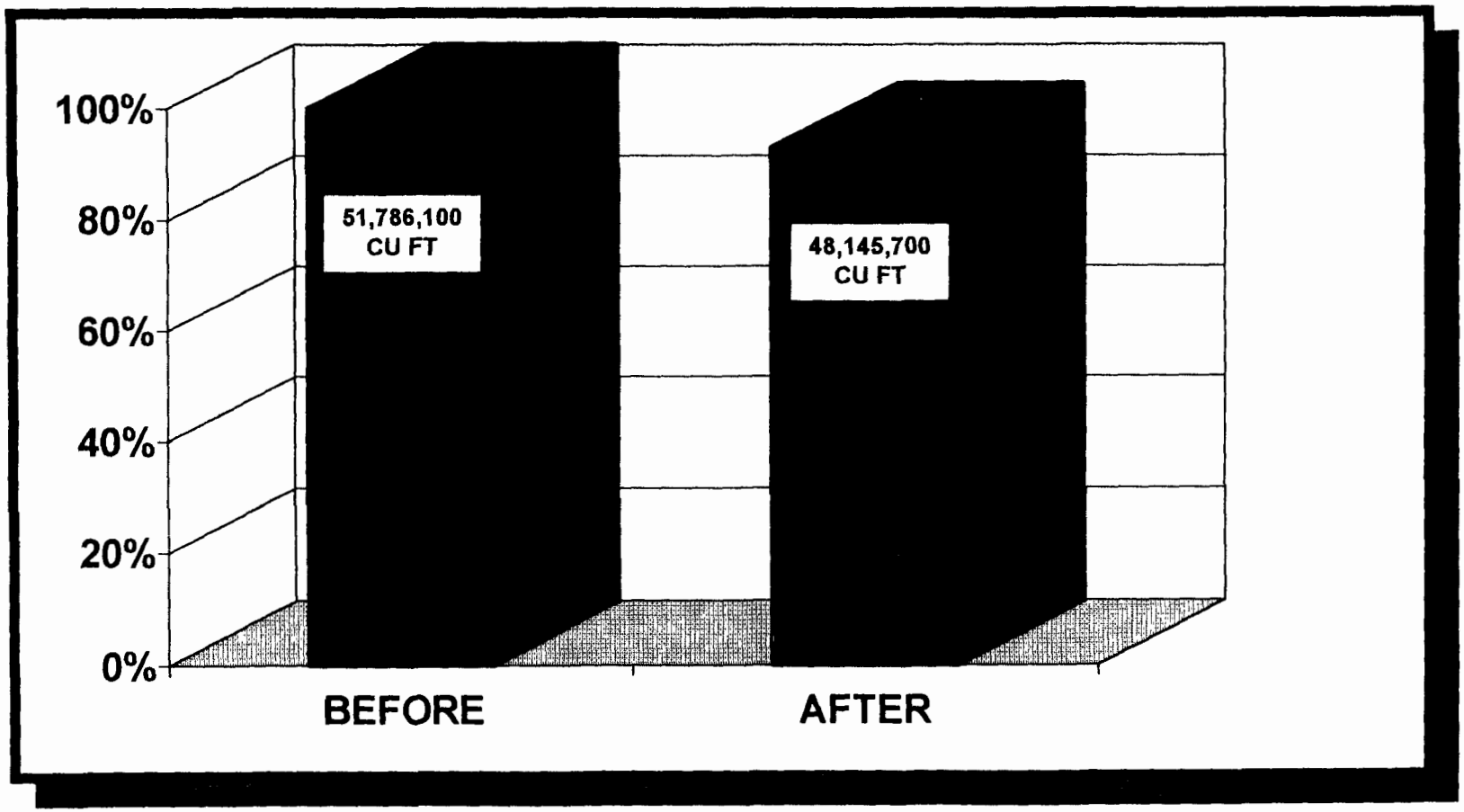
COST WENT FROM $34,219.00 TO $11,406.00 SAVINGS OF $22,813.00

LINE 76 NAIL POLISH SOLIDS
90% REDUCTION
HAZARDOUS WASTE GENERATION



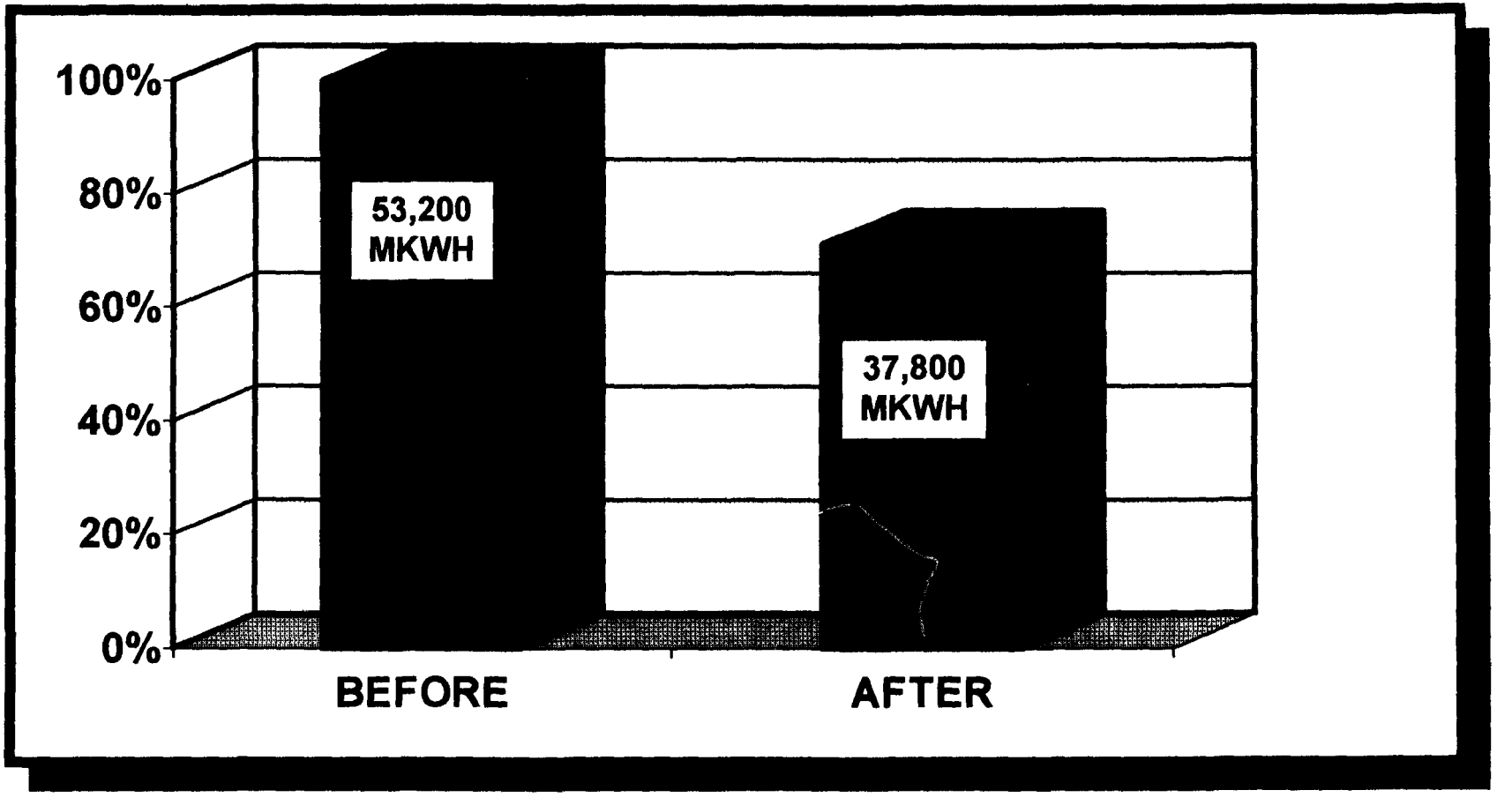
COST WENT FROM $36,464.00 TO $ 3,646.00 SAVINGS OF $32,818.00

NATURAL GAS CONSERVATION
7% REDUCTION IN
NATURAL GAS CONSUMPTION



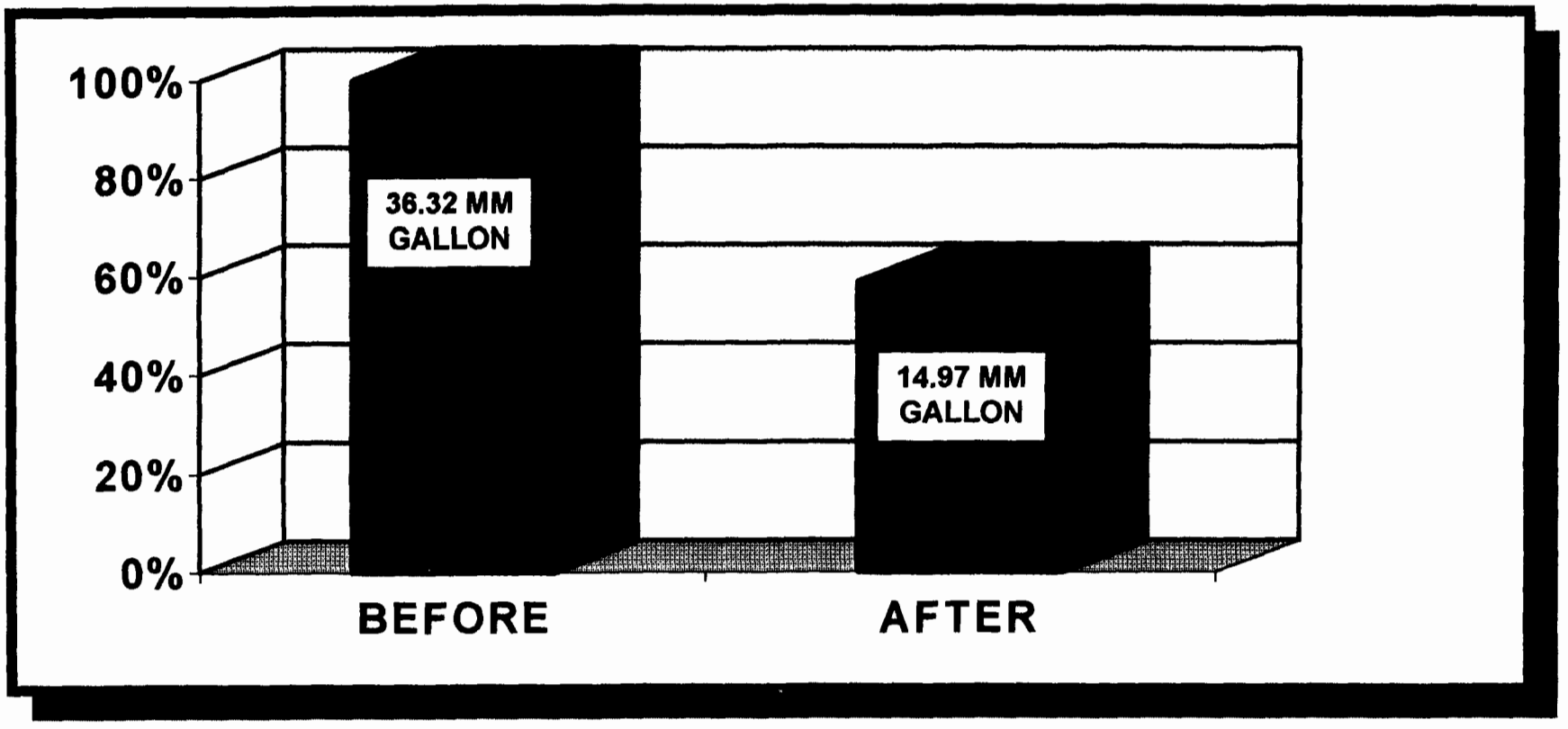
PRODUCTION INCREASED BY 14%

ENERGY CONSERVATION
29% REDUCTION
ELECTRICAL CONSUMPTION



PRODUCTION INCREASED BY 14%

WATER CONSERVATION
41% REDUCTION
WATER CONSUMPTION



PRODUCTION INCREASED BY 14%

Sylvia Ewing

Center for Neighborhood Technology

"Building Partnerships for P2 in the Fabricare Industry"

Syvia Ewing

Sylvia Ewing is Pollution Prevention Manager for the Center for Neighborhood Technology. She leads the Alternative Clothes Cleaning Demonstration Project. Sylvia works with the fabricare industry, the environmental community, and other stakeholders to reduce the use of the solvent perchloroethylene. Perc has been associated with health and environmental problems and is subject to growing liability concerns.

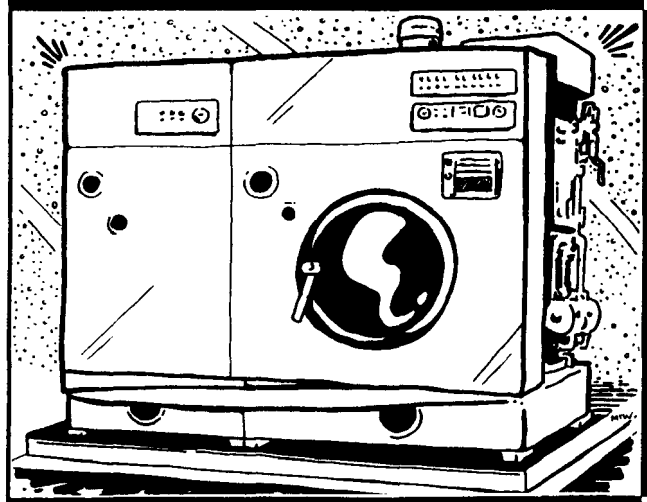
Sylvia is the Editor of Wetcleaning Update a small newsletter with an international audience. Sylvia produced 2 videos on wetcleaning and conducts wetcleaning training workshops around the country.

CNT is a non-profit, research, and technical assistance organization ,with a focus on environmental efficiency, and economic development. Sylvia's program continues the CNT tradition of working to find practical solutions, to environmental problems.

Building Partnerships for Pollution Prevention in the Fabricare Industry

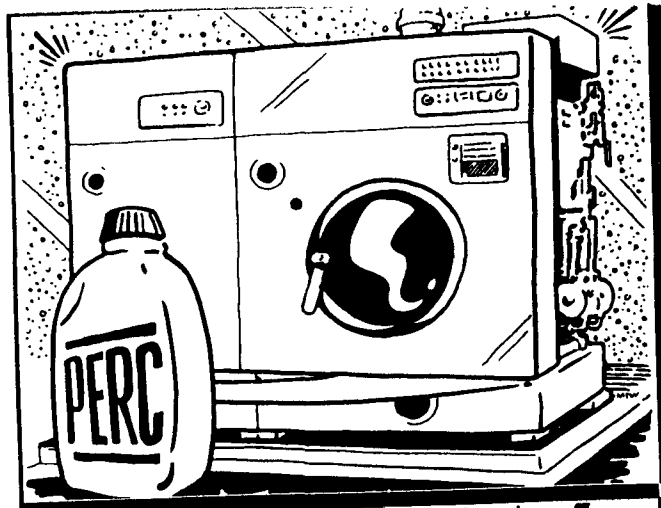
Sylvia Ewing

The cost of disposing of perc-contaminated wastes has already doubled in the last five years and will continue to grow.



The U.S. EPA estimates that newly-mandated pollution-control equipment will cost a typical dry cleaner $6,700 for the initial capital investment, and an additional $1,000 per year to operate.

Potential liability and cleanup costs for perc-contaminated soil and ground-water threaten many dry cleaners with bankruptcy and make it increasingly difficult for them to access capital.

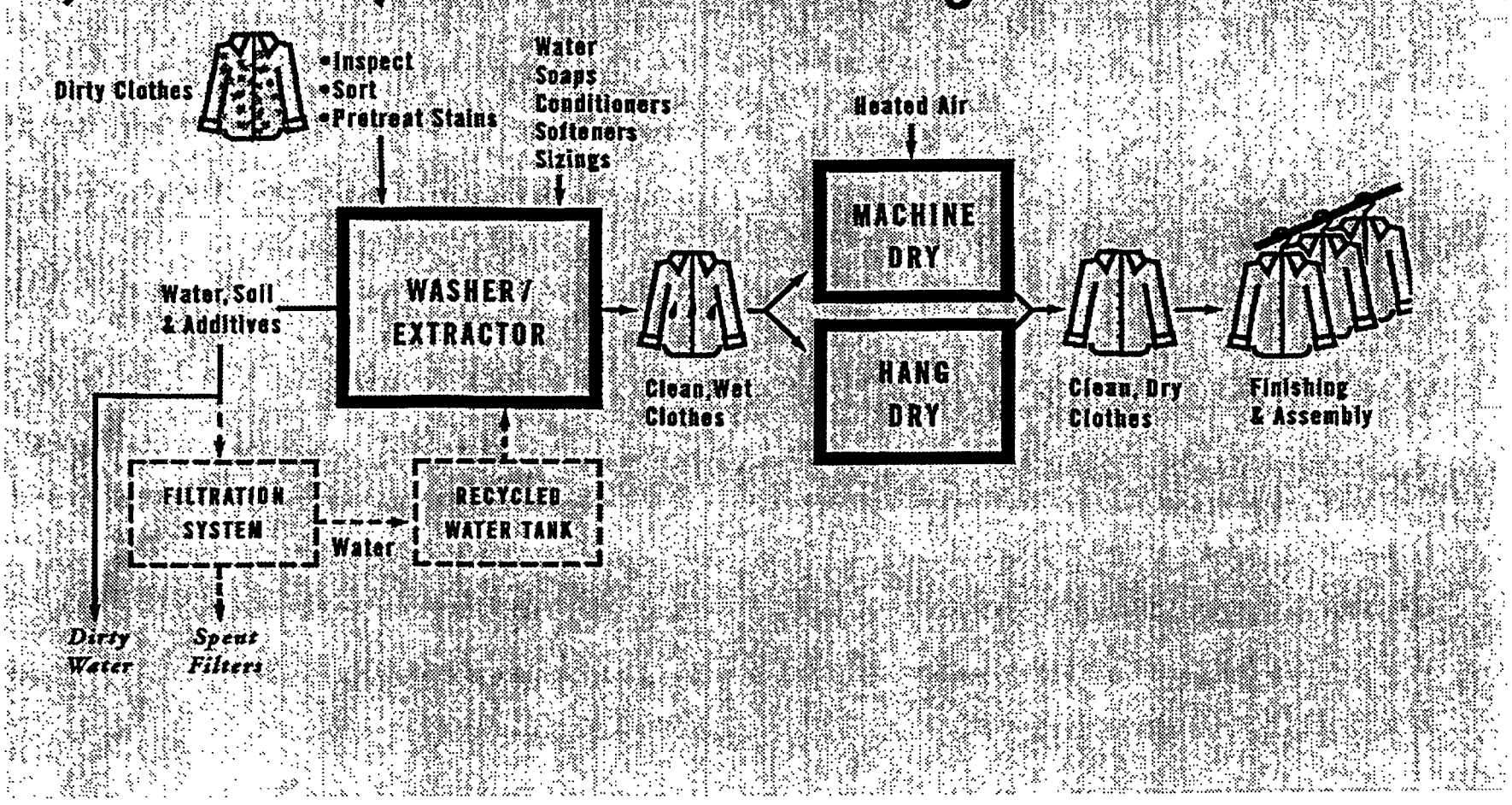


Dry cleaning isn't actually dry. Your clothes are put into a washing machine filled with chemical solvents. And even dry cleaners must use water to remove water-based stains like sweat.

Perc enters the air of nearby businesses and homes, as well as soil and groundwater. Due to soil contamination, at least 25 percent of dry cleaning plants pose a threat to public health, according to a recent article in Drycleaners News.

For days afterwards, your newly cleaned clothes will release perc into the air of your car, office and home. The EPA says that about 100 million people are exposed to perc this way each year.

Figure 6.1 Garment Wet Cleaning Process Flow Diagram



What is Professional Wetcleaning?

Wetcleaning is an increasingly popular service offered by professional cleaners to care for your special clothes. It is an important option which allows solvent-free garment care.

Your cleaner has the specialized equipment, skills and training to safely clean in water those garments previously cleaned in chemical solvents.

	Benefits	**Concerns**
Effect on Clothes	No chemical smell. Whiter whites. Easier to remove water based stains. Some items come out cleaner.	Can shrink some garments. Can cause color change. More difficult to remove grease based stains.
Environmental Effects	No hazardous chemical use. No air pollution. No water or soil contamination.	Increased water use.
Cost	A larger portion of the cost of cleaning your clothes goes to pay workers rather than to chemical production and hazardous waste disposal.	Your cleaner may charge more for some items to cover the increased labor in pressing and finishing.
Examples of Appropriate Types of Clothes	Cotton. Wool. Silk. Leather/suede. Wedding gowns. Highly decorated beads and sequins.	Some acetate linings. Antique satin. Gabardine. Some highly structured (tailored) garments.
Availability	All cleaners have the capacity to wetclean some items with their existing equipment and skills. Around the country there are a growing number of wetcleaning shops with specialized equipment and trained personnel.	Today's wet cleaning takes more knowledge of fibers and fabrics, and often requires specialized equipment that the average cleaner may not have yet.

Wet Cleaning Fact Sheet #2
Produced by:
Center for Neighborhood Technology
773/278-4800 ext. 299
www.cnt.org/wetcleaning

Wetcleaning Information Request Form

Center for Neighborhood Technology ● 2125 W. North Ave. ● Chicago, IL 60647
773/278-4800 ext. 299 ● 773/278-3840 fax ● http://www.cnt.org/wetcleaning

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Please Send Me the Following:

[ ]	NEW! *Today's Wet Cleaning* Video	($8 each)	_____ Copies
[ ]	*Wet Cleaning: The Wave of The Future* Video	($10 each)	_____ Copies
[ ]	Final Report of Findings from the Greener Cleaner	($15 each)	_____ Copies

Save on shipping and handling charges. Get all three for $25.
[Please make check payable to: CNT. Call for Credit Card Purchasing Information]

Free CNT Publications:

[ ] Executive Summary of the Findings from the Greener Cleaner
[ ] Wet Cleaning Equipment Report (Also available in Korean and Spanish)
[ ] Professional Wet Cleaning Partnership Agreement
[ ] Back issues of *Wet Cleaning Update* Newsletter

Other Free Wet Cleaning Information:

[ ] EPA Fact Sheet on Perchloroethylene
[ ] Report/Fact Sheet from Massachusetts demo shop
(Produced by CNT Partner, Toxics Use Reduction Institute, Lowell, Mass.)
[ ] Executive Summary of the UCLA Wet Cleaning Project in Santa Monica, California

---

[ ] Please put me on your wet cleaning mailing list.
(We will send you *Wet Cleaning Update*, and inform you about wet cleaning events in your area.)

Name: _____

Title: _____

Business/Organization: _____

Address: _____

City/State/Zip Code: _____

Telephone: _____

Fax: _____

E-mail: _____

Robert T. Fallon

Eli Lilly and Company

"Case Study: Alternatives to Solvents in Bulk Pharmaceutical Equipment Cleaning P2 Opportunities in Cleaning"

Biography:

Robert T. Fallon is an Engineering Consultant for Eli Lilly and Company. He holds a BS in Chemical Engineering from Tri-Sate University. He has been with Lilly for 20 years holding various management positions in Bulk Pharmaceutical Manufacturing, Engineering, Environmental Compliance and Operations, and Industrial Health and Safety at Lilly facilities in Lafayette, Indiana, Mayaguez, Puerto Rico and Carolina, Puerto Rico. In 1996, He initiated an engineering Cleaning Technology Center with primary focus on development of bulk pharmaceutical cleaning technologies and methods for implementation across worldwide Lilly manufacturing facilities.

Case Study:

Alternatives to Solvents in Bulk Pharmaceutical Equipment Cleaning

Pollution Prevention Opportunities in Cleaning

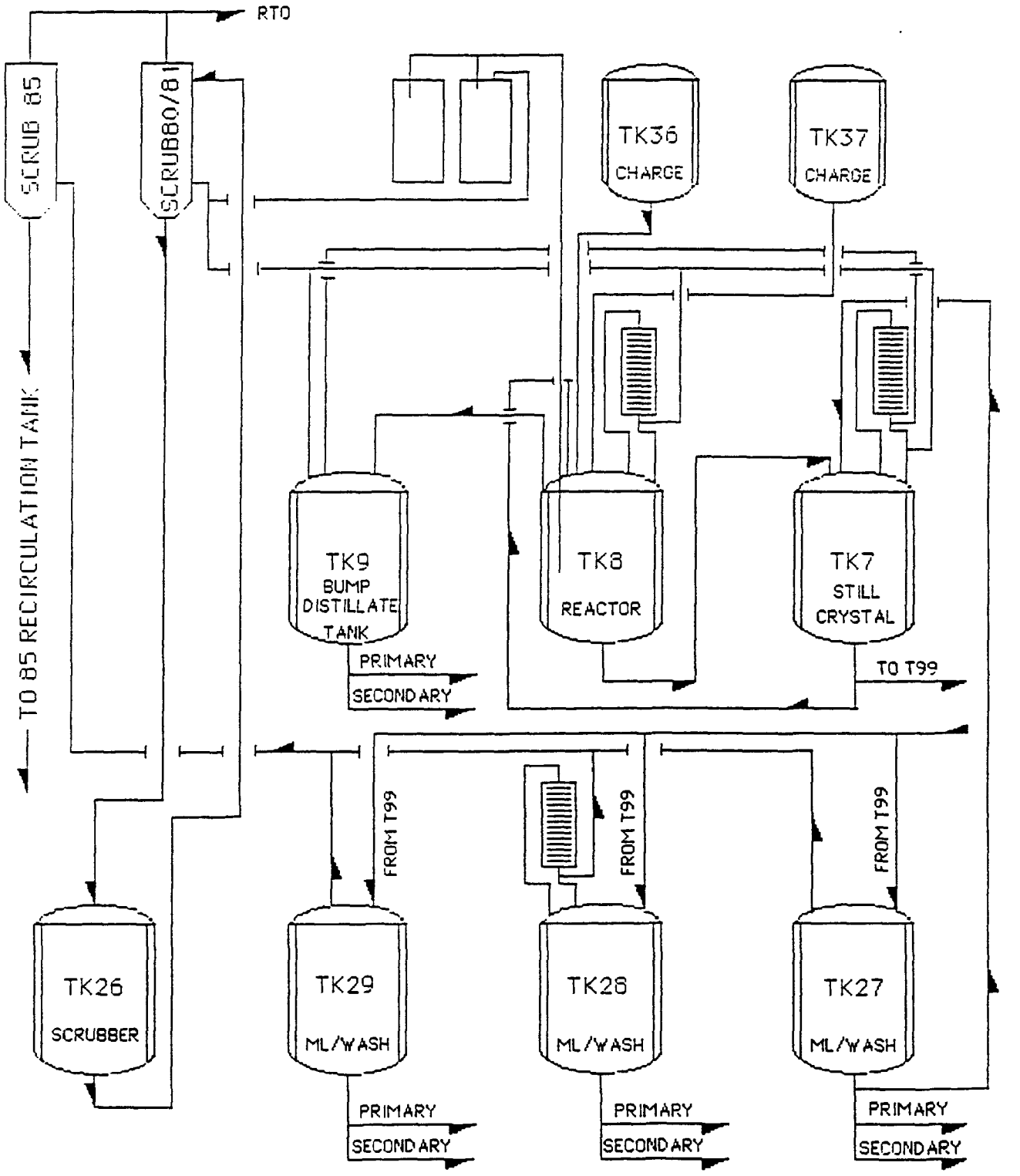
Pharmaceutical Cleaning Objective

- **Primary Objective:**
  - ***Protect the Safety and Efficacy of Any Product Subsequently Manufactured in the Cleaned Equipment.***

- **Secondary Objectives:**
  - ***Minimize Personnel Exposure***
  - ***Minimize waste generation***
  - ***Productivity***
  - ***Extension of Equipment Life***

Typical Equipment Flow

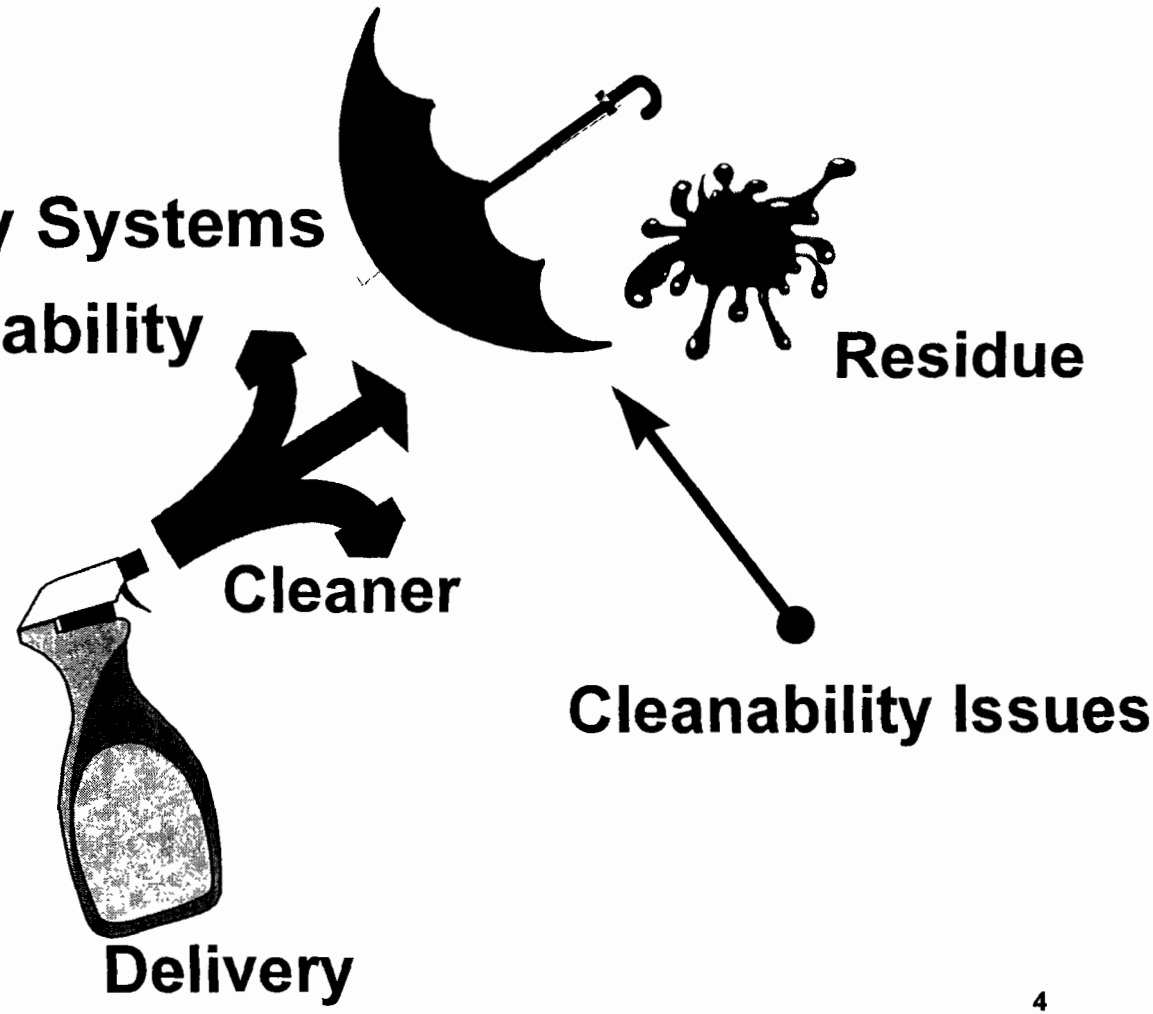
- 9 1000 - 4000 gallon glass tanks
- 70 valves, 3 pumps, 2 scrubbers
- 1100 feet TFE/SS piping
- Centrifuge, dryer, mill



The Cleaning Process

Evaluate every aspect for pollution prevention opportunities:

- Cleaning Agents
- Cleaning Delivery Systems
- Equipment Cleanability
- Cleaning Flow
- Analytical Methods
- Data Management



Typical Bulk Pharmaceutical Cleaning Agent Use

- 70 % solvent cleaner
- 30 % water based cleaner

Cleaning Agents

Goal: ***Identify Cleaning Agents That Maximize Removal Mechanisms for a Specific Residue AND Are Environmentally Sound and Cost Effective***

- **Cleaner Mechanisms for Residue Removal**
  - **Solubilization**
  - **Chemical Reaction**
    - Hydrolysis
    - Oxidation
    - Enzymatic
  - **Detergency**
    - Wetting
    - Dispersion
    - Emulsification

Cleaner Priority

Water

Formulated Aqueous Cleaners

Detergents ***Chelating Agents*** ***Oxidizers***

Commodity Chemicals -Acids, Bases

Surfactants, Emulsifiers

Solvents ***"Super Solvents"***

Semi-Aqueous Cleaners ***Solvent Blends***

"Novel" Cleaners

Supercritical Fluids ***Enzymes*** ***Bacteria*** ***"Kill" Solutions***

Cleaning Delivery Systems

Integrate Cleaning Agent and Delivery System for Cleaning Optimization.

Potential benefits can be:

- ✓ Reduction of cleaner quantities
- ✓ Cost and time savings
- ✓ More effective and reliable cleaning process

Types of Cleaning Delivery Systems

turbine pipe cleaners

mechanical - buffing, blasting

dynamic spray nozzles

fog, foam

ultrasonic

vapor (boil-outs)

COP

laser ablation

dry ice cleaning - snow, pellet

immersion - partial, full

megasonic

CIP

static spray nozzles

sonic (5-10 micron size)

circulation, agitation

manual - scrubbing, scrapping

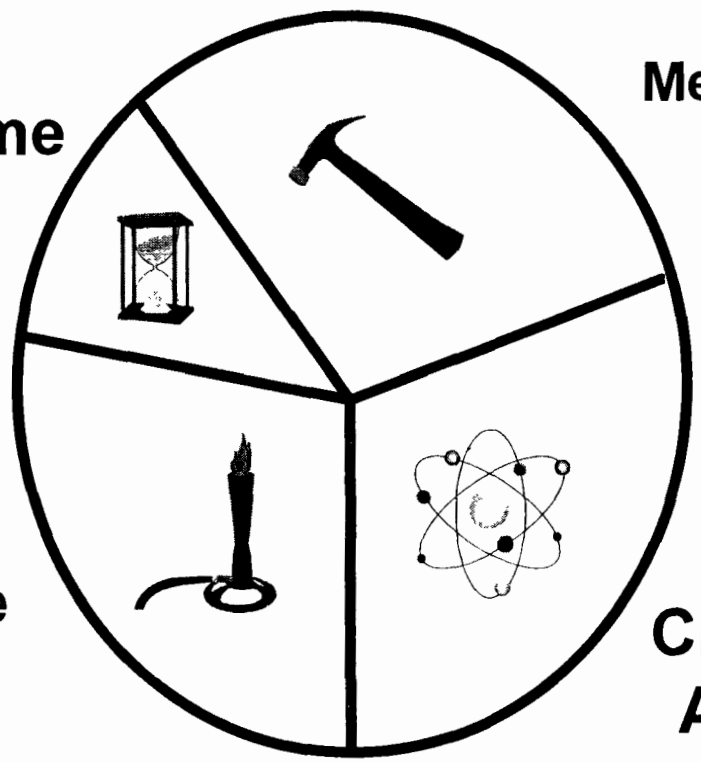
liquid nitrogen cryogenic blasting

plasma (oxygen, air, argon, nitrogen, oxygen/CF4 mixture)

Cleaning Agent Screening Program

- **Screen Various Types of Cleaners**
  - Use Worst Case Residue Conditions
    - Dried On, Baked On, Extended Times and/or Temperatures
  - Low Turbulence Agitated Immersion
    - SS, Glass, Hastelloy, Teflon Test Coupons
  - Secondary Screening - Solubility or dispersion of residue in cleaner
- **Evaluate Cleaner for Applicable Delivery Systems**
  - Lab Simulations:
    - Agitation, Spray Wash, Manual, Ultrasonic

Interaction of the Four Cleaning Parameters



Time

Optimize

Mechanical Action

- *Spray balls*
- *Agitation*

Temperature

Optimize

Optimize

Chemical Activity

- *Cleaning Agent*
- *Concentration*

Goal: Reduce Time by Optimizing the Other Three Cleaning Parameters

Cleaning Agent Screening Results

Results after 50 product/residue screenings:

- 33 (66%) water based alkaline cleaner
- 13 (26%) water based acid cleaner
- 4 (8%) solvent or emulsion based cleaner

92% of materials can be cleaned effectively with a water based cleaner !

Formulated Aqueous Cleaners

	Solvent	Aqueous
Advantages	*Reliable *Available *Often part of process	*Cost *Safety *Waste Minimization
Disadvantage	*Cost *Safety *Disposal	*Selection *Confusion *Confirm removal after use
Issues	*Image	*Substrate Effects

Formulated Aqueous Cleaners

- **Possible Components:**

Component	Function
Water	Solvent
Surfactants	Wetting, solubilization, emulsification, dispersion
Builders	Assist in detergency
Acids	Acidity source, hydrolysis
Bases	Alkalinity source, hydrolysis
Chelants	Tie up calcium, iron
Dispersants	Suspend solids
Solvents	Solubilization
Antimicrobials	Kill, reduce microbes
Oxidants	Oxidize, kill microbes
Corrosion Inhibitors	reduce corrosion rate
Defoamers	reduce foam formation

Why Consider a Formulated Aqueous Cleaner?

- **Potential Benefits:**

  - ✓ Solvent Use Reductions
  - ✓ Hazardous Waste Reductions
  - ✓ Cost Optimization of Cleaner (Concentration/Temperature Adjustments)
  - ✓ Efficient Cleaning Across a Variety of Chemical Types
  - ✓ Formulated for CIP Systems
  - ✓ Safer Manual Cleanings than solvent
  - ✓ Reduction of Commodity Acid and Base Use

Case Study A: Evista, Raloxifene Intermediate

Evista: Prevention of Osteoporosis

Change: Replaced methyl alcohol/ethylene dichloride with an aqueous alkaline cleaner.

	Old	New	% Reduction
MeOH/EDC Usage	117,699 L	11,761L	90
(with new assay	117,699 L	400 L	99)
Cleaner costs	$18,300	$7,995	56
Cleaning Time	23.5 days	16 days	32

Case Study B: Antifungal Developmental Product

Change: Replaced acetone with an aqueous alkaline cleaner /detergent booster.

	Old	New	% Reduction
Acetone Usage	10,500 L	1,800 L	83
Cleaner Costs	$4,050	$1,310	68
Cleaning Time	5.2 days	5.1 days	2

Case Study C: Micotil, Tilmicosin

Micotil: Treatment of respiratory disease in cattle

Change: Replaced methyl alcohol with an aqueous acid cleaner.
Used spray devices for tank cleaning.

	Old	New	% Reduction
MeOH Usage	8,600 L	3,000 L	65
Cleaner Costs	$2,400	$ 998	58
Cleaning Time	15 days	5.9 days	80

Benefits Realized from Cleaning Improvements

Impact of implementing aqueous based cleaners to replace solvents used in 3 pharmaceutical process cleanings:

- ✓ Reduction of 238 tons of acetone, methyl alcohol, EDC
- ✓ Reduction of 222 tons of hazardous waste
- ✓ Reduction of 6 tons of hazardous air pollutants
- ✓ Cleaner savings of $30,000
- ✓ Time savings of 33 days
- ✚ Progress in reducing personnel tank entries for cleaning

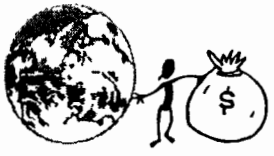
Cleaning Process

Summary:

✓ Know What Residues You Are Trying to Clean.

✓ When Choosing a Cleaner, Evaluate Different Types of Cleaners... Don't Just Grab the First One That Comes to Mind.

✓ Many Companies Are Aggressive in Moving Toward Aqueous Based Cleaners Resulting in Significant Waste Minimization and Cost Savings.



Sam George/Steve T. Hale

Madison Chemical Co., Inc.

"Metal Pretreatment Sealing Processes Containing No Chromium or Molydbenum "

Sam George

SAM GEORGE, Vice President and Director of Corporate Affairs, first began work at **Madison Chemical Company** while a student at Hanover College. As a night shift supervisor, he oversaw production for a laundry detergent contract with the federal government. On graduation, he succeeded Dick Goodman as plant manager. Sam received a law degree in 1983 from the University of Louisville School of Law and worked four and a half years at the American Commercial Barge Line Company as Assistant to the General Manager specializing in environmental regulations and compliance. In 1995, Indiana Governor Evan Bayh appointed Sam to the Indiana Emergency Response Commission. Sam belongs to the Indiana, Kentucky, and Louisiana Bars. He returned to **Madison Chemical Company** in 1988; his current responsibilities include regulatory compliance and consulting. In addition, Sam assists customers regarding their Hazard Communications Programs and the Community Right To Know responsibilities.

METAL PRETREATMENT SEALING PROCESSES CONTAINING NO CHROMIUM OR MOLYBDENUM

Metal manufacturing facilities want their raw metal cleaned and coated with a surface preparation which will extend the service life of their finished parts. These firms use "sealers" as one of the final pretreatment steps. After the metal is cleaned and iron phosphated, a sealer is applied prior to the application of the paint to assure paint adhesion and increase corrosion resistance of their final product.

Chromium and molybdenum are considered toxic and are increasingly regulated by government agencies. Eliminating chromium and molybdenum from sealers prevents employee exposure and assures less chromium and molybdenum reaches the environment. Elimination of these two metals in sealers reduces waste treatment expenses, thus reducing operating expenses for affected companies. Madison Chemical Co , Inc. desires to design sealers that contain no chromium and molybdenum, but still meet the needs of metal manufacturers.

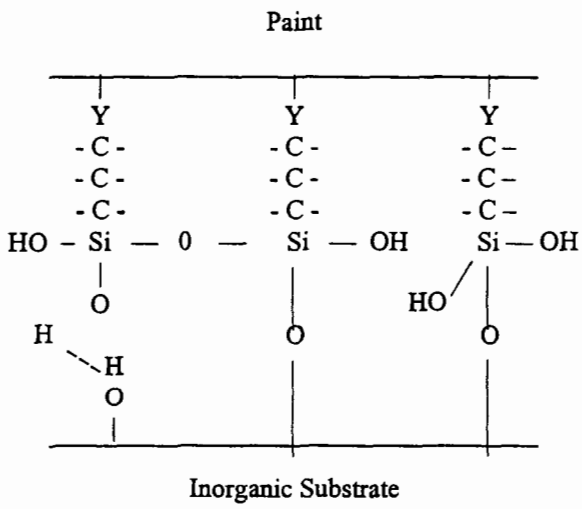
Since at least 1973-1974, Madison Chemical, a manufacturer of specialty chemicals utilized during prepaint applications, has developed an increasingly effective series of non-chromium sealers. The earliest products were not much more than phosphoric acid, and did not come close to chromium in their performance benefits. More successful products were developed, but they frequently contained other metals, chelates, and oxidizing or reducing agents. These products did not always meet customer specifications for paint adhesion and corrosion resistance, and seldom performed as well as chromium. In 1987, molybdenum became a component of several of the more effective non-chromium sealers formulated by Madison Chemical. The Indiana Department of Environmental Management awarded a Pollution Prevention grant to Madison Chemical in 1996. The P^2 funds allowed us to devote more research hours into the effort to eliminate chromium and molybdenum from our sealers.

Literature searches found many descriptions for silanes being instrumental in increasing adhesion between a polymer and an inorganic substrate. Silanes are reported to exhibit "adhesion promotion" effectiveness with the following polymers: acrylic, butyl, cellulosics, epoxy, furan, melamine, neoprene, nitrile, nitrocellulose, phenolic, polyamide, polyester, polyolefin, polysulfide, polyurethane, polyvinyl butyral, urea-formaldehyde, and vinyl. The P^2 research resulted in the identification of a single silane, specifically gamma-aminopropyltriethoxysilane (CAS # 919-30-2), which allowed Madison Chemical to develop a product for metal pretreatment sealing processes containing no chromium or molybdenum.

The following description of a typical bifunctional organofunctional silane is taken from the article "Silane Coupling Agents Improve Performance" by Bruce Waldman of OSi in the February 1996 issue of Modern Paint & Coatings, pages 34 - 39.

Organofunctional group $Y - R - Si - X_3$ Hydrolyzable groups

Y is an organofunctional group and is chosen for reactivity with the resin.
R is the linking group, frequently a propyl chain, and provides a Si-C bond stable under many conditions.
X is the hydrolyzable group and provides reactivity to the substrate. Three groups for X usually provide more moisture-resistant bonds. In order to become active, the silane must first hydrolyze. Naturally occurring substrate acidity or alkalinity is usually sufficient to catalyze this hydrolysis. Hydrogen bonds occur with the substrate and upon release of water, a direct covalent bond with the substrate is formed. Some of the X groups condense with themselves forming a crosslinking network of Si-O-Si. The adhesion process is completed when Y reacts with the resin or binder of a coating. A drawing of the completed coupling of paint to substrate follows.



The silane-based sealers developed by Madison Chemical directly drop-into existing production equipment at metal manufacturers. Similar concentrations and times of application are required compared to chromium, molybdenum, and other competitive sealers. Tank life is similar among these three sealer types and is largely dependent upon carryover into the sealer solution of iron from the previous phosphating step. The average cost per gallon of use-solution is 1.5-2.0 cents for chromium, 5.0-6.0 cents for molybdenum, and 10-15 cents for silane sealers. If charging cost and performance were the only criteria, chromium would still be widely used. It is not due to its carcinogenic nature, and subsequent cost and liability with regard to employee exposure, in addition to waste treatment necessary to prevent chromium from entering the environment. Molybdenum is increasingly regulated in waste treatment permits and it rarely performs as well as silane in sealer applications making it less desirable to use.

The silane is typically used in the sealer use-solution at 0.1%. Higher levels up to 0.5% active silane have occasionally been necessary. With the higher levels, it is advisable to post-rinse with deionized water to reduce the amount of unreacted silane on the surface prior to painting. Unreacted silane can cause aesthetic defects in the cured paint film. Silane levels above 0.1% are helpful when the contact time is unusually short such as less than 10 seconds. It is theorized that silane levels above 0.1% are helpful when the phosphate coating weight is low, such as less than 25 milligrams per square foot, to partially makeup for the lesser number of oxide sites for silane bonding. Silane levels above 0.1% are helpful to allow a paint to withstand extremely severe or unusual customer specifications. Finally, silane levels above 0.1% can allow the usage of a less capable and less expensive paint to achieve customer specifications at an overall reduction in total cost.

The silane can be applied by immersion or spray methods at temperatures of 65°F. to 160°F. Recommended contact times are 30 to 60 seconds. Optimum results are obtained when the treated surface is allowed to dry completely before paint application. The optimum promotion of adhesion is frequently the simple combination of silane and water, which exhibits a pH of approximately 10, dependent upon water quality. Occasionally, better results are obtained by adjusting the pH to 4.0 - 7.0 with phosphoric acid. It is not well understood why this is occasionally necessary, although it is theorized to be an interrelation of the variables of water quality, time, temperature, phosphate coating, and paint chemistry. Fortunately, this is not an impediment to metal manufacturers, since it is common practice to extensively pretest these pretreatment and painting variables before implementation into production.

Laboratory and in-the-field testing has confirmed the usefulness of silane and optimized usage conditions. Testing has included acrylic, epoxy, polyester, and polyurethane polymers, and has shown positive adhesion promotion for all. Much of our work has been with powder paint, but waterborne and conventional solvent paints also show positive adhesion promotion. Cathodic electrocoat is the only paint class that has not shown positive adhesion promotion. Inorganic substrates tested and showing positive promotion of adhesion are steel, aluminum, zinc, galvaneal, and stainless steel. Silane cross-linking has provided coated substrates with great resistance to salt spray, condensing humidity, and vapor humidity in tests conducted by Madison Chemical. Silane sealers have also demonstrated mild corrosion protection for unpainted steel. This is favorable for certain production conditions of inadequate rinsing or dryoff prior to painting. It can assist in the prevention of flash rusting during the curing of waterborne paints. Silane sealers have allowed Madison Chemical customers to achieve or surpass corrosion specifications, and reduce rejects and product returns.

In virtually all laboratory and field-testing accomplished by Madison Chemical, a silane sealer has outperformed a molybdenum sealer. The comparisons to chromium sealers have not been as consistently good, although one salt spray result showed the silane to outperform hexavalent chromium at 720 hours of testing and they were equal at 1000 hours of testing. Results indicate a chromium sealer can provide more salt spray hours than a silane sealer when cleaning, phosphating, and/or rinsing are not in specified

ranges. This is likely due to the strong oxidizing power of chromium sealers resulting in passivation for the substrate in corrosive environments. Silanes do not passivate the substrate to nearly the same extent as chromium. Silanes rely upon chemical bonding to achieve better adhesion between the substrate and the paint. When conditions are not optimum to achieve sufficient chemical bonding, it is likely that chromium sealers will still outperform silane sealers.

Chromium sealers have been de-emphasized by Madison Chemical and our customers for a number of years. We had one customer for a hexavalent chromium sealer and one customer for a trivalent chromium sealer prior to the grant. The former trivalent chromium sealer customer has successfully converted to our silane sealer. The hexavalent chromium sealer customer uses two pounds of elemental hexavalent chromium per year. They continue to use hexavalent chromium due to its low volume and easy treatability in their existing waste treatment system for chromium electroplating wastes.

The usage of molybdenum at Madison Chemical has decreased each year since the receipt of our P^2 grant. The 1995 yearly average was almost 87% greater compared to the 1998 amount.

Molybdenum usage in pounds	Year
936	1995
670	1996
642	1997
501*	1998

* extrapolated from the molybdenum used from January 1 to May 24, 1998.

Perhaps more significantly, silane usage for the grant period was 11,190 pounds. Madison Chemical has converted many previous molybdenum users to silane chemistry and most new customers are starting with the silane chemistry. On average, one pound of silane in a sealer replaces 0.3 pound of molybdenum. 11,190 times 0.3 equals 3357 pounds of molybdenum not used at Madison Chemical, or discharged into the environment by our customers, during the grant period due to the success of the silane sealers.

Sherri Gruder

Solid & Hazardous Education Center University of Wisconsin Extension

"Transport Packinging Savings"

BIOGRAPHY

Sherrie Gruder

Ms. Gruder is the Source Reduction & Recycling Specialist of the Solid and Hazardous Waste Education Center at the University of Wisconsin-Extension in Madison. She provides statewide technical assistance and education to businesses and communities on evaluating decisions involved in planning and implementing successful source reduction, reuse and recycling programs.

Ms. Gruder just served 2 terms on the Board of Directors of National Recycling Coalition. She is one of the founders and a steering committee member of the National Source Reduction Forum where she lead a project team that developed tools for businesses on source reduced and reusable transport packaging. Sherrie is a past long-term board member of AROW (Associated Recyclers of Wisconsin), the state recycling organization. She helped to develop Wisconsin's recycling law serving on the Wisconsin Legislative Council Special Committee on Solid Waste Policy and continues to be involved in the policy arena.

Sherrie Gruder received an M.S. degree in Ecology from the University of Illinois, Urbana-Champaign; and a B.A. degree from the University of Pennsylvania.

TRANSPORT PACKAGING $AVINGS
Reduce, Reuse and $ave
By Sherrie Gruder,
Source Reduction & Recycling Specialist
University of Wisconsin-Extension Solid and Hazardous Waste Education Center

Businesses can reduce the costs of their transport packaging as well as conserve resources and decrease waste by using source reduced and reusable transport packaging and dunnage. One third of municipal solid waste is packaging and transport packaging comprises one half of all packaging waste (USEPA). Clearly, manufacturers, suppliers, distributors and purchasing personnel are in a position to impact resource use and waste generation by reducing transport packaging. In addition, any business, small or large, simple or complex – can save money by reducing costs of purchasing, moving, storing and disposing of their transport packages (see fig 1.). The National Recycling Coalition's *Case Studies In Source Reduced And Reusable Transport Packaging* as well as other NRC publications and slide show illustrate how.

Traex (Dane, WI), a company of 130 employees that makes plastic injection molded products for the food service industry, saved $50,000 in just one year using a substitution strategy. For their internal packing, rather than baling and recycling shrink-wrap, the company switched from shrink-wrap to reusable rubber pallet bands. Traex not only saved the cost of baling the shrink-wrap, it recovered its investment in the pallet rubber bands in four shifts. Other savings realized from this strategy include:

- Costs of processing 1.3 million square feet of stretch-wrap per year;
- Reduced employee time (and costs) on the line, in the warehouse, and handling the wrap;
- Avoided stretch-wrap purchasing costs; and
- Reduced costs resulting from avoided workplace accidents and injuries

Fig 1.
$Avings
Environmental savings:
conserving resources
preventing waste
Additonal savings:
√ purchasing
√ labor
√ damage
√ material handling
√ disposal
√ storage

√ transportation

Strategies to Reduce Packaging

There are several options and strategies for reducing transport packaging. It is recommended that businesses consider the strategy(ies) most appropriate for their operation, product and customer needs so that packaging changes do not compromise essential functions of a package—the product's safety and integrity. The packaging options presented in fig 2. offer some packaging reduction ideas. You may combine two or more options in order to save money and use as little material as possible i.e. durable, reusable shipping container made with recycled material and that, ultimately, will be recycled. Xerox Corp. is saving $5-6 million annually on packaging reduction programs including reduction, standardization, and reusables.

Strategies implemented by companies to successfully reduce the amount of packaging material used include:

- Elimination- eliminates the package or packaging component altogether, e.g. a racking system (which is reusable too) or furniture unpackaged with heavy blankets used for protection. Elimination may require redesigning the transport package itself.
- Lightweighting – use less material in a package or substitute lighter weight materials. Examples include reduced fiber corrugated, stretch wrap vs. cardboard boxes, corrugated corner pieces, and pallet rubber bands vs. stretch wrap.
- Bulk- eliminate packaging of individual goods or ship in larger volume containers. Examples are using a silo or intermediate bulk containers (IBCs) versus individual bags, and 55-gallon drums rather than 5-gallon buckets.
- Package redesign and substitution – increases transportation efficiency while reducing materials use. Changing from round to square containers is one example.
- Durables/Reusables – durable packaging may be reused in the same form. Examine existing containers, packing material and shipping platforms for reusability. Reusables include plastic, steel, wood, fiberboard and durable corrugated boxes, bags, totes, bins, pails, drums, pallets, cushioning and internal packaging. Palletized containers, reusable shipping racks and fabric shipping wraps, quilts and bags are other examples. Pallet reconditioning is a widely available option for wood pallet reuse.

Once you've considered these options, you'll be ready to start talking with your supplier/vendor about the feasibility of each strategy for your business. A good place to start is to examine your shipping system. If your suppliers or customers have dedicated shippers with empty back-haul, returnable containers will very likely make a lot of sense. In addition, if you ship or receive a high volume of packaged goods from a few sources/destinations, reusable containers may be justified.

Dataserv, Inc (Chanhassen, Mn) reuses corrugated paper boxes and foam cushioning to ship circuit boards. The same boxes are reused three times in one division, twice in

another. Box reuse saves Dataserv more than $26,000 annually in purchasing cost. Reusing custom foam cushioning saves the company an additional $17,775 a year. Dataserv's total savings from reusing transport packaging are $44,000 a year with added savings from eliminating more than one and a half tons of waste (MN Office of Waste Management).

Some reusable container manufacturers are willing to work with customers to handle all take-back shipping logistics. Working with a third party leasing or logistics company may enable your business to use reusable containers when, otherwise, it would not be feasible.

One such case is Inserra Supermarkets (Mahwah, NJ) who contract with Dom's Empty Packaging Supply (New Paltz, NY) for the removal of a variety of reusable packages from its stores. Inserra Supermarkets is a chain of 24 grocery stores with each store employing 200 people on average. Dom's finds markets for redistribution and recycling of salvaged containers and wrap. The procedure is simple; Dom's provides the stores with reusable, heavy-duty collapsible corrugated (Gaylord) boxes. These are stacked on wood pallets and delivered by Dom's. Employees are easily instructed on how to fill the boxes with several container types. These include; wirebound crates, formed, non-collapsible wood boxes, recyclable plastics (including polystyrene containers and shrink wrap), and waxed corrugated boxes.

The average store fills six to eight Gaylords per weekly collection. A few smaller stores lacking storage space are serviced twice a week. Prior to hiring Dom's, these materials were tossed into compactors and trashed The supermarket saves more than $100,000 annually. They realize reduced disposal costs of $103 per ton plus $1,000 per week in hauling fees and waste container rental fees. The resources from the packaging are saved and other businesses such as sweet corn growers, clam fisherman and produce farmers benefit.

Is Reusable Packaging Right for My Business?

Now that you have considered the possibilities for reducing your transport packaging, here are some tips on how to get started.

1. **Get the boss' OK.** Involve management early on.
2. **Organize a waste reduction team.** Get input from every area of company
3. **Evaluate transport packaging options for your company.**
   A. Evaluate developing a closed-loop shipping system
      - within the plant
      - with suppliers

   B. Look at your assembly line for reuse opportunities
      - Can Just in Time portable, returnable racks be used?
      - What type of reusable container would work best?
      - Can the same container be used more than 1 time in assembly process?

   C. Involve your parts suppliers

- show them how it will save them $
- will they share start-up costs

4. **Set realistic goals**. Establish goals that are clear, measurable, and achievable within a relatively short period of time.
5. **Design a packaging reduction plan**. Design a strategy to accomplish the project's goals that can be phased in to the company's operations. Consider a pilot test of one package type.
   A. Test sample containers
      Examine:
      - ease of assembly & collapse
      - return ratio- full to empty shipping volume
      - ease of stacking & cleaning
6. **Document savings, costs & waste benefits**
   - payback period
   - amount of solid waste eliminated, solid waste service savings
   - work-load reductions
   - savings from damage decreases
7. **Implement change in packaging**
   - one product at a time
8. **Follow-up**
   - gather feedback from staff
   - address any problems at their source
   - keep management informed
9. **Build on Your Success**

Once the packaging change has succeeded, proceed with the next opportunity to implement packaging reduction options.

Reprinted from *Returnable Packaging Solutions* supplement in *Packaging Technology & Engineering*, in press.

For more information on this topic or to order packaging publications including: a *Directory of Source Reduced and Reusable Transport Packaging Manufacturers* ; *Source Reduced & Reusable Transport Packaging Case Studies; Transport Packaging Savings; a slide presentation on strategies and case studies;* and Purchasing Strategies to Reduce Waste & Save Money, contact the National Recycling Coalition, 1727 King St. Alexandria, VA 22314-2720; phone: 703 683-9025 x211, fax 703 683-9026; WEB site: www.nrc-recycle.org

Steve T. Hale/Sam George
(see Sam George for paper)
Madison Chemical Co., Inc.

"Metal Pretreatment Sealing Processes Containing No Chromium or Molydbenum "

Steven T. Hale

STEVEN T. HALE, Director of Research & Development, graduated from Rose-Hulman Institute of Technology in 1973 with a B.S. in Chemistry and joined **Madison Chemical Company** in September of that year. He belongs to the American Society for Testing and Materials (ASTM), the Association for Finishing Processes/Society of Manufacturing Engineers (AFP/SME), the American Electroplaters & Surface Finishers Society (AESF), and the National Fire Protection Association (NFPA). He was appointed to the Board of Advisors for the AFP/SME in1996. Steve directs the technical aspects of **Madison Chemical Company** as they relate to the Product Support Group, production, sales and service staff, and customers. His current areas of research and development include formulating environmentally friendly chemical specialties for conversion coatings, rust preventives, and detergents.

S. Jean Hall

CMTI/Purdue University

"Reduction of Emissions via Technology Development in Conductive Plastics"

S. Jean Hall

S. Jean Hall joined the staff of the Indiana Clean Manufacturing Technology and Safe Materials Institute (CMTI) in June 1995 as a Professional Assistant, providing engineering consultant services to Indiana businesses. Mr. Hall earned a Bachelor of Science degree in Industrial Engineering from Ohio State University and a Master of Science degree in Management from Indiana Wesleyan University. Mr. Hall has over twenty-five years of hands-on managerial experience in shop operations, manufacturing engineering, environmental and safety compliance with several major corporations, spanning a very broad array of products and processes..

[redacted]

Reduction of Emissions via Technology Development in Conductive Plastics

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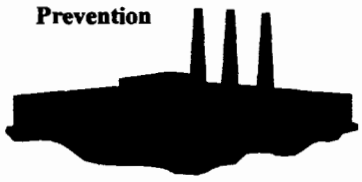
[redacted]

- Injection molded, exterior automotive parts
- Northeastern Indiana (Berne)
- 350 employees
- Typical customers: Ford, Toyota, Saturn, Mitsubishi, and GM
- $80 million annual sales
- Environmentally attuned
- **Recipient of 1998 Indiana Governor's Award for Excellence in Pollution Prevention**



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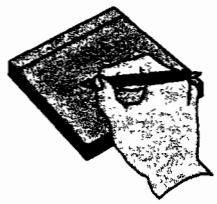
- Injection-mold automotive, external mirror housings (and other)
- Spray-paint housings to match automotive finishes
- VOC/HAP-based paint, $60 to $120 per gallon

- State-of-the-art equipment and process
  - Electrostatics
  - Computer-controlled paint handling
  - Robotic application
- Over 300 current colors, 100 of which are regularly used
- Fibrils (Hyperion Catalysis International)

[redacted]

- Elimination of primer step
- One-component-paint use
  Reduction: 15%
- Two-component-paint use
  Reduction: 80%
- Clear-coat over two-component-paint use reduction: 40%
- Slightly improved molding cycles



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[redacted]

- VOC emissions reduced 20 tons, per year (partial implementation), 80 ton potential
- Includes 15 tons HAPs reduction
  - Methyl benzene
  - xylene
  - N-butanol
  - 2-butoxyl acetate
- Also 1.5 tons non-VOC, HAPs reduction
  - Barium Sulfate

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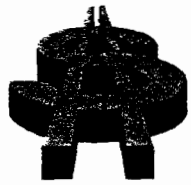
[redacted]

- Improved application rate: up to 300 percent, depending upon pre-fibril painting process



- Estimated cost savings: $500,000. per year (conservative estimate)

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[redacted]

- Extend fibrils technology to vast pool of additional external auto parts manufacturers (500 tons VOC mirror housings only -- US market)
- Use of electrostatic principles to reduce air emissions in open-mold lay-up/spray-up applications
- Water-based paints

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P² BRIEF

UNITED TECHNOLOGIES AUTOMOTIVE
Berne, Indiana

April 1998

POLLUTION PREVENTION
Case Study

INTRODUCTION

In April of 1995, members of the Indiana Clean Manufacturing Technology and Safe Materials Institute (CMTI) met with representatives of United Technologies Automotive (UTA) at Berne Indiana, to discuss potential pollution prevention opportunities. Discussion soon focused on UTA's parts-painting operation. Although the plant's emissions were within the limits of its air permit, those emissions were significant and eventually could be a constraint to increased production.

COMPANY BACKGROUND

The Berne Indiana facility of United Technologies Automotive occupies 120,000 square feet and produces injection molded thermoplastic components for exterior automotive use, such as rearview mirror housings. The facility employs nearly 350 people and supplies its products to both domestic and foreign owned companies such as Ford, Toyota, Mitsubishi, and GM. It is a proactive, environmentally-attuned business with an organized approach and systems for tracking and reporting of appropriate data pertaining to regulated materials and wastes.

MANUFACTURING PROCESS

UTA employs up-to-date, automated, computer-controlled, electrostatic painting techniques; but it could not fully utilize the process. Some products were totally unable to utilize electrostatics, while those that did use the process, could only partially tap into its effectiveness.

In UTA's parts finishing process, molded plastic parts are placed on an overhead-conveyor carrier rack for transport through the cleaning and painting process steps. Reliable, initial electrical continuity between carrier and part (an essential to the process) was erratic, even though extra, manual-spraying effort and attention were being expended in the application of conductive primer paint to all surfaces including body mount areas. Related rework

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and waste were consistently of significant concern. Also, added manual spray was needed before, and after, the automatic electrostatic-spray application of the color-basecoat.

Poor continuity between carrier and part was clearly an area to be addressed; but no immediate solution was apparent. The use of conductive plastic was discussed as a potential solution, if such materials could meet the stringent engineering requirements of UTA's customers.

Electrostatic application of paint is known to improve transfer efficiency (the weight of paint solids that deposit on the part per unit weight of paint solids sprayed; all other factors remaining constant). If a suitable conductive plastic could be identified or developed to facilitate electrostatic spraying, it might make it possible where it could not previously be accomplished. If it improved the quality and transfer efficiencies of applications that already incorporated electrostatics, then P2 would be achieved and the accompanying reduction in paint usage could help offset the increase in the price of the new plastic blends.

ENVIRONMENTAL ISSUES

Automotive manufacturers demand that painted, external automotive parts incorporate ultra high quality paints that will continue to appear bright and shiny throughout years of exposure to harsh environmental conditions (ultraviolet rays, broad temperature ranges, salt, etc.). In spraying applications, paints that meet these requirements are generally solvent-based and very expensive. The solvent mixtures that are applied, typically, contain volatile organic compounds (VOCs) and hazardous air pollutants (HAPs).

Improvements in transfer-efficiency of a painting operation result in a reduction of VOCs and HAPs released to the atmosphere. Better coverage means less usage of those materials.

P^2 PROJECT

Although conductive plastics have been around for over thirty years, it was apparent they had not made inroads into the arena of electrostatic application of paint. Higher material cost and degradation of physical properties were conjectured to be possible barriers to using any then-available conductive plastics. It was agreed that CMTI would investigate the availability of any suitable conductive-plastics technology.

Subsequently, CMTI's research staff performed an extensive literature review. The review confirmed that the additives that are typically used for this purpose substantially add to raw-material cost and, also, result in physical-property degradation. This review identified no new, suitable, conductive-plastics technology.

Subsequently, follow-up with various suppliers of plastic materials, by CMTI's technical assistance staff, provided a lead on a more current development--an extremely small carbon fibril (phonetically: "fib-rill", not "fibe-rill"). Fibrils, reportedly, could be used to provide conductivity in paint primers or in plastic, itself, at concentrations lower than three percent of total (by weight). This very low loading-level of additive could

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change both the economic perspective and the physical-property considerations.

CMTI subsequently arranged a meeting with the developer of fibrils, Hyperion Catalysis International of Cambridge, Massachusetts (HCI), and UTA to explore opportunities and applications. The result of the prior, several months' efforts was a project agreement between UTA, HCI, and CMTI to test fibril applications on several mirror-housing product lines at the UTA plant.

Thermoplastic materials are given low-conductivity traits by blending fibrils into the plastic using extruder equipment. HCI's process for producing fibrils, and its process for making a "master" resin blend containing its fibrils are both proprietary. The master blend can then be reblended with additional quantities of the normal plastic compound to achieve the desired material containing one-half (½) to three (3) percent fibrils. For materials initially tested at UTA, HCI also performed this final blending step; initially, on a grade of NORYL GTX for mirror housings being painted electrostatically and, later, for mirror housings made of an ABS plastic that were not being electrostatically painted.

From the standpoint of painting, fibrils-technology results ranged from *very good* to *excellent*. In the case of the mirror housings that ordinarily utilized hand-spray application, painting with electrostatics resulted in almost a threefold improvement of the application rate, from approximately eighty (80) mirror housings coated per gallon to about 290 housings coated per gallon. Clearly, coverage rates were greatly enhanced and elimination of some primer application was made possible. UTA's one-component paint usage reduction was projected in excess of fifteen (15) percent. Two-component paint usage reduction was expected to be near eighty (80) percent. Clear-coat usage for the two-component paint was estimated to be lessened by forty (40) percent.

The molding parameters (setup and operation of equipment) for the test material required no significant alteration from the norm. Process times, if anything, seemed to improve slightly. UTA determined the vibration-resonance characteristics of the materials to be slightly improved and deemed the physical-property changes to be insignificant.

All tests were deemed by UTA to have been successful and it embarked on a lengthier testing program to secure approval from its customers. To this end, UTA approached GE Plastics, its supplier of NORYL GTX resin, to develop a fibril based conductive NORYL GTX resin. In response, GE Plastics developed the NORYL GTX 990EP conductive resin using its "Design for Six Sigma process for developing a new product".

After one full year of testing Ford and Mitsubishi products, results were very positive. Still, Ford sought the even stronger proof of testing out this material variation as if it were a totally new material. UTA continued with extended tests and, in October 1997, Ford's approval was received; production of Ford Taurus and Mercury Sable mirror housings incorporated the new technology.

At the end of the first eight weeks production, paint transfer-efficiency had improved twenty to twenty five percent.

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POTENTIAL ENVIRONMENTAL AND COST BENEFITS

Based on test observations, it is estimated that VOC emissions may be reduced by eighty (80) tons per year. This includes a HAP decrease of fifteen (15) tons. Another one and one-half (1½) tons of non-VOC HAPs will also be eliminated. Production data, after eight weeks history, indicated a thirty-five percent reduction in VOC emissions.

Often, P2 strategies are considered too costly to implement. However, at UTA, the reduction in paint usage will be so effective that resulting cost decreases were expected to substantially outweigh the increased cost of raw material. It was conservatively estimated that the use of fibrils by UTA would save the company over $500,000 per year. Typical production results at UTA indicate $50,000 to $200,000 savings per program conversion for exterior mirrors, dependent upon volume and process variables.

CONCLUSION

The process has proven to create adequate economic benefits to UTA to provide a price reduction to Ford on fibril-blended products and to retain some benefits for itself. Thermoplastic resin suppliers like GE Plastics support the project and are now developing new product lines for the marketplace, incorporating the fibril technology. As other companies follow UTA's lead, large-scale use of fibril technology will make the products that incorporate it more economically affordable and beneficial in the future.

Additional benefits and opportunities are expected to result from this project. The estimated cost savings do not include in-depth analyses of other monetary, intangible, or more-difficult-to-identify savings and benefits that will be derived from related waste reduction, energy conservation, and so forth. Further benefits, environmentally and economically, will also be gained by the plastics industry throughout Indiana, and beyond, as knowledge of this local, successful, pioneering venture is disseminated. Extrapolation to similar products across the USA suggests that 6.7 million pounds of VOC emissions reduction could be achieved.

Note: In September 1998 United Technologies Automotive (UTA in Berne, IN) received the "Indiana Governor's Award for Excellence in Pollution Prevention" in the Research and Development category as a result of this project's successful implementation.

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John R. Heckman

Roy F. Weston,Inc.

"P2 Through Life Cycle Management: Case Studies Mapped to Project- and System-focused Management Strategies"

John R. Heckman, Ph.D., has more than five years experience in solving environmental problems and supporting strategic management decisions. His research experience covers product stewardship and environmental efficiency implementation strategies, functional responses in restoration ecology, and applications of active science and problem solving in educational settings. Dr. Heckman has experience in assessing strategic management practices and implementing ISO 14001 compliant environmental management systems within Fortune 500 manufacturing, service, and utility companies. His current research involves the integration of eco-efficiency performance metrics with structured management systems to bootstrap sustainable thinking in business organizations.

Pollution Prevention through Life Cycle Management:
Case Studies Mapped to Project- and System-focused Management Strategies

by John R. Heckman* and Agis D. Veroutis
Roy F. Weston, Inc.

Applications of management systems to increase overall business operational efficiency have become commonplace in this era of "Business Re-engineering." The two dominant ISO systems (9002 and 14001) are excellent examples of these. A relative newcomer to the field is the Life-Cycle Management (LCM) approach. LCM is based on Life-Cycle Assessment (LCA), but accommodates environmental, technical, and cost considerations in an evaluation and decision-making process. LCA has been expansive by design, seeking to collect and analyze information from a system-wide perspective, looking at a product system from raw materials extraction through to final disposition (cradle-to-grave) and assimilating material inputs and outputs, emissions to air and water, solid waste, and energy inputs and outputs. Life-Cycle Management affords a more focused approach, scalable to the specific improvement needs of the organization engaging it. The basic approach seeks to identify improvement opportunities in specific target areas of the organization's product system, and then explore the environmental, technical, and cost implications of the resulting changes across the product system life-cycle. The objective of the approach, more times than not, is to also provide financial improvement in concert with environmental performance improvement.

Life-Cycle Management is fast becoming recognized as a valuable approach that can allow focused environmental analysis and improvement of specific aspects of the overall product system, while addressing and accommodating technical and cost considerations that are not typically covered in Life-Cycle Assessment efforts. Numerous organizations, among which Commonwealth Edison is notable for its success, are using LCM to continuously improve and manage parts of their operations to increase shareholder value and improve their environmental performance. Examples from ComEd's LCM program discussed in the paper demonstrate how successful implementation of LCM can add almost immediate and measurable business value.

Even with these successes, an underlying organizational concept concerning LCM has not been fully understood. LCM applications often take place as discrete projects focused on a single process or operational unit. Systemic approaches offer the potential for true integration and greater overall efficiencies. This paper will explore the parallels and differences between example LCM methodologies based on a (1) preliminary project-focused LCM process and (2) the system-focused ISO 14001 methodology.

The LCM Rationale

There are many reasons why life-cycle management has been successfully applied to enhance competitiveness. Looking at correlations between business and environmental performance reveals that there are direct links between waste management for reduction/minimization, and the costs associated with the manufacturing of the product, or the provision of the service[1].

Resource Efficiency: One facility operated by a company may be better equipped to handle a particular type of emission (e.g., better air emission controls) while another may be very well

equipped in controlling another emission (e.g., better waste water treatment technologies.) The company may use this information to focus pollution prevention programs for different facilities, rather than pursuing, for example, an air-emissions reduction program across-the-board in all its facilities. This information may also be used to determine if it is beneficial concentrate the production of one product-line to a smaller number of facilities, and tailor the production at different plants to the areas in which they can handle the associated costs/emissions most effectively. In such an instance, the company uses the *functional unit* as the measurement vehicle to identify appropriateness of its facilities to the production of one product vs. another. This may result in reductions in operating costs though matching the best product-facility combinations, or may assist in the identification of capital improvement projects that will reduce environmental abatement costs.

Market Drivers: A division of a chemical company which manufactures foams for use in automobiles found that it was losing market share because its customers were using alternative products which were more expensive, but less hazardous to handle in manufacturing. By providing training to its customers on proper handling of the product, and providing significant product technical support, the company was able to restore customer confidence in the integrity of the product. By expanding its circle of concern beyond the manufacturing stage of this product's life-cycle to the use stage, this company was able to quickly identify the reason for declining market share, and remedy the situation.

Resource Productivity: A global electronic component manufacturer identified that significant forest resources were expended by its under-utilizing the palettes on which the raw materials were shipped-in by it's suppliers. An aggressive re-use program reduced the total number of palettes they disposed annually by an order of magnitude. The results to the bottom line were just as effective. Another example which is now the stuff of legend is that of the shipping crate specifications for parts provided by suppliers to the original Ford Model T. Ford Motor Company had tightly specified the dimensions, material, and design of the crates in which suppliers shipped their parts to Ford. Ford then used the sides of the crates as floor panels, from which it build the floor of the Model T's. This is probably one of the earliest examples of zero-waste manufacturing strategies. Although not specifically developed as a life-cycle thinking based example it goes a long way to demonstrate how expanding the circle of concern beyond the life-cycle stage in which the company has ownership of the product can reduce cost while also enhancing resource productivity.

Moving outside the "box" of strictly defined Life-Cycle Assessments lies a wealth of product life-cycle information that companies have been using within Life-Cycle Management programs and projects to gain a competitive advantage in the marketplace. The "life-cycle thinking" perspective has allowed companies such as AT&T to establish their commitment to the environment, as is seen through the "AT&T Life-Cycle Matrix" and be on the cutting edge of environmental considerations in product development. Clairol, a BMS company, has used life-cycle thinking and information to develop its herbal ingredients-based hair coloring product line, which is claimed to have increased that product line's annual revenues from $30MM/yr to $100MM/yr.

How Life-Cycle Management Information is Generated

Life-Cycle Management information has many forms. From the traditional Life-Cycle Inventory (LCI) where energy, material, and emission data are compiled on a functional-unit basis, to Life-Cycle Cost (LCC) information and focused substance-flow studies that examine the use, utilization, and management of a specific material through the product's life-cycle. The Life-Cycle concept is a "Cradle to Grave" approach to thinking about products, processes and services. It recognizes that all life-cycle stages have environmental and economic impacts. LCM can be more focused to the life-cycle stages that are most likely to produce improvement, or are under the direct control of the company.

Specifically, companies track life-cycle costs of products or systems which they make to identify target areas for cost reductions. For example, a major European chemical manufacturer delivers a product which is used as an additive in cleaning chemical formulations. The additive packaging must be disposed of as a hazardous waste. By understanding their customers' costs, packaging designers of the manufacturer designed dissolvable packaging, which in turn created a disposal cost savings for their customers. Expanding their circle of concern to their customer gave them a competitive advantage in their industry, from which they are still reaping benefits. Examples of life-cycle management improvement objectives which can impact competitive advantage could include:

- Energy use
- Resource productivity
- Legal costs associated with product-use lawsuits
- Environmental abatement costs
- Marketing feedback on customer concerns
- Stakeholder issues analysis
- Regulatory compliance costs at each stage of the product life-cycle
- End-of-life management issues

Table 1. Examples of Product Life-Cycle Information with Impact on Competitiveness

	Life Cycle Stage				
Business Impact	**Material acquisition**	**Manufacture**	**Distribution**	**Use**	**Disposal**
Reduce Cost	Environmental abatement costs	Resource productivity	Pallet efficiency/ space utilization	Customer service costs related to env. Issues	Closed-loop recycling income
Increase Revenue		Sales based on meeting customer environmental requirements	Sales based on meeting customer packaging/Shipping requirements	Sales based on customer confidence in product handling training	Sales based on reduced disposal costs for customer
Liabilities	Use of non-hazardous materials	Elimination of hazardous materials from processes		Number and size of product liability lawsuits	Litigation based on product disposed
Reputation	Use of renewable resources	Meeting community standards	Use of energy efficient transport	Speed of response to env. incidents related to product	

The relative significance of these issues will vary from company to company, so it is important to analyze each business and prioritize which issues to track. For many organizations, this prioritization might need to be further segmented by product line.

How to Decide What to Measure and What to Track

It is not generally practical for a for-profit organization to track all possible types of life-cycle management information. Therefore, the process of identifying and prioritizing information to be collected or tracked is critical. There are a number of criteria which should be used to determine which information is relevant:

- Potential cost savings
- Potential impacts on customer perceptions/sales
- Potential corporate liability
- Cost of collecting data
- Practicality of using the information (i.e., can the information be easily interpreted to help in decision-making)

Understanding where the opportunity for competitive advantage lies is half of the battle. Finding effective measures to achieve the desired results is the other half. Often, a decision support tool, such as the example shown below, can be helpful in identifying opportunities for enhancing competitiveness during various stages of the product life-cycle.

The simple matrix provided in Table 2 can be used at several different levels, depending on what is the evaluation/identification focus:

1. Identify business issues for the organization
2. Evaluate areas for focusing improvement efforts for a specific product-line
3. Benchmark competitive products, to identify areas where there is a competitive advantage to be achieved.

Once the areas for improvement have been identified one can increase the detail of data collected according to the requirements of the improvement and measurement effort.

Table 2. Decision Support Tool to Identify What to Track

	Decision Factor				
Type of Data	**Effect on Cost**	**Effect on Revenu**	**Effect on Liability**	**Ease of Collection**	**Collect Information?**
Resource Productivity	yes	No	no	difficult	Yes
# of product lawsuits	yes	Yes	yes	Moderate	Yes
Supplier environmental performance	no	No	yes	difficult	No
Customer environmental requirements	yes	Yes	yes	Moderate	Yes

Organization of LCM Efforts

Applications of Life-Cycle concepts, including LCA and LCI, have traditionally taken the shape of individual projects operating within the context of operational reviews or product design. This approach is analogous to individual environmental control programs aimed at mitigating a specific issue such as thermal pollution or VOC discharge. Such control programs carry the benefit of specificity, e.g. solutions to a VOC discharge must be highly focused during the design phase in order for them to fully address the problem at hand.

Figure 1 demonstrates one potential organizational scheme for conducting project-level LCM studies. The emphasis in this scheme is on understanding the life-cycle cost, technical, and environmental issues concerning the specific product system of concern. The scheme is designed to be invoked when a decision is necessary and further, life-cycle, information is warranted. It is not designed to become an integrated into all decisions made within an organization.

Incorporation of LCM into all decisions is analogous to the current trend towards managing environmental issues through fully integrated environmental management systems (EMS). Figure 2 shows a schematic representation of an ISO 14001 conforming EMS. One strength of this structure is its logical progression from policy to objectives and targets, through

Figure 1. Example of a Project-Level LCM Protocol[1]

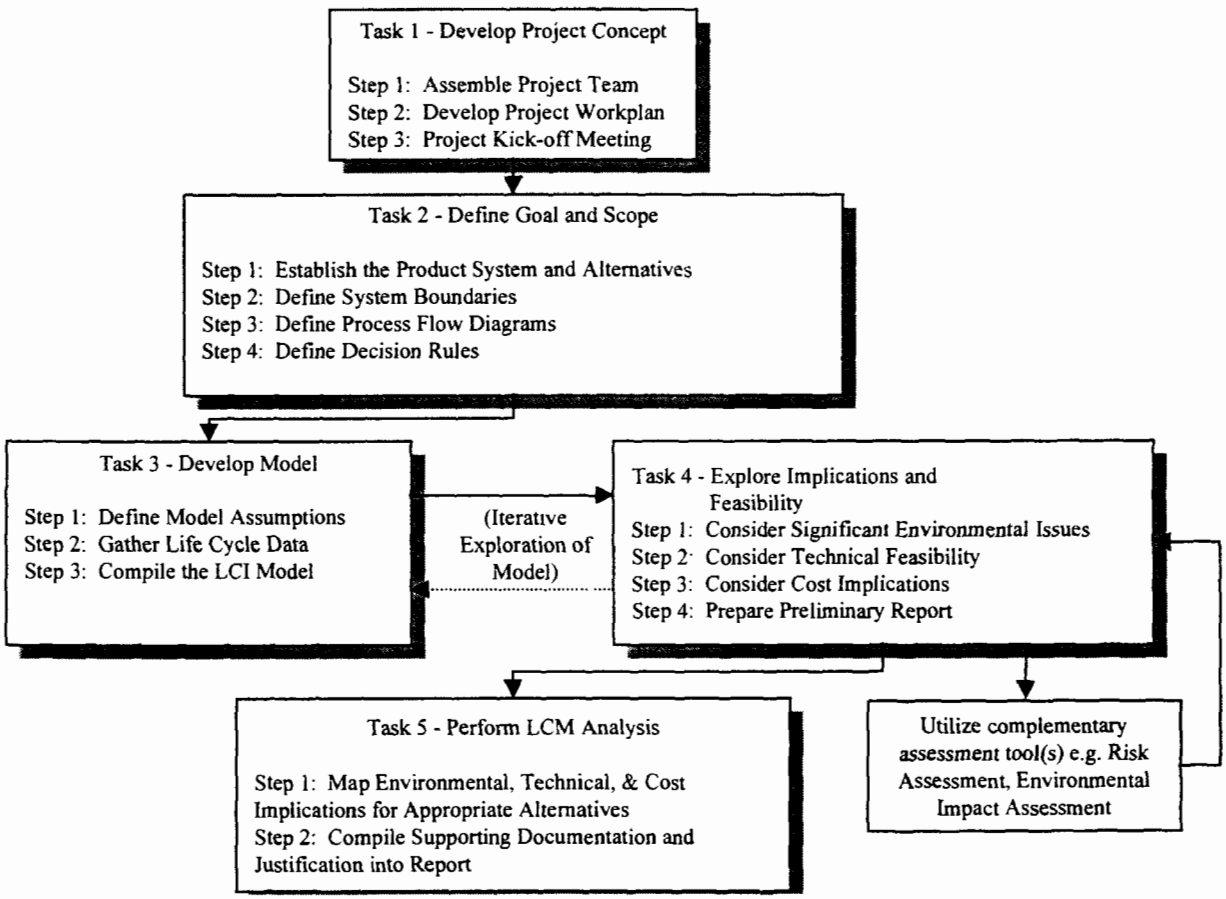
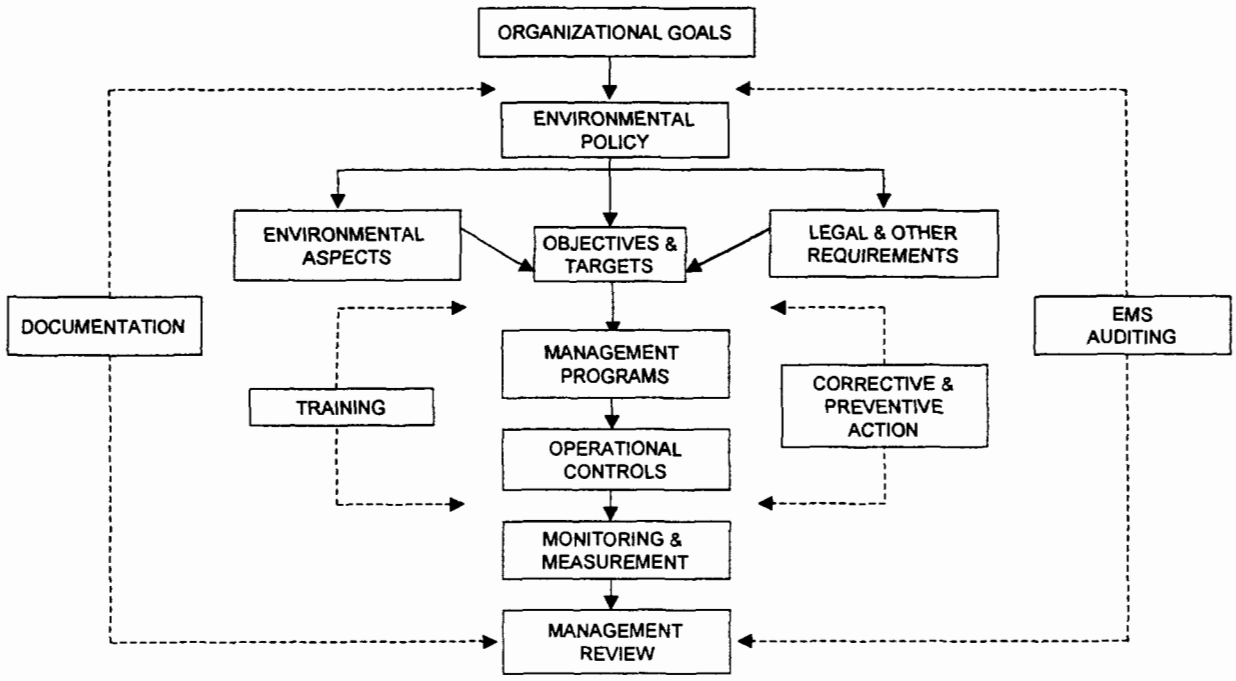


Figure 2. Schematic of an ISO 14001 Conforming Management System



environmental programs, monitoring, and review. Such a structure can easily be applied to a LCM program, allowing the program to formally exist as a part of the organizations overall management plan. Benefits from such integration include:

- Matching of company/organization goals and policies with LCM activities
- Full saturation of LCM concepts through formalized training
- Documentation of LCM activities within standard document and informational control systems
- Communication of LCM progress to maximize public relations and market opportunities
- Management involvement, ensuring the connection between goals and progress

Example of a System-Level LCM Program: Commonwealth Edison

ComEd is the utility company for the Chicago area. Over the last three years ComEd has implemented an intensive LCM program which has produced for the company over $100 million[3] through reduced costs and revenues enhancements during this period. In the threshold of deregulation the company selected LCM as the tool that it uses to review and re-evaluate individual parts of its operations and assets to become more competitive, and consistently improve the value it delivers to the shareholder. Two drivers exist for ComEd's LCM program: Environmental stewardship, and Business performance improvement.

The way their program operates is straightforward. The LCM activities are not separate from normal company operations, but rather are integrated into the way the company routinely addresses decision-making. The company has acquired software tools that are available to

anyone within the company to apply to purchasing decisions. People are stimulated to think about parameters that were not traditionally included in a decision, and thus become able to identify hidden costs that impact the company's financial performance, and take appropriate measures to address these in the most cost effective manner.

The process has been so successful in the company because it has become a natural way of doing business, instead of a function assigned to a particular department. With five people, its core LCM group serves more as a facilitator and coach and a catalyst for applying the technique and thinking process, rather than as a resource for implementation of the results of each analysis. The approach that this group uses to expand the use of LCM in the company includes user-friendly decision-support software, pilot projects, metrics, and publicity. Members of the LCM group spend time working with the appropriate department/group that seeks to apply the techniques to a specific decision, and help them understand its details through analyzing the decision together. Surely, in a short period the knowledge of how to apply the techniques, and the fundamentals of LCM are passed from the LCM facilitator to the group, and thereafter they can apply it where appropriate. In this way, the LCM group becomes a resource to the organization, and the knowledge from the program's implementation is integrated into the culture of the organization. ComEd's ultimate goal for LCM is to have everyone in the company aligned with using new LCM strategies, and eventually share those experiences and practices with their customers as another service the company can offer beyond selling electricity.

Some examples of ComEd's successes through LCM include:

- Conversion of unused oil storage capacity to gas storage in the company's Collins station. The empty tanks had a cost of maintenance of as much as $3 million per year. Now they have been converted to gas storage, and are revenue generators[2].
- Transformer refurbishment and decommissioning. That activity was performed by an outside contractor, and produced a revenue of $263,000. By moving that activity internally, ComEd was able to increase revenue to $900,000 almost immediately, while reducing purchase costs by re-using more of the transformers.
- Coal Ash marketing. Through identifying the potential use of flyash for back-filling, ComEd performed pilot projects in the City of Chicago, and determined that the flyash byproduct of coal combustion was a quick setting flowable alternative to conventional material, and appropriate for marketing and sale to appropriate applications. One such application has been in use of the flyash for stabilization of mined-out areas of an underground limestone quarry. In that way, what was a cost of the coal life-cycle has be turned into a revenue. Total recycle/reuse for flyash has increased to 90%[3].
- Beneficial use of wood chips produced from overhead line clearance activities increased to 96%.
- Nuclear low-level radioactive waste was reduced by half through efforts emanating from waste audits at four nuclear plants.
- Replacement of the biofouling control in steam condensers has dramatically reduced the costs, through elimination of chemicals, and use of dehumidification instead. This also reduced the chemical discharges to waterways dramatically.

Continuous use of the LCM approach will undoubtedly result in a shift of the way the company makes strategic and operational decisions, and subsequently probably improve the company's competitiveness in the long term, through being more effective in identifying improvement opportunities that may not have been previously obvious.

Conclusion

Life-Cycle Management goes beyond being a technique for improving environmental performance. Through integration of environmental and financial parameters companies have been able to utilize this knowledge to identify novel improvement opportunities that help them to *"do well by doing good"*. This is however an approach that will provide most benefits to a company when integrated into the culture of the company and communicated effectively both internally and externally.

Approaches for implementing LCM programs can be organized as both individual projects and/or overall systems integrated into everyday operations. Project-level LCM programs, analogous to LCI and LCA projects, can produce good information to help decisions but can be costly due to ramp-up/ramp-down costs and duplication of effort. The examples available today show strong evidence for adopting system-level LCM programs to maximize efficiency gains while ensuring long-term continuity.

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Doug Heimlich

U.S. EPA
Waste Minimization Branch

"Draft RCRA PBT Chemical List"

Biographical Profile

Doug Heimlich
Program Analyst
U.S. EPA
Waste Minimization Branch

Currently Mr. Heimlich serves as Outreach Coordinator for the Waste Minimization Branch, focused mainly on outreach/marketing communications for the Waste Minimization National Plan, and the recently released Draft RCRA Waste Minimization PBT Chemical List. Mr. Heimlich has been with the Agency for seven years; four of those years he conducted evaluations, Information Collection Requests, and Paperwork Burden Reductions for the RCRA Land Disposal Restrictions Program, as well as writing regulations, before joining the Waste Minimization Branch in 1995.

Mr Heimlich has a B.S. in Journalism from the University of Maryland and a Masters in Public Administration from the George Washington University.

DRAFT RCRA PBT CHEMICAL LIST

1

What This Package Covers

- What are PBT chemicals?
- Why EPA developed the Draft RCRA Waste Minimization PBT Chemical List
- How the Draft List was developed
- The draft List
- How EPA, other government agencies, industry trade associations, individual companies, environmental groups, individuals or other organizations could use the List
- Public comments

2

What are "PBT" Chemicals?

- **Persistent** chemicals do not readily break down in the environment
- **Bioaccumulative** chemicals are not easily metabolized and can accumulate in human or ecological organisms and foodchains through consumption or uptake
- **Toxic** chemicals may be hazardous to human health or the environment in a variety of ways, depending on the chemical and the organism that is exposed
- **PBTs** may be released in very small quantities, even from legally permitted facilities
- **PBTs** are a national and international concern

3

Why Did EPA Develop the Draft RCRA PBT List?

- PBT chemicals pose long term risks
  - PBT chemicals cause chronic human and ecological problems
  - Releases in very small quantities (including permitted facilities) can build up overtime
  - Some PBTs are hard to treat prior to disposal or remove from the environment once released
  - Reducing RCRA waste stream quantities may not necessarily reduce the amount of PBT chemicals in the waste

4

Why Did EPA Develop the Draft RCRA PBT List? (cont'd)

- Extensive public meetings and comments on EPA's waste minimization program focused attention on setting waste minimization priorities to reduce human and ecological risk
- EPA incorporated comments from federal and state agencies, industry associations and companies, environmental groups and citizens into the Waste Minimization National Plan (1994)

5

Why Did EPA Develop the Draft RCRA PBT List? (cont'd)

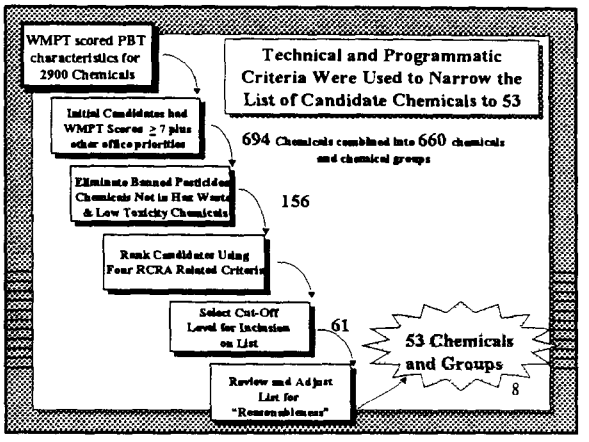
- The Waste Minimization National Plan commits to several national goals
  - Reduce the most persistent, bioaccumulative, and toxic (PBT) chemicals in the nation's hazardous waste 10% in 2000, and at least 50% in 2005
  - Use source reduction measures to reduce generation of PBTs Focus on recycling as 2nd preference over treatment and disposal of hazardous waste
  - Focus on multi-media reductions of chemicals and avoid transferring PBT chemicals to different media
  - Rely on voluntary approaches to encourage source reduction and recycling (many of which may occur in a regulatory setting--e g , promoting source reduction to meet compliance requirements)

6

How Did EPA Develop the Draft List?

- EPA ranked the PBT characteristics of 2900 chemicals using the Waste Minimization Prioritization Tool (WMPT)
- EPA identified several technical and programmatic criteria (described in the next several pages) to narrow the list of candidate chemicals to those which present the greatest concern from a national perspective
- EPA selected 53 chemicals and chemical groups for the Draft RCRA PBT List and is requesting public comment on the List

7



8

Waste Minimization Prioritization Tool (WMPT) Scores PBT Characteristics for 2,900 Chemicals

- WMPT-- Windows-based ranking and screening tool
  - Assigns PBT scores to 2900 chemicals based on scientific study data
  - Displays relative ranking of chemical scores, and scientific data
  - Each chemical receives separate scores from 1 (low) to 3 (high) for P, B, and T
  - The higher of a human concern score ($P+B+T_{Human}$) and ecological concern score ($P+B+T_{Eco}$) was used as the total score for each chemical.
  - Scores range from 3 (lowest) to 9 (highest) for each chemical
- Example
  - Chemical xyz P=3, B=3, T_{Human}=3, & T_{Eco}=2 Total score= 3 + 3 + 3 = 9

9

Initial Candidates: Chemicals With High WMPT Scores, Plus Other EPA Priority Chemicals

- 681 chemicals which received a score of 7 or higher (on a scale of 3-9) for either human health or ecological concerns were considered as initial candidates Some were grouped to match TRI categories, leaving 660 chemicals and chemical groups as candidates for the RCRA PBT List
- 34 chemical priorities from other EPA programs were added to the candidate list
- Initial candidates = 694

10

Eliminated Banned Pesticides, Chemicals not found in Hazardous Wastes, and those with Low Toxicity

- Eliminated banned pesticides
- Eliminated chemicals which are not likely to be found in RCRA hazardous waste based on TRI and NHWCS data
- Checked to ensure no candidates have low toxicity value (T = 1)
- Remaining Candidates = 156

11

156 Chemicals Were Ranked Using Four Criteria

- Four criteria were used to rank the 156 candidates
  - Higher of WMPT human and ecological PBT scores
  - Quantity and frequency in hazardous waste
  - Presence in the environment
  - RCRA programmatic concerns
- Scores were summed and the candidates were ranked-- from highest to lowest score on a scale of 1-100
- The scoring methods used for these criteria are illustrated on the next several pages

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Criterion 1 Higher of WMPT human and ecological PBT scores

Criteria	Data Source	Range	Score
PBT	WMPT	Higher of eco or human WMPT score equals 9	3
	WMPT	Higher of eco or human WMPT score equals 8	2
	WMPT	Higher of eco or human WMPT score equals 7	1
	WMPT	Eco and human WMPT score < 7	0

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Criterion 2 Quantity and frequency in hazardous waste

Criteria	Data Source	Range	Score
Envr'l Presence	Nat'l Sediment Inventory	not on list	0
		1-99 detects	1
		100-999 detects	2
		>999 detects	3
	Fish Advisory Database	no advisories in database	0
		1-9 advisories	1
		10-99 advisories	2
		>99 advisories	3
	ATSDR HazDat Database	no sites reported	0
		1-99 sites	1
		100-499 sites	2
		>499 sites	3

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Criterion 3 Presence in the environment

Criteria	Data Source	Range	Score
Quant/ Prevalence	TRI chemical qty (lbs)	<1	0
		1-1 x 10⁶	1
		>1x10⁶-1x10⁷	2
		> 1x10⁷	3
	TRI # of generators	0	0
		1-9	1
		10-99	2
		>99	3
	NHWCS chemical qty (lbs)	<1	0
		1-100,000	1
		>1x10⁵-1x10⁶	2
		>1x10⁶	3

15

Criterion 3 (cont'd) Presence in the environment

Criteria	Data Source	Range	Score
Quant/ Prevalence	TRI chemical qty (lbs)	<1	0
		1-1 x 10⁶	1
		>1x10⁶-1x10⁷	2
		> 1x10⁷	3
	TRI # of generators	0	0
		1-9	1
		10-99	2
		>99	3
	NHWCS chemical qty (lbs)	<1	0
		1-100,000	1
		>1x10⁵-1x10⁶	2
		>1x10⁶	3

16

Criterion 4 RCRA programmatic concerns

Criteria	Range	Score
RCRA Program Factors	Presence on a list of chemicals that are either DNAPLs "hard to treat" being addressed under the MACT Combustion Rule	4
	Presence on the Toxicity Characteristic List or Appendix VIII list of chemicals, serving as the basis for hazardous waste listings	3
	Presence on the land disposal restrictions universal treatment standard list	2
	Presence on the RCRA Plan of action hazardous waste, the U list of toxic waste, the Appendix VII hazardous waste constituent list, or the Appendix IX ground water monitoring list	1
	Chemical not present on any of the above RCRA lists	0

17

Criterion scores were summed and converted to a scale of 1-100

- The four criteria were weighted equally (i e , each was assigned 25 points)
- Criterion scores (e g , from 0-3) were converted to 25 point scales
- Total points were added for the four criteria

18

Selected Cut-Off Level for Inclusion of Chemicals on The List

- EPA believes a List of 50-60 chemicals is appropriate for a national program in light of limited federal, state and private resources
- EPA narrowed the ranked list of 156 candidates to the 61 chemicals which scored above 50 (midpoint on the scoring scale)
- Candidate List = 61 chemicals and chemical groups

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Final Adjustments

- Programmatic adjustments
  - Added chemicals from the U.S./Canada Binational Agreement Level 1 Chemical List which are production related
  - Eliminated some chemicals
    - chemicals from other programs which had low or no PBT scores
    - a chemical delisted from the TRI
    - chemicals no longer in production
    - isomers of another PBT chemical on the List
- Draft RCRA PBT List includes 53 chemicals and chemical groups

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Data Sources Used in Developing the List in addition to WMPT and RCRA Lists

- Toxics Release Inventory (TRI) (selected TRI as primary database for measuring national PBT reductions in hazardous waste), provides chemical specific data
- Biennial Reporting System, provides supplemental wastestream data
- National Hazardous Waste Constituent Survey (NHWCS)
- EPA's Fish Advisory Database
- National Sediment Inventory
- ATSDR HazDat Database

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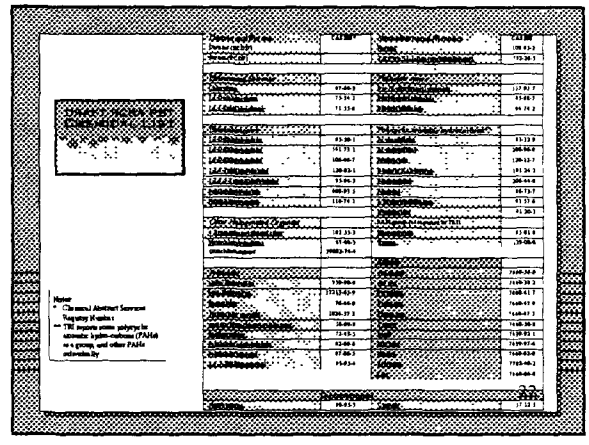

Implemention: How Can EPA, other Government Agencies, Industry, Environmental Groups and Individuals Use the List?

- EPA will work with States, industry associations, individual companies, environmental groups and other interested parties to promote source reduction and recycling measures which reduce the generation of PBTs
- EPA will publish periodic national progress reports through 2005
- Government agencies could use the list to focus pollution prevention technical assistance resources on working with individual companies or industry sectors

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Implementation (continued)

- Government agencies and companies could use the RCRA PBT list to develop Project XL proposals in cases where significant reductions in the generation of PBT chemicals are possible, but regulatory flexibility is needed to achieve the reductions
- Industry trade associations or individual companies could use the list for setting waste minimization priorities and reducing treatment technology costs
- Citizen groups could use the PBT list to leverage pollution prevention efforts during siting hearings or other waste management forums

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EPA Invites Public Comment

- EPA is requesting public comment for 60 days after the publication of the draft RCRA PBT List in the Federal Register
- EPA will hold a public briefing about 2 weeks after the draft List is published
- EPA will convene a focus group about 6 weeks after the draft List is published to discuss the methodology used to develop the List
- EPA will convene public focus groups to discuss implementation approaches in the spring of 1999

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For More Information

- Contact Doug Heimlich (703-308-8489) or Newman Smith (703-308-8757)
- Go to our Webpage @ www epa gov/wastemin
- E-Mail us smith.newman@epamail epa gov

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Daniel Hopkins

U.S. EPA Region 5

"PBT Initiatives"

Dan Hopkins
Bio

- Dan is a Regional Team Manager for the Environmental Protection Agency's Region 5. He leads the Toxics Reduction Team which is responsible for helping to implement the Great Lakes Binational Toxics Strategy with Canada and pursues the reduction of other toxic chemicals in Region 5.

- He has worked in Region 5 EPA for over nineteen years. He has worked in the Air and Superfund programs and has experience as a supervisor, project manager, environmental engineer, and team leader.

- He has a Bachelors-of-Science degree in Chemical Engineering from the University of Illinois.

A Multimedia Strategy for Priority Persistent, Bioaccumulative, and Toxic (PBT) Pollutants

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EXECUTIVE SUMMARY

Purpose and Goal

The goal of this strategy is to further reduce risks to human health and the environment from existing and future exposure to priority persistent, bioaccumulative, and toxic (PBT) pollutants.

The U.S. Environmental Protection Agency (EPA) has developed this draft strategy to overcome the remaining challenges in addressing priority PBT pollutants. These pollutants pose risks because they are toxic, persist in ecosystems, and accumulate in fish and up the food chain. The PBT challenges remaining stem from the pollutants' ability to travel long distances, to transfer rather easily among air, water, and land, and to linger for generations, making EPA's traditional single-statute approaches less than the full solution to reducing risks from PBTs Due to a number of adverse health and ecological effects linked to PBT pollutants -- especially mercury, PCBs, and dioxins -- it is key for EPA to aim for further reductions in PBT risks. The fetus and child are especially vulnerable. EPA is committing, through this strategy, to create an enduring cross-office system that will address the cross-media issues associated with priority PBT pollutants.

Building on a Strong Foundation

This strategy reinforces and builds on existing EPA commitments related to priority PBTs, such as the 1997 Canada – U.S. Binational Toxics Strategy (BNS), the North American Agreement on Environmental Cooperation, and the recently released Clean Water Action Plan. EPA is forging a new approach to reduce risks from and exposures to priority PBT pollutants through increased coordination among EPA national and regional programs. This approach also requires the significant involvement of stakeholders, including international, state, local, and tribal organizations, the regulated community, environmental groups, and private citizens.

Approach to PBT Reductions

1 ***Develop and Implement National Action Plans for Priority PBT Pollutants***. EPA is initially focusing action on the 12 BNS Level 1 substances aldrin/dieldrin, benzo(a)pyrene, chlordane, DDT, hexachlorobenzene, alkyl-lead, mercury and compounds, mirex, octachlorostyrene, PCBs, dioxins and furans, and toxaphene. EPA is developing action plans that will use the full range of its tools to prevent and reduce releases of these 12 (and later other) PBTs. These tools include international, voluntary, regulatory, programmatic, remedial, compliance monitoring and assistance, enforcement, research, and outreach tools. EPA will analyze PBT pollutant sources and reduction options as bases for grouping pollutants, activities, and sectors to maximize efficiencies in achieving reductions. EPA will integrate and sequence actions within and across action plans, and will seek to leverage these actions on international and industry-sector bases.

Activities ready for near-term action include:

- Conduct process-specific and pollution prevention (P2) projects under the mercury action plan, including regulatory actions to reduce mercury and voluntary reductions through potential partnerships with various industries (e.g., chloralkali industry, hospitals using mercury-containing products).
- Focus enforcement and compliance assistance activities on PBTs, analyzing compliance within PBT-related sectors for problems and opportunities Select industries, sectors, or regulations that would benefit from focused compliance attention/assistance. Target actions with high potential to reduce PBT releases.
- Develop or revise water quality criteria for mercury and other priority PBTs, and revise methodology for mercury water quality criteria.
- Conduct research and analysis on PBTs, especially on mercury emission control approaches for coal-fired utility boilers, and on the transport, fate, and risk management of mercury. Develop P2 options for preventing mercury/dioxin risks from industrial combustion.
- EPA is actively engaged in international efforts beyond the BNS to reduce PBT risks, including the recently negotiated Persistent Organic Pollutants (POPs) and Heavy Metals protocols to the UN Economic Commission for Europe's Long Range Transboundary Air Pollution Convention, the preparation for the upcoming negotiation of a global POPs convention under UN Environmental Program auspices, and the Regional Action Plans on DDT, chlordane, PCBs, and mercury developed under auspices of the North American Commission for Environmental Cooperation.

2. ***Screen and Select More Priority PBT Pollutants for Action.*** Beyond the BNS Level 1 substances, EPA will select additional PBT pollutants for action. EPA will apply selection criteria in consultation with a technical panel Candidate chemicals will be those highly scored by EPA's Waste Minimization Prioritization Tool and other chemicals of high-priority to EPA offices. EPA will seek internal and external comment on the proposed selection methodology in 1999.

3. ***Prevent Introduction of New PBTs.*** EPA is acting to prevent new PBT chemicals from entering commerce by. (a) proposing criteria for requiring testing/restrictions on new PBT chemicals; (b) developing a rule to control attempts to re-introduce out-of-use PBT chemicals into commerce; (c) developing incentives to reward the development of lower-risk chemicals as alternatives to PBTs; and (d) documenting how PBT-related screening criteria are taken into account for approval of new pesticides and re-registration of old pesticides.

4. ***Measure Progress.*** EPA is defining measurable objectives to assess progress. EPA will use direct and indirect progress measures, including: (a) human health or environmental indicators (such as National Health and Nutritional Examination Surveys and a national study of chemical residues in fish); (b) chemical release, waste generation or use indicators (such as enhancing the Toxics Release Inventory and using other release reporting and

monitoring mechanisms); and, (c) program activity measures (such as EPA compliance/enforcement data).

Mercury -- An Action Plan Example

EPA's PBT Strategy is a living document that supports the development and implementation of action plans on priority PBTs. Attached to the strategy is EPA's draft Mercury Action Plan. It illustrates an action plan that is national and even international in scope, and describes the kinds of actions EPA may take to reduce risks posed by other priority PBT pollutants. Each substance or group of substances will present its own set of action opportunities.

A MULTIMEDIA STRATEGY FOR PRIORITY PERSISTENT, BIOACCUMULATIVE, AND TOXIC (PBT) POLLUTANTS

I. PURPOSE -- THE CASE FOR COORDINATION

A key purpose of this strategy is to overcome the remaining challenges in addressing priority persistent and bioaccumulative toxic (PBT) pollutants. EPA has a long history of successful programs in controlling PBT pollutants -- pollutants that are toxic, persist in the environment, and bioaccumulate in food chains, and thus pose risks to human health and ecosystems The challenges remaining on PBT pollutants stem from the fact that they transfer rather easily among air, water, and land, and span boundaries of programs, geography, and generations, making single-statute approaches less than the full solution to reducing these risks To achieve further reductions, a multi-media approach is necessary Accordingly, EPA is committing, through this strategy, *to create an enduring cross-office system that will address the cross-media issues associated with priority PBT pollutants*

Many single-medium offices have established a sequence of activities aimed at further reducing PBT risks within their media To better address the cross-media aspects of PBT pollutants, however, EPA programs must integrate their work across media more thoroughly and align their domestic and international activities more effectively The intention of this strategy is to make the whole of the Agency's efforts on PBT pollutants more than the sum of its parts. EPA will coordinate its use of statutory authorities and resources to maximize public health and environmental protection. Environmental results anticipated from implementing this strategy will derive from stronger multi-media coordination among national and regional EPA programs, and through the significant involvement of stakeholders.

Groups outside EPA also recognize the need for a cross-program, multi-media approach to environmental problems like PBTs Recommendations consistent with this strategy are in three recent reports: (a) the 1998 Natural Resources Defense Council Report, "Contaminated Catch – The Public Health Threat from Toxics in Fish" (prevent persistent pollution, control pollutants that cross media); (b) the National Academy of Public Administration's 1995 Report, "Setting Priorities, Getting Results – A New Direction for EPA" (set priorities by risk, integrate efforts across media/statutes); and, (c) the Organization for Economic Cooperation and Development's (OECD) 1996 Report, "Environmental Performance Review of the United States" (coordinate/integrate EPA chemical programs with EPA media programs)

II. GOAL -- REDUCE RISKS FROM PBT POLLUTANTS

The goal of this strategy must be measurable in terms of environmental results. **EPA's strategic goal is to identify and reduce risks to human health and the environment from**

current and future exposure to priority PBT pollutants. PBTs are associated with a range of adverse human health effects, including effects on the nervous system, reproductive and developmental problems, cancer, and genetic impacts. People who eat large amounts of fish from local waters contaminated with certain PBTs are at risk for adverse effects. The developing fetus and young child are at particular risk for developmental problems. Birds and mammals at the top of the food chain are also at risk. The most famous example is the serious decline of the bald eagle in the 1960's because the fish they ate contained DDT. The DDT did not kill them or make them sick, but it did make their eggshells so thin it seriously threatened their ability to reproduce.

Characterizing Chemicals as Persistent, Bioaccumulative, and Toxic

This strategy characterizes PBT chemicals as those that partition primarily to water, sediment or soil, and are not removed at rates adequate to prevent their bioaccumulation in aquatic or terrestrial species. Chemicals characterized as suspected persistent bioaccumulators typically have been confirmed as such based on accepted test methods. Follow-on toxicity testing leads to their identification as persistent and bioaccumulative toxic chemicals.

III. FOUNDATION AND GUIDING PRINCIPLES

Building on a Strong Foundation. This strategy reinforces and builds on an existing federal commitment to deal with PBT pollutants. EPA's commitment to control, remediate, and prevent releases of PBTs (such as lead, mercury, PCBs, and DDT) is reflected in efforts that span 25 years. Among EPA's current commitments on PBTs are the 1997 Canada-U S. Strategy for the Virtual Elimination of Persistent Toxic Substances in the Great Lakes (Binational Toxics Strategy or BNS), its cross-Agency Task Forces on lead, mercury, and dioxin, its Waste Minimization National Plan, its Contaminated Sediment Management Strategy, its recently announced Clean Water Action Plan, and the PBT emphasis in its new Chemical Right-to-Know program announced by the Vice President in April 1998.

Identifying and managing PBT pollutants is a priority for key international organizations at both regional and global levels.[1] Recognizing that many PBTs circulate at regional and even global scales, nations find they must cooperate to reduce PBT risks. Often spurred by U.S Government leadership, these international organizations are developing and implementing risk reduction measures ranging from technical assistance programs to build institutional capacities for dealing with PBTs to legally-binding international agreements for phasing out production and use of selected PBTs.

[1]PBT pollutants are addressed by such fora as the North American Commission for Environmental Cooperation (CEC), the UN Economic Commission for Europe Convention on Long Range Transboundary Air Pollution (LRTAP), the Arctic Council, the UN Environment Program (especially its negotiations on a global Persistent Organic Pollutants Convention), and the Intergovernmental Forum on Chemical Safety (IFCS)

Guiding Principles. EPA will follow these principles in carrying out its PBT strategy:

* Address problems on multi-media bases through integrated use of all Agency tools
* Coordinate with and build on relevant international efforts.
* Coordinate with relevant Federal programs and agencies.
* Emphasize cost-effectiveness (e.g., amount of PBT removed per dollar spent).
* Involve stakeholders
* Emphasize use of innovative technologies and pollution prevention
* Protect vulnerable sub-populations.
* Base decisions on sound science.
* Use measurable objectives and assess performance (see page 10 on GPRA).

IV. APPROACH TO PBT RISK REDUCTIONS

Four elements are central to EPA's PBT strategy. They are: (1) developing and implementing national action plans for priority PBT pollutants using the full range of EPA tools to achieve risk reduction, (2) screening and selecting more priority PBT pollutants for action; (3) preventing the introduction of new PBT pollutants into commerce; and, (4) measuring progress by linking activities to environmental results. All of these elements require a heightened level of multi-office integration in planning, budgeting, and implementation. Figure 1 on page 7 shows the framework EPA is using to carry out these elements.

Below is a description of activities being undertaken in 1998-1999. Following that is a more detailed explanation of each of the four strategy elements.

Activities Underway or Planned for Near-Term Action[2]

Offices abbreviated in parentheses are funding the stated activity. Generally, all other offices are also participating.

- ***Develop and Integrate National Action Plans.***
  - Support/build upon evolving BNS Level 1 action plans as bases for developing national action plans on 12 Level 1 pollutants (as listed on p. 6) (GLNPO, OIA, OW -- Fall 1998 - ongoing).
  - Focus on appropriate risk, use, and release reduction actions, and sequence them as needed for implementation. When possible, group chemicals for action to achieve efficiency and consistency (Fall/Winter 1998 - ongoing).
  - Align work and roles across Headquarters and Regional programs to prepare for implementing action plans (OPPTS, OSWER, Regions -- Fall 1998 - ongoing).

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[2]Office abbreviations for this section are OAR (Office of Air and Radiation), OECA (Office of Enforcement and Compliance Assurance), OIA (Office of International Activities), OPPTS (Office of Prevention, Pesticides, and Toxic Substances), ORD (Office of Research and Development), OSWER (Office of Solid Waste and Emergency Response), OW (Office of Water) and GLNPO (Great Lakes National Program Office).

- ***Engage Stakeholders Nationwide*** (OPPTS).
  - Engage stakeholders on (1) draft strategy, (2) development/implementation of action plans, and (3) criteria for selecting more PBTs for action (Fall 1998 -- ongoing).

- ***Implement Process-Specific and Pollution Prevention (P2) Projects Under Draft Mercury Action Plan*** (OAR, OECA, OPPTS, OSWER, OW, Regions).
  - Use regulatory authorities to reduce mercury emissions. (Recently-final municipal waste combustor and medical waste incinerator rules will get significant reductions.) Evaluate linkages between air emissions and water quality impacts for targeted, regulatory action. Develop pollution prevention (P2) guidelines and incentives in rulemakings addressing mercury (Summer 1998 and ongoing).
  - Seek voluntary reductions in uses of mercury through partnerships with the chlor-alkali industry, hospitals using mercury-containing products, laboratories, and manufacturers and users of mercury switches (Fall 1998 and ongoing).
  - To improve citizens' right-to-know on mercury, seek to lower the reporting threshold for mercury under the Toxics Release Inventory, which could lead to more reporting of mercury releases (end of 1998).

- ***Focus Enforcement and Compliance Assurance Activities on PBTs*** (OECA, Regions, Winter 98/99 - ongoing).
  - Analyze compliance within PBT-related sectors to identify problems and opportunities for action.
  - Select industries, sectors, or regulations that would benefit from focused compliance attention and/or assistance.
  - Target actions with best potential to reduce PBT releases.
  - Develop Supplemental Environmental Projects and models to use with enforcement actions to enhance P2/reduction opportunities.

- ***Identify PBT chemicals to measure national reductions in hazardous wastes*** (OSW, Regions).
  - Using the Waste Minimization Prioritization Tool and selection criteria reflecting Resource Conservation and Recovery Act (RCRA) concerns, publish a draft RCRA PBT List in a *Federal Register* notice (early November 1998).
  - Hold stakeholder meetings to discuss criteria (Fall 1998).
  - Finalize and release list of RCRA PBT chemicals (Winter 1998/99).

- ***Develop or Revise Water Quality Criteria*** for mercury and other specific priority PBTs. Revise methodology for mercury water quality criteria. (OW, Spring 1999)

- ***Support International Efforts beyond the Binational Toxics Strategy*** (OAR, OECA, OIA, OPPTS, ORD, OSWER, OW, 1998 and ongoing).

- Support the North American Commission for Environmental Cooperation's (CEC) Sound Management of Chemicals work program, including the implementation of the Regional Action Plans on DDT, chlordane, PCBs, and mercury.
- Promote the early implementation of the Persistent Organic Pollutants (POPs) and Heavy Metals Protocols recently negotiated under the UN ECE's Convention on Long Range Transboundary Air Pollution.
- Provide leadership in the negotiations on a global POPs convention under the auspices of the UN Environment Program.
- Continue working with developing countries to phase out use of lead in gasoline.

- ***Conduct Research and Analysis on PBTs*** (ORD, OAR, OPPTS, OSWER, OIA, Regions, 1999 and ongoing).
  - Develop/promote mercury emission control approaches for coal-fired utility boilers.
  - Conduct research on mercury and POPs transport, fate, and risk management.
  - Use P2 tools (Design for the Environment tools, environmental accounting materials management, etc.) in voluntary components of action plans.
  - Develop and improve test methodologies for environmental persistence.
  - Conduct Science Workshops on mercury and emerging PBTs.
  - Develop P2 options for mercury and dioxin risks from industrial combustion.
  - Publish "Status and Needs" paper on use of bioaccumulation data to assess sediment quality (Fall 1998).

- ***Screen and Select Additional Priority PBTs for Action*** (OPPTS, OSWER, Regions).
  - Finalize Waste Minimization Prioritization Tool for use in prioritizing PBTs (Summer 1998).
  - Catalog chemicals and modify data systems as needed (Fall 1998 - ongoing).
  - Select chemicals beyond the Level 1 list (1999).

- ***Prevent the Introduction of New PBT Chemicals*** (OPPTS-led).
  - Propose criteria for requiring testing/restrictions on new PBTs (Fall 1998).
  - Develop rule to control re-introducing out-of-use PBTs into commerce (1999).
  - Develop incentives to reward development of lower-risk alternatives to PBTs (Ongoing).
  - Document how PBT screening criteria are taken into account when approving new pesticides and re-registering existing ones (Fall 1998)

- **Measure Progress** (OAR, OECA, OPPTS, OSWER, OW, OIA, Regions).
  - Help develop *National Health and Nutrition Examination Surveys* to analyze U.S population for pesticides/dioxin in serum, and mercury in blood/hair (Summer '98).
  - Begin working with the National Institutes of Health (NIH) to monitor PBTs in fetal cord blood of Alaskan native groups (Fall 1998 - ongoing).
  - Design and peer review *National Study of Chemical Residues in Fish* for estimating trends in environmental measures (1998-early 1999). Begin sampling in 1999.
  - Propose a rule adding dioxins/possibly other PBTs to the Toxics Release Inventory (TRI); lower reporting thresholds for dioxins and PBTs listed on TRI (end of 1998).

Update air emission inventory, especially for dioxin/mercury sources (Fall 1998 - ongoing), and support coal sampling and stack testing for mercury at utilities (Fall 1998 - ongoing).

- Design activity measures (1999).

Strategy Elements

1. Develop and Implement National Action Plans

Developing National Action Plans. In this strategy, EPA is affirming the priority given by the United States and Canada to the Level 1 substances under the Binational Toxics Strategy (BNS), and making these substances the first focus for action. The Level 1 substances are:

aldrin/dieldrin	mercury and compounds
benzo(a)pyrene	mirex
chlordane	octachlorostyrene
DDT(+DDD+DDE)	PCBs
hexachlorobenzene	PCDD (Dioxins) and PCDF (Furans)
alkyl-lead	toxaphene

EPA is focusing on these substances first because the BNS reduction goals for them are national, and most of these substances are already targets of existing and pending international agreements. EPA believes there is much to gain by building on the efforts of its Great Lakes National Program Office (GLNPO) and EPA Region 5 to virtually eliminate these PBT pollutants in the Great Lakes Basin.

EPA will use the work plans being developed by BNS multi-stakeholder work groups as starting points for national action plans under this strategy. The BNS framework relies heavily on stakeholder involvement, and has a preference for voluntary action when adequate to meet BNS goals. BNS work plans will likely yield regionally-specific model actions that can serve as foundations for national action plans under this strategy. EPA is evaluating whether, for the Level 1 substances, assembling national workgroups (or some other configuration) to involve Regions and complement BNS workgroups may help in the timely development of national action plans. For a summary of linkages between this strategy and the BNS, see page 15

National action plans will draw on the full array of EPA statutory authorities and national programs. EPA may use regulatory action where voluntary efforts are insufficient. EPA will likewise pursue, in the short-term or longer-term as appropriate, actions for enforcement of and compliance with current regulations, international coordination, place-based remediation of existing PBT contamination, research, technology development and monitoring, community and sector-based projects, and use of outreach and public advisories. EPA will focus on action, while bearing in mind the need to address uncertainties and data gaps through data collection and scientific and technical research. EPA will sequence activities to lay any groundwork necessary for longer-term action.

Strategy Elements Framework

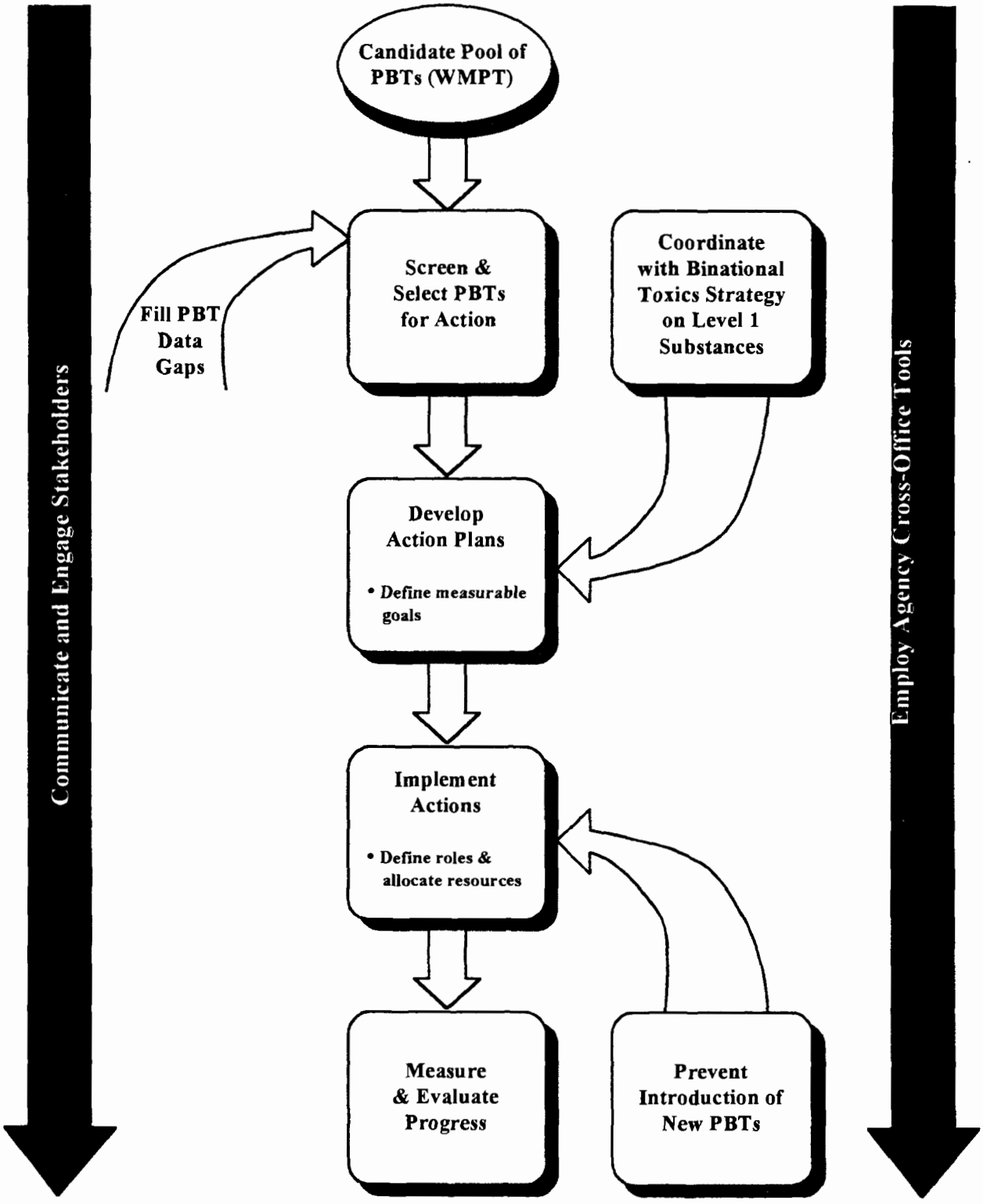

Figure 1.

The Draft Mercury Action Plan in *Attachment 1* illustrates how EPA can coordinate the use of its tools to achieve reductions for a PBT pollutant. This plan represents EPA's preferred approach, since it involves multi-media and cross-office actions, quantitative challenge goals, stakeholder engagement, international coordination, and long-term emphasis on pollution prevention. Such an action plan is possible because EPA has extensive knowledge of and a mature program on mercury, more so than for most other PBT pollutants. Action plans for banned substances like canceled pesticides or PCBs, or substances with much less risk characterization like octachlorostyrene, will differ substantially from the draft mercury action plan. EPA has begun implementing some reduction activities for mercury. See the next section and *Appendix B* for the status of developments on all 12 BNS Level 1 substances.

Maximizing Opportunities for Integration. As EPA develops action plans, it will align program efforts and integrate actions across media. Whenever possible, EPA will address groups of pollutants rather than individual pollutants, to prevent or reduce risks for multiple pollutants at the same time. As individual action plans mature, EPA may see opportunities to integrate activities in ways that achieve greater cost savings in amounts of each PBT removed per dollar spent. EPA may also be able to identify facility-wide pollution prevention and technology transfer opportunities for specific industry sectors. Maximizing opportunities for integration will avoid transferring problems across media or to chemical substitutes.

Implementing PBT Reduction Actions. Some of the activities being planned for the 12 BNS Level 1 substances are already reasonably well outlined This is especially true for mercury, as noted above on pages 4 and 6. What follows highlights some of the activities on some of the other 11 substances on the BNS Level 1 list.

- EPA will prepare a BNS status report by December 31, 1998 on the use or release of chlordane, DDT, aldrin-dieldrin, mirex, and toxaphene from sources that enter the Great Lakes Basin. EPA will continue "Clean Sweeps"[3] in the Great Lakes Basin, and will seek to extend Clean Sweeps on a national basis. EPA will work with Mexico to reduce DDT/chlordane reliance, speed registration of reduced-risk pesticides, and encourage states' promotion of biological controls through State Management Plans.

- EPA will prepare a BNS status report by December 31, 1998 on alkyl-lead to confirm no use in automotive gasoline. EPA will encourage stakeholder minimization of use/release from aviation and racing sources in the Great Lakes Basin, and will seek to extend these efforts on a national basis.

- EPA will publicly release the final Dioxin Reassessment in Spring 1999.

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[3] Agricultural "Clean Sweeps" is a popular term for waste pesticide collections undertaken at State and local levels to dispose of pesticides that are suspended, canceled, or no longer fit for use States conduct Clean Sweeps as a prudent investment to avoid potential spills and costly clean-up.

2. Screen and Select More Priority PBT Pollutants for Action

Looking beyond its initial focus on the BNS Level 1 substances, the Agency will screen and select additional PBT pollutants for action. It is likely that the opportunities for pollution prevention will be greater for the additionally selected PBT pollutants. EPA will use a primary and secondary screening process to make these selections.

Primary Screening: Preliminary Criteria. EPA will apply a primary screening process to candidate PBT pollutants EPA is defining candidate pollutants as (a) those highly scored by EPA's *Waste Minimization Prioritization Tool* (WMPT) for human or ecological concern, and (b) other high-priority chemicals for EPA headquarters and regional program offices. The WMPT prioritizes chemicals based on their cumulative persistence, bioaccumulation, and chronic human and ecological toxicity. The purpose of the primary screen is to reduce the number of candidate pollutants under consideration. A chemical will pass the primary screen if it meets at least one of the following criteria:

- The chemical is currently produced within the U S. or imported;
- The chemical is being released to the environment;
- The chemical is generated/managed in waste; or
- The chemical has been detected in the environment at levels of concern (as yet undefined).

Secondary Screening: Ranking Criteria and Technical Panel. EPA will then use secondary criteria to rank those PBT pollutants that pass the primary screen. EPA's Office Directors and the PBT Plenary Group are developing the secondary criteria. EPA is carefully crafting these criteria to represent its priorities and will define them, in part, by the availability of sound scientific and technical data. The criteria will be related to PBT characteristics (especially hazard), potential exposure, pollution prevention opportunity, and suitability for an EPA-wide national focus (including potential for grouping chemicals for action). EPA will apply the secondary criteria in consultation with a technical panel which, in turn, may consult with a network of experts to ensure that chemical selection is based on sound science. Details about the selection criteria, process, and technical panel remain under development.

The proposed methodology will undergo internal and external review in 1999. The methodology and decisions will also be periodically reassessed as more data become available that may affect EPA's selection process.

3. Prevent the Introduction of New PBT Pollutants

EPA will be taking four actions to prevent new PBT chemicals from entering commerce, using authorities under the Toxics Substances Control Act (TSCA) and the Federal Insecticide, Fungicide and Rodenticide Act.

- EPA will propose a PBT category for screening new chemicals, to enhance EPA's ability to evaluate the potential risks of new PBTs and to use testing requirements and other restrictions as necessary to protect the public. Under its TSCA-based New Chemicals Program, EPA groups new chemicals with shared structural and toxicological properties into categories. These categories allow submitters of Premanufacture Notices and EPA reviewers to benefit from accumulated data and decisional precedents. If EPA identifies a new substance as being in the PBT category, EPA will evaluate the potential health or environmental concerns associated with the category, and the potential exposures and releases of the new chemical. If EPA concludes the new substance may pose an unreasonable risk to human health or the environment, EPA may require testing and restrictions.

- EPA will develop a significant new use rule to control attempts to re-introduce out-of-use PBT chemicals into commerce. This rule will apply to PBTs previously in commerce but not being manufactured, as identified from updated reporting on U.S. production, including polychlorinated terphenyls and hexachlorobenzene.

- EPA is developing incentives to reward the development of lower-risk chemicals as alternatives to existing, higher-risk PBT chemicals. EPA will create these incentives through its New Chemicals Program and its green chemistry activities

- EPA will document how PBT-related screening criteria are taken into account for approval of new pesticides and re-registration of existing ones. EPA will seek acceptance of these criteria by international organizations working on persistent organic pollutants (POPs), including the OECD chemical/pesticide program, the Binational Toxics Strategy, the IFCS, and the CEC.

4. Measure Progress: Link Activities to Environmental Results

EPA will measure progress on actions under this strategy through: (1) environmental or human health indicators, (2) chemical release, waste generation, or use indicators, or (3) programmatic output measures. EPA believes that tying its indicators of progress to environmental results through real world measures (e.g., reduced levels of PBTs in human blood or fish tissue) will encourage the Agency and its stakeholders to think creatively about how to achieve the progress in risk reduction that both seek.

This approach to measuring progress meets the requirements of the Government Performance and Results Act of 1993 (GPRA). GPRA requires federal agencies to define measurable goals and objectives, measure progress, and report accomplishments. Appendix A shows that the goal of this strategy matches EPA's goals and objectives under GRPA, including Goal # 1 clean air, Goal # 2 clean and safe water, Goal # 4 preventing pollution and reducing risk, Goal # 6 reducing global and cross-border environmental risks, Goal # 8 sound science, and Goal # 9 credibly deterring pollution and increasing compliance with the law.

EPA will use the following measures to track progress in reducing risks from PBT pollutants, as shown in Figure 2. EPA will evaluate and use other progress measures as appropriate.

- **Human Biomarkers.** EPA will use the National Health and Nutrition Examination Surveys (NHANES) as its primary measure of human exposure. Conducted by the CDC's National Center for Health Statistics (NCHS), NHANES trace the health and nutritional status of U.S. civilians. Surveys use adult, youth, and family questionnaires, followed by standardized physical examinations. The primary NHANES objective is to obtain national population health and nutrition parameters, using suitably precise estimates for age, gender, and race/ethnicity (whites, blacks, and Mexican-Americans). EPA expects NHANES IV to analyze most Level 1 substances. EPA has worked with NCHS to add analysis for mercury in blood and hair for some survey participants. EPA also will begin working with NIH and other U.S. government entities to conduct fetal cord blood monitoring for PBTs in Alaskan native groups.

- **Food Chain/Environmental Measures.** A cornerstone of the measurement effort will be a National Study of Chemical Residues in Fish. This EPA study will statistically evaluate the incidence and severity of mercury and other PBT residues in fish, both downstream from suspected problem areas and in background areas. On a national basis, the study will calculate concentrations of priority PBT chemicals in fish. On a regional basis, it will also calculate concentrations of some other PBT chemicals in fish. The study will allow for estimating trends over time. EPA will work with State Departments of Health and Environmental Protection, coordinating with state fish advisory programs to help fill data needs identified in the survey. Study design and peer review will be completed in fiscal year 1998 (FY98) or early FY99. Sampling begins in FY99 and concludes in Summer FY01. Study results will be available in FY02

- **Environmental Release Data.** To help characterize trends in environmental releases and waste management, EPA intends to propose a rule to add dioxins and possibly other PBT substances to the Toxics Release Inventory (TRI). This rule will also propose lowering reporting thresholds for PBT chemicals -- some already listed on TRI, like mercury and mercury compounds, and some being added, like dioxins. Lowering reporting thresholds could increase reporting of PBT chemicals and thereby enhance TRI's value for tracking progress in reducing PBT pollution. Plans are to propose the TRI PBT rule by close of 1998 EPA expects a final rule by the end of 1999, with reporting to begin in 2000. The first public release of the data obtained through the TRI PBT rule would be in 2001.

  Reductions of volumes of hazardous wastes containing PBTs will also be measured using the 1991 Biennial Reporting System[4] data as a baseline on hazardous waste generation

[4] The Biennial Reporting System contains data on hazardous waste generation and management for facilities regulated by the Resource Conservation and Recovery Act (1976). EPA collects the data every two years pursuant to the Hazardous and Solid Waste Amendments of 1984, and publishes it in the Biennial RCRA Hazardous Waste Report.

trends. Reductions of specific high-priority PBT chemicals in hazardous wastes will also be measured using TRI data. Reductions of chemicals in hazardous wastes is one indicator of whether the reductions are occurring at the source, prior to generation of hazardous wastes. EPA will use these methods to report progress on reducing PBTs in hazardous wastes by 50% by 2005, a subobjective under GPRA Goal 4 (see discussion of GPRA on page 10).

Beyond TRI, EPA will also evaluate the results of ongoing monitoring programs, such as the Integrated Atmospheric Deposition Network and those used by other Federal agencies like the U.S. Geological Survey. EPA will also evaluate and support improving outputs from international monitoring and modeling programs. These include national emission inventories and related modeling of long-range transboundary fluxes, conducted pursuant to the POPs and heavy metals protocols to the UN ECE's Convention on Long Range Transboundary Air Pollution.

- **Activity Measures**. EPA will also use PBT-related activity measures, especially at the start, since risk reductions might not be readily apparent in the short term. Activity measures include negotiation and implementation of international agreements; Federal or State compliance assistance; public/industry workshops and educational outreach; pollution prevention agreements or other voluntary activities by the regulated community; focused compliance monitoring and enforcement; and regulatory and permitting changes.

V. MANAGING FOR SUCCESS

To manage the effort under this strategy, EPA will rely on sustained senior-level support, a strong organizational structure for coordination, sustained resources, a well-defined framework for carrying out the elements of this strategy, and stakeholder involvement.

Managing the Implementation of the Strategy

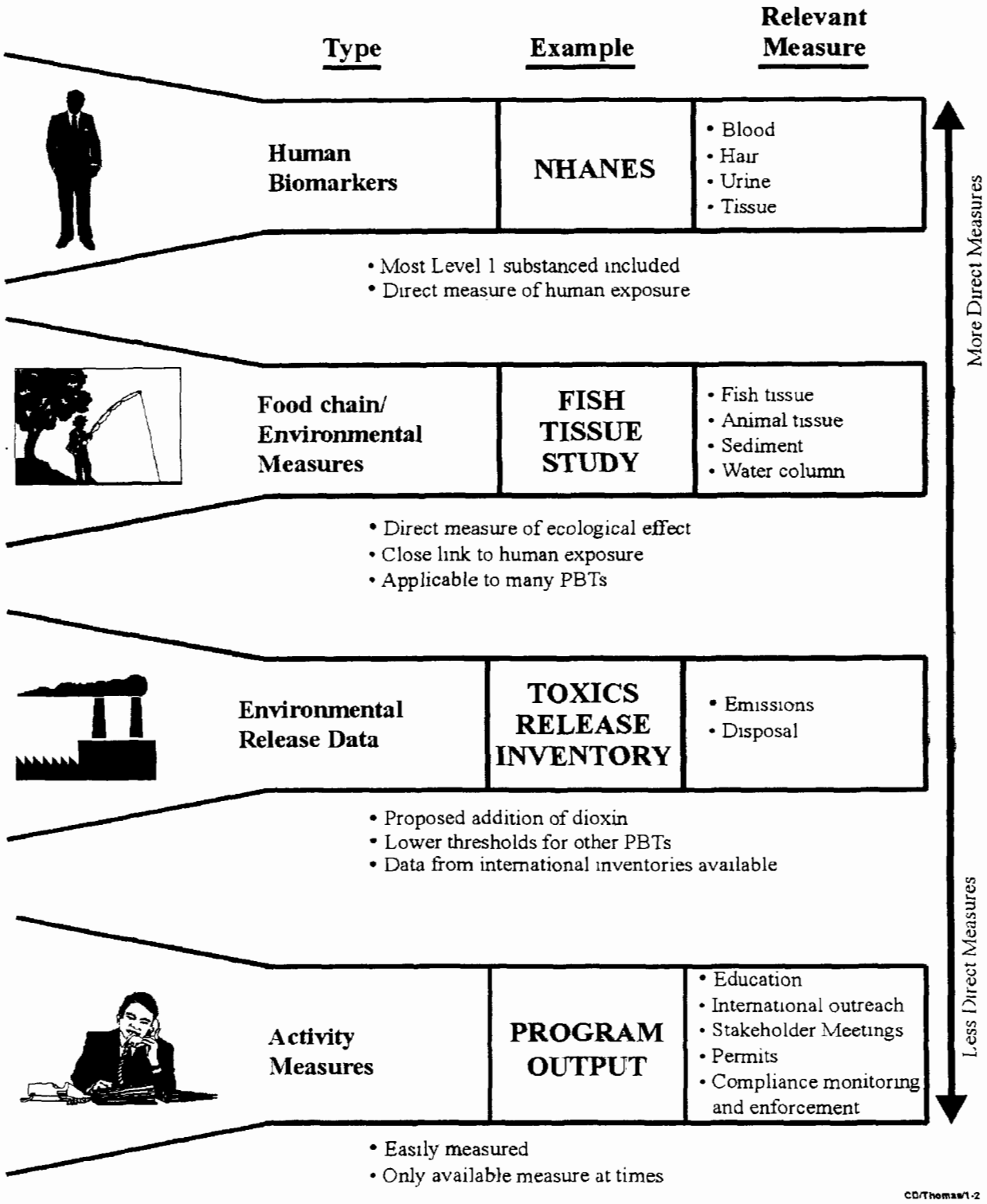
EPA is using the following organizational structure to coordinate and sequence activities under this strategy.

- The PBT Plenary Group, a body of EPA personnel instrumental in developing this strategy, will be responsible for integrating actions across Agency programs and recommending action priorities. This group will forward its recommendations to the Office Directors for decisions. It will also help track progress toward the strategy's goals.

- EPA's Office Directors' Multi-Media and Pollution Prevention Forum will define actions to be taken each fiscal year, based on Plenary Group recommendations. The Forum will also incorporate these actions into EPA's program planning process, and evaluate progress on activities towards the strategy's goal.

Figure 2

A Continuum of Activities that Measure Environmental Results



- Program and Enforcement Offices at the Headquarters and Regional levels will implement defined actions with the support of ad-hoc groups such as the Mercury Task Force and Dioxin Assessment Group. EPA has also established a network of Regional PBT contacts to facilitate these efforts at the Regional level.

Establish Linkages Among Current Program Efforts

Establishing linkages among programs is key to achieving the goal of this strategy.

Linkages with the Canada – U.S. Binational Toxics Strategy. EPA is coordinating its implementation of this strategy with that of the Binational Toxics Strategy. These efforts mutually contribute to the success of one another, as summarized in Table 1.

Table 1. Relationship Between the PBT Strategy and Binational Toxics Strategy (BNS)

Binational Strategy	PBT Strategy
Initial focus on Level 1 substances	Initial focus on Level 1 substances. Will select additional substances, providing a basis for BNS implementation decisions on Level 2 substances.
Much of the focus is regional in scope for water, and national in scope for air.	National in scope for all media, including Everglades, Gulf of Mexico, Chesapeake Bay, Lake Champlain.
Establishes quantitative challenge goals for virtual elimination of Level 1 substances	Provides scientific support for deciding whether more action is needed after challenge goals are met.
Progress tracking and accountability related to specific reduction (use/release) goals.	Builds on use/release tracking of BNS and expands progress tracking to measures closer to human and ecological levels and effects.
Identify key stakeholders and bring stakeholders' current technology to light	Coordinates research on new technologies and provides Agency tools such as environmental accounting, models, etc.
Specifies coordination with international efforts to ensure consistency	Expands coordination with international efforts

Linkages with International Chemical Management Efforts. To the extent that international voluntary activities and legally-binding agreements result in meaningful PBT risk reductions in other countries, these international steps would be a positive complement to this strategy. Likewise, domestic actions implemented by this strategy could serve as models for other countries. A number of international efforts in which EPA participates, including those listed below, are relevant to this strategy.

- The North American Commission for Environmental Cooperation (CEC), made up of the U S., Canada, and Mexico, is conducting a Sound Management of Chemicals Program.

- Through CEC, the U.S is working to implement Regional Action Plans on DDT, chlordane, PCBs, and mercury.
- EPA is continuing long-standing efforts to provide technical assistance to developing countries to eliminate the use of lead in gasoline.
- EPA is supporting the implementation of the Persistent Organic Pollutants (POPs) and Heavy Metal Protocols to the UN ECE's LRTAP Convention.
- EPA is a key US government participant in the ongoing negotiations of a global POPs Convention under UNEP auspices.

Linkages with the Waste Minimization National Plan. EPA is coordinating this strategy with its Waste Minimization National Plan which EPA launched four years ago. Supporting this National Plan is EPA's GPRA subobjective to "reduce the most persistent, bioaccumulative, and toxic chemicals in hazardous waste 50% by the year 2005 " In furtherance of the Plan and this subobjective, EPA: (1) has developed the Waste Minimization Prioritization Tool ; (2) is proposing this fall and finalizing this winter a list of those PBTs of most concern for tracking national reductions in hazardous wastes; (3) is using the RCRA Implementation Plan and its guidance on core measures for National Environmental Performance Partnerships with states to reinforce the PBT reduction goals for hazardous wastes; and, (4) will be finalizing methods this year to measure reductions of PBTs in hazardous wastes and reductions of hazardous wastes containing PBTs. The PBT Strategy will likewise be making use of the Waste Minimization Prioritization Tool and will seek consistency with other activities of the Waste Minimization National Plan to the maximum extent possible

Linkages with Sector- and Community-Based Efforts. The chemical-based PBT Strategy is complementary to sector-based and place-based approaches. Aspects of this strategy – assessing risk, overcoming single-medium approaches in establishing national baseline regulations and policies, targeting research, controlling more PBTs from entering commerce, creating incentives for safer substitutes, and facilitating coordination with U.S. and international agencies – can serve the needs of sector- and place-based approaches. Indeed, constructive collaboration can occur among all three approaches.

EPA, with the Common Sense Initiative Council, is developing a Sector-Based Action Plan to integrate the sector-based approach into core Agency operations. The Plan will, among other things, identify objective criteria for selecting future sector-based opportunities. EPA's regulatory framework already starts with "source categories" of releases to air, water, or land, and may serve as a point of reference. This PBT strategy may also be able to identify source categories by use or release of chemicals or chemical groups. Once a sector could be earmarked for significant PBT use or release, then sector-based and chemical-based approaches could use complementary analysis and stakeholder outreach to tackle PBT problems on a sector-basis.

EPA also seeks to implement Community-Based Environmental Protection (CBEP), a place-based, collaborative, multi-media, and multi-disciplinary approach to environmental protection. Embracing principles of ecosystem management and sustainable development, it convenes stakeholders within a geographic area to identify local concerns (including urban sprawl, shrinking biodiversity, and remediation of in-place PBT contaminants), set priorities and goals,

and forge comprehensive solutions. CBEP promotes integration of EPA programs and activities to complement and enhance community decision-making. Regional activities on the Chesapeake Bay and Great Lakes exemplify the CBEP approach and are also integral to the PBT Strategy (see Table 1).

Linkages with EPA Regional Programs. EPA Regional programs are essential to implementing this strategy. Among the roles they may take on are the following:

- Participating in GLNPO or national work groups as appropriate.
- Identifying geographic sources and sinks of priority PBTs.
- Participating in the chemical selection process.
- Assuming lead responsibilities for action plan development teams
- Managing region-specific projects during action plan implementation.
- Promoting compliance assurance and enforcement efforts.
- Supporting States and Tribes in addressing PBT issues in their jurisdictions.
- Carrying out PBT-related actions under EPA's National Waste Minimization Plan

Stakeholder Involvement

Building on the stakeholder involvement begun under the Binational Toxics Strategy is essential to this strategy. EPA's Region 5 and GLNPO are successfully engaging state and tribal program partners, industry, environmental groups, and others in taking actions on Level 1 substances. For example, the Council of Great Lakes Industries has helped educate and bring to the table other industries and sectors to identify possible voluntary actions. In cooperation with EPA, the National Wildlife Federation has begun mercury and dioxin reduction projects at Great Lakes hospitals. EPA will build on these efforts to engage stakeholders in areas of the country beyond the Great Lakes Basin.

EPA will seek stakeholder input on this draft strategy, the development and implementation of specific action plans for PBT pollutants, and the criteria for selecting more PBTs for risk reduction action. EPA will make *Federal Register* announcements of meetings in Washington, DC and EPA regional city locations for stakeholders to comment on the draft strategy EPA will invite State and tribal representatives to join the teams that develop the action plans, and will invite all others to review and comment on draft action plans. EPA will also invite all interested partners to join in developing voluntary agreements with EPA, agreements EPA considers essential to reaching the goal of this strategy

For answers to general questions about the PBT Strategy or to find out who to contact regarding particular aspects of the PBT Strategy, please contact Sam Sasnett, (202)260-8020, sasnett.sam@epa.gov

GLOSSARY

BNS	June 1997 Canada-U.S. Strategy for the Virtual Elimination of Persistent Toxic Substances in the Great Lakes (also referenced as "Binational Toxics Strategy").
CEC	North American Commission for Environmental Cooperation
GLNPO	EPA's Great Lakes National Program Office
GPRA	Government Performance in Results Act of 1993
IFCS	Intergovernmental Forum on Chemical Safety
LRTAP Convention	-- the UN ECE's Convention on Long Range Transboundary Air Pollution
NHANES	National Health and Nutrition Examination Surveys
NIH	National Institutes of Health (U.S. Department of Health and Human Services)
OAR	EPA's Office of Air and Radiation
OECA	EPA's Office of Enforcement and Compliance Assurance
OECD	Organization for Economic Cooperation and Development
OIA	EPA's Office of International Activities
OPPTS	EPA's Office of Prevention, Pesticides, and Toxic Substances
ORD	EPA's Office of Research and Development
OSWER	EPA's Office of Solid Waste and Emergency Response
OW	EPA's Office of Water
P2	Pollution prevention
PBTs	Persistent, bioaccumulative, and toxic pollutants
POPs Protocol	-- the Persistent Organic Pollutants Protocol negotiated under the UN ECE's LRTAP Convention
RCRA	Resource Conservation and Recovery Act
TRI	Toxics Release Inventory
UN ECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Program
WMPT	Waste Minimization Prioritization Tool

APPENDIX A

GPRA Goals and Objectives Supported by the PBT Strategy

Table A-1. The PBT Strategy Will Help Meet Goals and Objectives Stated in EPA's Strategic Plan

EPA Strategic Plan Goals and Objectives
■ ***GPRA Goal 1: Clean Air*** • By 2010, improve air quality for Americans living in areas that do not meet the National Ambient Air Quality Standards (NAAQS) for ozone and particulate matter (PM). • By 2010, reduce air toxics emissions by 75 percent from 1993 levels to significantly reduce the risk to Americans of cancer and other serious adverse health effects caused by airborne toxics. • By 2005, improve air quality for Americans living in areas that do not meet the NAAQS for carbon monoxide, sulfer dioxide, lead, and nitrogen dioxide. • By 2010, ambient sulfates and total sulfur deposition will be reduced by 20-40% from 1980 levels due to reduced sulfur dioxide emissions from utilities and industrial sources. By 2000, ambient nitrates and total nitrogen deposition will be reduced by 5-10% from 1980 levels due to reduced emissions of nitrogen oxides from utilities and mobile sources.
■ **GPRA Goal 2: Clean and Safe Water** • By 2005, protect human health so that 95 percent of the population served by community water systems will receive water that meets drinking water standards, consumption of contaminated fish and shellfish will be reduced, and exposure to microbial and other forms of contamination in waters used for recreation will be reduced. • Conserve and enhance the ecological health of the nation's (state, interstate, and tribal) waters and aquatic ecosystems – rivers and streams, lakes, wetlands, estuaries, coastal areas, oceans, and groundwater – so that 75 percent of waters will support healthy aquatic communities, by 2005. • By 2005, pollutant discharges from key point sources and nonpoint source runoff will be reduced by at least 20 percent from 1992 levels. Air deposition of key pollutants impacting water bodies will be reduced.
■ **GPRA Goal 4: Preventing Pollution and Reducing Risk in Communities, Homes, Workplaces and Ecosystems** • By 2005, public and ecosystem risk from pesticides will be reduced through migration to lower-risk pesticides and pest management practices, improving education of the public and at-risk workers, and forming "pesticide environmental stewardship" partnerships with pesticide user groups. • By 2005, the number of young children with high levels of lead in their blood will be significantly reduced from the early 1990's. • By 2005, of the approximately 2,000 chemicals and 40 genetically engineered microorganisms expected to enter commerce each year, we will significantly increase the introduction by industry of safer or "greener" chemicals, which will decrease the need for regulatory management by EPA. • By 2005, 15 million more Americans will live or work in homes, schools, or office buildings with healthier indoor air than in 1994. • By 2005, reduce by 25% (from 1992 levels) the quantity of toxic pollutants released, disposed of, treated, or combusted for energy recovery. Half of this reduction will be achieved through pollution prevention practices. • By 2005, EPA and its partners will increase recycling and decrease the quantity and toxicity of waste generated. • By 2003, 60% of Indian Country will be assessed for its environmental condition, and Tribes and EPA will be implementing plans to address priority issues.

Table A-1. The PBT Strategy Will Help Meet Goals and Objectives Stated in EPA's Strategic Plan (Continued)

EPA Strategic Plan Goals and Objectives
■ **GPRA Goal 6: Reduction of Global and Cross-Border Environmental Risks** • By 2005, reduce transboundary threats to human health and shared ecosystems in North America, including marine and Arctic environments, consistent with our bilateral and multilateral treaty obligations in these areas, as well as our trust responsibility to tribes. • By 2000 and beyond, US greenhouse gas emissions will be reduced to levels consistent with international commitments agreed under the Framework Convention on Climate Change, building on initial efforts under the Climate Change Action Plan. • By 2005, ozone concentrations in the stratosphere will have stopped declining and slowly begun the process of recovery. • By 2005, consistent with international obligations, the need for upward harmonization of regulatory systems, and expansion of toxics release reporting, reduce the risks to U.S. human health and ecosystems from selected toxics (including pesticides) that circulate in the environment at global and regional scales. Results will include a 50% reduction of mercury emissions from 1990 levels in the United States. Worldwide levels of lead in gasoline will be below 1993 levels. • By 2005, increase the application of cleaner and more cost-effective environmental practices and technologies in the U.S. and abroad through international cooperation.
■ **GPRA Goal 8: Sound Science, Improved Understanding of Environmental Risk, and Greater Innovation to Address Environmental Problems** • By 2008, provide the scientific understanding to measure, model, maintain, or restore, at multiple scales, the integrity and sustainability of ecosystems now and in the future. • By 2008, improve the scientific basis to identify, characterize, assess, and manage environmental exposures that pose the greatest health risks to the American public by developing models and methodologies to integrate information about exposures and effects from multiple pathways. • By 2008, establish capability and mechanisms within EPA to anticipate and identify environmental or other changes that may portend future risk, integrate futures planning into ongoing programs, and promote coordinated preparation for and response to change. • By 2006, develop and verify improved tools, methodologies, and technologies for modeling, measuring, characterizing, preventing, controlling, and cleaning up contaminants associated with high priority human health and environmental problems. • Provide services and capabilities, including appropriate equipment, expertise, and intramural support necessary to enable ORD to research innovative approaches to current and future environmental problems and improve understanding of environmental risks. • By 2005, EPA will increase the number of places using integrated, holistic partnership approaches, such as community-based environmental protection (CBEP), and quantify their tangible and sustainable environmental results in places where EPA is directly involved. • By 2005, test innovative facility- and sector-based strategies to achieve improved environmental protection, and make successful approaches broadly available. • By 2005, Regions will have demonstrated capability to assess environmental conditions in their Region, compare the relative risk of health and ecological problems, and assess the environmental effectiveness of management action in priority geographic areas. • Conduct peer reviews and provide guidance on the science underlying Agency decisions. • Incorporate innovative approaches to environmental management into EPA programs, so that EPA and external partners achieve greater and more cost-effective public health and environmental protection.
■ **GPRA Goal 9: A Credible Deterrent to Pollution and Greater Compliance with the Law.** • Identify and reduce significant non-compliance in high priority program areas, while maintaining a strong enforcement presence in all regulatory program areas. • Promote the regulated communities' voluntary compliance with environmental requirements through compliance incentives and assistance programs.

APPENDIX B

Status of Developments on Binational Toxics Strategy Level 1 Substances

Table B-1. Status of Developments on the Level 1 Substances under PBT Strategy

Binational Toxics Strategy Level I Substances		
Effort Level	**Timing**	**Features**
Mercury and Compounds		
High, probably the highest	U.S. challenge goal is, by 2006, 50% reduction in deliberate use and 50% reduction in release from human-activity sources. Draft action plan is complete. Many activities ongoing, with the BNS workgroup initiating others.	Activity is occurring in all National Program Offices and the Regions. EPA, through its draft mercury action plan, Mercury Task Force, BNS work group activities, and the PBT Strategy, will ensure activities are coordinated and complement each other. BNS work group activities have begun with a focus on voluntary action. The best description is in the attached draft Mercury Action Plan.
PCDD (Dioxins) and PCDF (Furans)		
High	U.S. challenge goal is 75% reduction in releases from human-activity sources by 2006. EPA will finalize an action plan after public release of its final Dioxin Reassessment, due Spring 1999, and a concurrent draft Cross-Media Dioxin Strategy. Meanwhile, the BNS work group will begin voluntary reduction efforts. EPA is addressing dioxins/furans in the negotiation of the global POPs convention, which began 6/98.	Beyond key steps already taken, actions will include BNS work group and PBT Strategy activities such as a Great Lakes state pilot to target air emissions using cross-media authorities, a national study of chemical residues in fish, new watershed decision-making using air data, research, and Gulf of Mexico activity. The BNS dioxin group will work closely with PBT Strategy dioxin efforts. EPA will work with other partners to better quantify dioxin/furan sources and release levels in representative developing countries as an input to the global POPs negotiations.

Table B-1. Status of Developments on the Level 1 Substances (Continued)

Binational Toxics Strategy Level I Substances		
Effort Level	**Timing**	**Features**
PCBs		
Medium to high (much is already done, given EPA's mature PCB program).	U.S. challenge goal is 90% reduction of PCBs used in electrical equipment by 2006. The BNS workgroup is developing a work plan. A draft national action plan is expected in 1999. EPA will address PCBs in the implementation of the LRTAP POPs protocol and the negotiation of the UNEP POPs convention, which began 6/98.	EPA heavily regulates PCBs. Problems include disposing of collected PCBs, remediating contaminated sediments, and motivating other countries (e.g., Russia) to reduce risks from PCBs. Two rules (one complete, one nearly so) will further facilitate industry's remediation, disposal, and replacement of PCBs. The BNS work group is pursuing voluntary reductions through expanding Region 5's PCB phase down program, encouraging national replication of the phase down program, a clean sweep pilot in Chicago, and encouraging a national PCB reduction effort. International capacity building efforts for PCB identification, management, and disposal are underway and will grow in volume and importance with the negotiation and conclusion of the UNEP POPs convention.
The Pesticides (Chlordane, DDT, Aldrin/Dieldrin, Mirex, Toxaphene)		
Medium low (collective level of effort, but possibly large impact of BNS)	EPA will submit a BNS status report on use or release from sources that enter the GL Basin by 12/31/98. BNS workgroup is developing a work plan this summer. A draft national action plan is expected in 1999. EPA is also addressing these pesticides through the UN negotiations on a legally binding global POPs convention, which began June 1998.	EPA will continue clean sweeps to reduce stockpiles in GL Basin, and work with stakeholders and GL states (NEPPS process) to reduce pesticide reliance. The possible contribution of long range transport to U.S. loadings is a significant issue to be resolved. OPP will work with Mexico to reduce DDT/chlordane reliance, speed registration of reduced-risk pesticides, and work with GLNPO to foster states' promotion of biological controls through State Management Plans. OPPTS and OIA will lead the EPA component of the U.S. delegation to the UNEP POPs negotiations.

Table B-1. Status of Developments on the Level 1 Substances (Continued)

Binational Toxics Strategy Level I Substances		
Effort Level	**Timing**	**Features**
Alkyl-Lead		
Low (air emissions estimated under 0.5 tons annually).	U.S. challenge goal is to confirm no use in automotive gasoline by 1998. Draft national action plan to be developed by 1999 based on BNS work plan.	EPA will submit "confirmation of no use in automotive gasoline" report under BNS by 12/31/98, broaden stakeholder involvement, encourage stakeholder minimization of use/release from other sources (e.g., aviation, racing), and track efforts to develop unleaded alternatives for aviation and racing fuel. The OECD risk management program and EPA's efforts to promote phasing out use of lead in gasoline are ongoing.
Hexachlorobenzene		
Low (collective level of effort, but possibly large impact of BNS).	BNS workgroup work plan is under development. Completion of final action plan may have contingencies (baseline levels not established and percentage goal not yet set under BNS).	An initial step under BNS is to quantify loadings to set a realistic percentage goal. The effect of long range transport remains a key issue. The BNS work group will consider approaches to reducing releases during pesticide manufacturing and use, chlorinated solvent manufacture, and possibly aluminum manufacturing. EPA may be able to address incineration sources through actions aimed at other PBTs, e.g., actions taken by other BNS work groups or recent MACT standards. A total phaseout is required under the LRTAP POPs protocol and will be proposed under the global POPs convention being negotiated under UNEP auspices.
Benzo(a)pyrene		
Low (collective level of effort, but possibly large impact of PBT Strategy and BNS).	BNS workgroup developing a work plan this summer. A draft national action plan is expected by 1999.	Benzo(a)pyrene is a polycyclic aromatic hyrdocarbon, a subset of polycyclic organic matter (POM), which is a large class of substances that are by-products of incomplete combustion. POM is an area needing more research. In the LRTAP POPs context, B(a)P will be used as one of several indicators for overall releases of PAHs, with the intention of ultimately reducing such releases.

Table B-1. Status of Developments on the Level 1 Substances (Continued)

Binational Toxics Strategy Level I Substances		
Effort Level	**Timing**	**Features**
Octochlorostyrene (OCS)		
Low (collective level of effort, but possibly large impact of PBT Strategy and BNS).	U.S. challenge goal is to confirm no use or release by 1998. In January 1998, the PBT Plenary Group prepared a preliminary draft action plan for use in discussions with BNS stakeholders. BNS workgroup is developing a work plan.	GLNPO will submit a BNS status report on use or release from sources that enter the GL Basin by 12/31/98. The BNS work group is leading the OCS effort with a focus is on defining sources, releases, and environmental loadings (and to some extent toxicity and bioaccumulation). Near-term reduction activities may need to rely on efforts directed at other PBTs to accomplish associated reductions in OCS.

Todd A. Houts/Peter C. Ashbrook
(see Peter C. Ashbrook for paper)
Chemical Safety Section
Division of Environmental Health and Safety
University of Illinois at Urbana-Champaign

"Waste Minimization Options for the Laboratory Worker"

Biographical Statement

Todd A. Houts and Peter C. Ashbrook have jointly been responsible for the chemical waste management program at the University of Illinois at Urbana-Champaign for over 10 years. Information about this program can be found at http://www.ehs.uiuc.edu/~chem/. They write a column on laboratory waste minimization for *Chemical Health & Safety* magazine. Mr. Ashbrook is coeditor of the book, *Pollution Prevention and Waste Minimization in Laboratories*, published by CRC/Lewis Publishers.

Mary Jakeway

Whirlpool

"Air Emissions Reductions in the Painting Process"

BIOGRAPHICAL BACKGROUND

MARY K. JAKEWAY

Mary Jakeway holds a BS in Microbiology, MS in Environmental Chemistry from Civil Engineering, and an MBA from Ohio State University. Mary worked as an Environmental Specialist at Franklin County Engineers tracking federally funded projects and recording comments from public hearings on bridge and highway projects. Mary then worked as a Wastewater Chemist with the City of Columbus, Ohio, Sewers and Drains Division The City was establishing a central laboratory and Mary was part of the initial design and equipment and method selection/standardization. Mary then served as the Supervising Chemist for the Jackson Pike WWTP to oversee laboratory operations, complete EPA reporting, and advise plant operations. For one year Mary served as the Operations and Maintenance Training Coordinator as a $400 million upgrade was installed for one of the City's two wastewater treatment plants For five years Mary was the Industrial Pretreatment Coordinator for the City, establishing the program. For the past eight years Mary has served as the Environmental Engineering Supervisor for the Whirlpool Marion Division. This includes responsibility for all aspects of the environmental issues.

Whirlpool Corporation
Marion Division
1300 Marion-Agosta Road
Marion, Ohio 43302

Contact: Mary Jakeway
Supervisor, Environmental Engineering
740-383-7607

SUMMARY 1995

Whirlpool Corporation, Marion Division, is a dryer manufacturer with 2400 employees. Plant personnel have undergone extensive reviews of existing paint systems to respond to the 1990 Clean Air Act and the economy of efficient production. For the Division base year of 1988 Hazardous Air Pollutants (HAP's) were 1,684,714 pounds.

Cooperation of the paint vendor and the manufacturing disciplines of environmental, facility, and "futures" engineering for product and process resulted in research and actions which have steadily decreased our emissions levels. A switch to "high-solids" paint was completed in 1991, which significantly reduced VOC emissions per year (245,000 pounds/year). In July, 1992, our flow-coat paint was replaced by an e-coat system which further reduced VOC emissions by 230,000 pounds/year. These changes reflect a change of 60% for the targeted chemicals for the 33/50 initiative from 1988 levels and are consistent with our commitment to the 33/50 USEPA Pollution Prevention Initiative.

Beginning in 1993 research was initiated to determine the feasibility of electrocoat paint as a finish coat for external dryer parts. Electrocoat paint has never been used as a Class A finish for exterior appliance parts. Currently electrocoat is being used in many industries as a primer for topcoat paint, or as a paint for non-visible parts. It is being used in a very few industries as a One Coat paint for non-critical applications. If Whirlpool is successful we can eliminate one of our Wet Paint systems, thereby gaining:

- o Reduced Labor Costs.
- o Reduced volatile organic compounds released to the atmosphere
- o Elimination of solid and liquid waste from that system
- o Increased potential production capabilities from our paint systems.

Bench testing was conducted in 1993 and a full scale trial has been completed to date with encouraging results and the decision to proceed for requests for capital funding required to complete plant rearrangement to begin in-plant use. Because of the complexity of moves and the necessity to maintain the existing operation this will be a long process, slated to require a minimum of two years for completion.

In May, 1994, the "small color" paint system was eliminated resulting in a further reduction of 19,000 pounds/year.

1998

SUMMARY

The Marion Division of Whirlpool Corporation has been committed to Ohio Prevention First since inception. Prior to this program Whirlpool had committed to the USEPA 33/50 Initiative and had practiced active waste minimization for many years. Success in the 33/50 initiative was achieved primarily with a switch from low solids paint to high solids and elimination of a flowcoat process which was replaced with electrodeposition. Goals have been achieved with a 25% increase in production from 1987 to 1997.

Specific projects identified in 1997 included returnable containers for packaging in place of cardboard and replacement of a petroleum based drawing compound with a synthetic lubricant. The returnable container project has been ongoing since 1991. In 1990 cardboard was segregated from our general trash. This resulted in a reduction of 50% in general trash in 1990 (nearly 2,500 tons/year!). The cardboard has been recycled since then. Since 1991 cardboard has decreased from 3.88 million pounds to 1.47 million pounds in 1997. This has been due to the returnable container program. Investment for purchase of these containers has totalled over $400,000 since 1990 - 1997 cost was $100,000.

The switch to a synthetic lubricant involved a cross-functional team to evaluate the impact on the environmental, tooling, pressroom, and finishing areas. This team spent 18 months evaluating vendors and products, developing a matrix for evaluation, and setting up a systematic trial process to ensure that no areas suffered during the transition. Because of the sheer volume of steel processed at the Division, transition has been completed one press at a time. Transition involved switching from spray application to roller application at a cost of $80,000 followed by die cleaning and implementation of the synthetic. Total cost savings are projected at $375,000 per year and actual savings documented to date have been $30,000 per month since January, 1998. Approximately 55% of the switch is complete as of May 1. Favorable pollution prevention benefits have included less material usage and elimination of a hazardous constituent. The TRI list was expanded to include chlorinated hydrocarbons in 1996 and our volume was such that the drawing compound represented over 25,000 pounds for 1996 reporting from the chlorinated paraffins. The synthetic lube is water-based instead of petroleum-based and therefore less waste oil from treatment or clean-up operations is generated. In 1997 54000 gallons of waste oil was transported to Heritage for recycle as number 4 diesel. This will be eliminated at full switch-over. In 1997 we captured 90,451 pounds of oil debris waste (7,538 pounds/month). This has reduced to 4,250 pounds per month to date and is also anticipated to virtually disappear at full switch-over.

History

As a charter member of Ohio Prevention First (1995) the Whirlpool Marion Division has made great strides toward achievement of the commitment from the Division management to the target goals of:

80% reduction in VOC's;
70% reduction in 33/50 chemicals;
50% reduction in general trash;
70% reduction in hazardous waste;
35% reduction in WWTP sludge;
80% reduction in TRI chemicals.

Stretch goals beyond these commitments included 50% reduction in cardboard based on 1991 and 20% reduction in water usage based on 1988. Tables of data are attached as Appendix A. General trash was halved with the inception of cardboard recycle in 1990. **Pollution prevention was responsible for reductions in TRI, VOC, 33/50, cardboard, hazardous waste, and water usage.**

Since 1990 funds have been expended to incorporate returnable containers into as many shop operations as possible. In 1997 **$100,000** was spent in this area, and to date, since 1991, cardboard has decreased from 3.88 million pounds in 1991 to 1.47 million pounds in 1997.

Changes in materials used and application processes have resulted in the following reductions:

TRI	74.3% to base year or 1.59 million pounds/year;
VOC	69% or 1.22 million pounds/year;
33/50 chemicals	89% or 0.77 million pounds/year;
Hazardous waste	97% or 0.36 million kg/year;
Water usage	35% or 0.099 cubic meters/yr from 1991 to 1997.

These changes have included a switch in 1992 to high solids paint, followed by a change to a one-coat e-coat paint process in 1995 which eliminated a primer step and greatly reduced the volume of paint required. Further material changes of the e-coat paint

constituents have decreased the VOC and TRI content. Hazardous waste was minimized with implementation of a xylene recovery still in 1990 followed by pollution prevention due to reduced color changes which decreased the need for xylene, as part of the one-coat change. Hazardous waste was reduced 70% from 1995 to 1997 due to this process change (23,796 kg/year change during this time period). These goals have been achieved with a 25% increase in production levels from 1987 through 1997.

PROJECT DESCRIPTION - 1997 Focus

1996 was the first year that chlorinated hydrocarbons were identified as TRI chemicals. For the Marion Division our use of a traditional drawing compound with this constituent put us over the threshold reporting level of 25,000 pounds/year. This factor, coupled with many other variables including industrial hygiene concerns, housekeeping, and cost, helped to drive a project team which investigated switching from the trusted standard of many years' use to a synthetic lubricant. One major goal was to standardize both the method of application and the chemical used throughout the press room. It was crucial to the group to include hourly personnel who worked in the affected area as members of the team.

Savings are calculated based on usage and cost/gallon plus miscellaneous costs including absorbent floor dry and gloves plus scrap costs plus environmental costs for 1997 when traditional lube was used versus costs to date as the transition is made through the press room. To obtain more uniform coating and prevent industrial hygiene concerns from misting, roll applicators have been installed at a cost of $80,000. With 50% of the switch in place savings are greater than $30,000/month. Material savings represent pollution prevention similar to the savings seen from one-coat e-coat because significantly less material is required, and the material does not have a TRI constituent, nor does it represent a wastewater treatment concern. Savings beyond material cost have been achieved with improved housekeeping leading to less use of floor dry and thus lower disposal costs, less glove usage since the material does not saturate the glove, and lower treatment costs because the material is not a petroleum based product. Below is the analysis of solely the environmental impact from this project to date.

1997 efforts resulted in a reduction of TRI chemicals of 184,765 pounds from 1996.

Environmental Benefits

A striking benefit is the elimination of 25,000 pounds/year of chlorinated hydrocarbons from the TRI list. This represents 5% of our 1997 reporting. The impact on the wastewater treatment area is approximated by switching from the present drawing compound to a synthetic which will not require an acid break for treatment. The acid

savings is based on an average of 1200 gallons/month at a cost of $1.15/gallon. There will not likely be an oil layer since only a small amount of mill oil is on the steel, and there is a decreased volume to be processed. The organic demand (BOD) will increase and may require the use of polymer to clarify the effluent prior to discharging it to the City of Marion for secondary treatment.

From an unrelated change, the pH can be decreased from 10.2 S.U. to lower the lime usage. This will probably not be below 9.0 S.U. due to the solubility of zinc. Provided this does not raise zinc levels above 1,600 ug/l, the lime usage is projected to go down 20%, which saves $3,500/year and primarily affects sludge generation, estimated to decrease 25%, or 250 tons/year. At $32/ton, this is $8,000 and avoids 18 trips at $160 each or $2,880.

ANNUAL SAVINGS DUE SOLELY TO ENVIRONMENTAL ISSUES

(Actual 1997 Heritage cost for waste oil recycle was $21,425) + (Floor dry purchased was $4740) + (Oil debris disposed as a drum waste cost of $10,000) + (decreased lime $3,500) + (decreased acid $16,560) = Proposed savings of **$56,165**

VS

(Increased cost of BOD surcharge at $8,000) + (polymer cost of $10,800) = **$18,800**

TOTAL SAVINGS = $37,365/annually

Heritage Waste Oil	BOD Surcharge	Polymer Cost	Acid Cost	Lime Cost	Sludge Hauling/Disposal
9x6000 gals	6MGDx8.34	$900/mo	14,400 gals x	20% reduction	25% reduction
54,000 gals	x120 mg/l x		$1.15/gal	50,000 lbs x	250 tons x $32/
at $2000/trip	$0.11/lb x 12 mos =			$0.07/lb	ton = $8,000 - 18 trips x 160 $2,880 -
$18,000 - 1997 actual $21425	$8,000 +	$10,800 +	$16,560 -	$3,500 -	$10,880 -

HEALTH AND SAFETY BENEFITS

We have seen elimination of the use of floor dry absorbent in our raw parts warehouse and have switched to a product which is non-dusting and will biodegrade oil to a landfillable waste for any remaining needs for absorbents. Previously we had been collecting the oil and floor dry waste and sending it to fuel blending facilities such as Heritage or Safety Kleen. Our generation rate had reached 40 drums every quarter, which was a cost of $125+ per drum or $5000/quarter. This wastestream has decreased by one-half at this point and will be eliminated with full switch-over.

Glove usage is decreasing drastically and hourly employees have been involved with the team to assist in the evaluation and switching presses to the new lube. Comments have been favorable. An Operational Excellence Program has been initiated at Whirlpool wherein engineers are trained on quantitative methods, design of experiments, etc. The lube change has been pursued as an OPEX project. This has given the project discipline and has assisted in tracking on a monthly basis for the cross-functional areas impacted. With 55% of the press room switched gradually since January, 1998, through April 30, 1998, costs have decreased from $51,000 to $45,900 for the corresponding timeframe in 1997 for glove purchase and cleaning and floor dry. This corresponds to a penny per unit saving at this point.

Roller application of the drawing compound is favorable because misting is eliminated. This decreases industrial hygiene (employee health) issues. Standardization of the rollers throughout the press area is beneficial for repairs. The roll application allows a much more even distribution which decreases lube waste. The water-based synthetic is far more preferable for employee handling and contact.

One other possibility is being pursued which may allow elimination of a production washer. Because of the lack of oil in the synthetic compound this appears feasible.

MANAGEMENT COMMITMENT

As stated in the history section, the Marion Division management team has endorsed the commitment to the Ohio Prevention First program which includes establishment of targeted goals and adoption of a general policy to continually search for pollution prevention alternatives for chemical use and waste generation.

One program which has been ongoing since 1992 is the annual Quality Awards celebration. Projects are submitted by the developing team for judging at the Division level. Depending on the rating received, the project may qualify for submittal to the corporate level for competition with other division projects. This project has received a "gold" level at the Division (highest possible) and will be the only Marion Division project in contention at the corporate level. Prizes, based on rating received, are given to team members of winning projects. Examples of prizes at the Division level include logo jackets, $100 savings bonds, shirts, sweatshirts. The 1998 submittal of the project is attached as Appendix B.

The Division also offers a "performance share" program in which accounts are identified and a base year established. As improvements are made which lower expenditures in specific accounts, reduce electrical use, improve quality, or reduce scrap the savings per unit against the base year are calculated and payouts are made to all employees on a quarterly basis. Within this program is a cost improvement program which allows all employees to submit suggestions and be eligible for quarterly prizes which have included grand prizes of riding mowers, vacations, barbeque grills, etc. Suggestions can be as major as the lube improvement or as small as an individual or department change. Payouts for 1997 were over $1000 per person (plant population is 2500).

TRANSFERABILITY

Within Whirlpool transferability of information is achieved through the OPEX program which uses a Lotus Notes database program to track project savings and costs. This program is available to all divisions for review.

The environmental engineers, corporate environmental manager and director, and international environmental director hold an annual conference for exchange of this sort of information. The conference was held this year in Tulsa and this project was presented as a "Best Management Practice" for the corporation.

Whirlpool has been a charter member of Ohio Prevention First and the Clyde Division received an award earlier in the program. Whirlpool staff are committed to sharing information gained from this project with other industries through the annual data summaries compiled for the State and through conferences/workshops as requested.

ECONOMIC BENEFITS

This project has been pursued for over 18 months from conception to implementation and the implementation will be a 9 month process. Dies must be cleaned prior to any switch so the implementation has been one press at a time. Roll applicators have had to be

capitalized at a cost of $80,000, a bulk tank system was installed at a cost of $15,000, and the applicators have been switched just ahead of the lube use. Tracking on a monthly basis indicates savings of $30,000 per month even on this transitional phase. Eventual savings with full phase-in are anticipated to be $375,000/year.

VOC SUMMARY

(LBS)

1987	1775312
1988	1544699
1989	1509824
1990	1116150
1991	1194116
1992	715294
1993	502325
1994	517840
1995	742099
1996	646868
1997	557590

69.2% reduction from 1987 to 1997 with 25% increase in production

WHIRLPOOL CORPORATION MARION DIVISION

TOXIC RELEASE INVENTORY CHEMICALS SUMMARY

Year	Pounds Released
1987	2,134,616
1988	1,787,269
1989	1,765,708
1990	1,296,612
1991	981,260
1992	692,341
1993	509,441
1994	496,341
1995	667,700
1996	635,000
1997	510,000

76.1 % REDUCTION

WHIRLPOOL CORPORATION MARION DIVISION

313 LISTED CHEMICALS

33/50 INITIATIVE

Year	Pounds Released
1988	861,796
1989	840,714
1990	683,621
1991	424,730
1992	173,600
1993	202,000
1994	112,000
1995	161,000
1996	125,000
1997	93,000

89.2% REDUCTION

Keith O. Legg

Rowan Catalyst, Inc.

"Metal Finishing P2 by Chrome Plating Replacement"

Keith O. Legg **BIOSKETCH** **November, 1998**

Keith Legg is President of Rowan Catalyst, Inc., a company that has been carrying out market analysis, technology evaluation, and technology development for commercial and government clients since 1990. He has been involved in coatings and surface modification for more than 20 years, and is internationally known for his work in clean coating technology. He has been heavily involved in chrome plating clean-up and replacement for a number of years, carrying out projects and analyses for EPA, DARPA, and commercial clients. He is the technical lead for HCAT, the primary DoD effort to replace chrome plating in Defense Department depots and vendors in the US and Canada, and is currently evaluating technologies for internal diameter chrome replacement.

Metal Finishing Pollution Prevention by Chrome Plating Replacement - The DoD HCAT Experience

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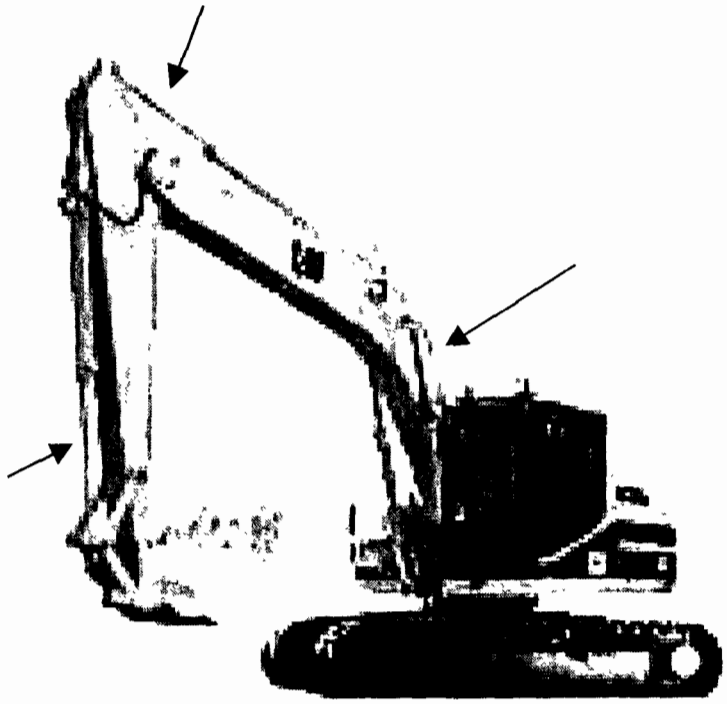
U.S. EPA Region 5

1998 Waste Minimization/P2 Conference,
December 14, 1998

Keith Legg
Rowan Catalyst, Inc.
(847) 680-9420

Bruce Sartwell
Naval Research Lab
(202) 767-0722

Major Uses - Hydraulics



- Single largest use of chrome plate
  - almost all hydraulic actuators chromed
  - includes aircraft landing gear, actuators
  - seal and rod wear, corrosion

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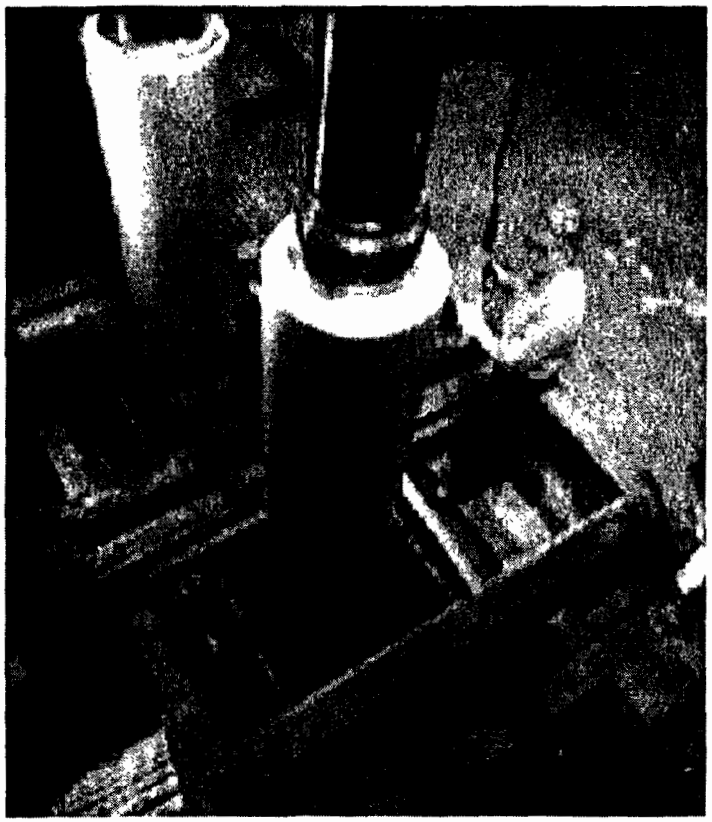
Major Uses - Industrial Rolls



- Almost all continuous strip/film processes
- Steel, aluminium, plastics, paper, etc.
- Wear, lubricity, corrosion

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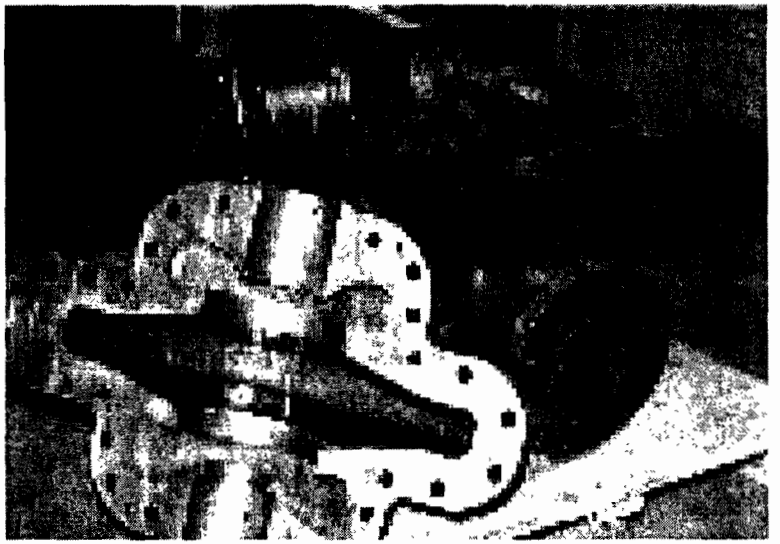
Major Uses - Repair



- Small shops all across Canada
- Engines, pumps, hydraulics, valves
- Aircraft landing gear, hydraulics, other components

Esp. DoD

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DoD Impact of More Stringent Chrome Plating Regulation

- Metal plating - large contributor to DoD site groundwater contamination
- New chrome plating shops cost about $5 million - overhaul and repair depots
- Navy analysis of cost to meet 0.5 pel
  - $22 million up-front for improved facilities
  - $46 million/year
  - DoD Cr plating might no longer be feasible
- Reduction in mission readiness

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DoD Response

- Base commanders now being held liable for environmental problems
- New plating shops, improve old ones
- Look for alternatives
  - Hard Chrome Alternatives Team
  - JG-APP (single process initiative) Boeing and Canadian landing gear manufacturers
  - Green Gun Barrel Project

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What does it take to replace chrome in aircraft?

- Suitable process and material
  - OEM and rebuild
  - Proof that it works as well as chrome
  - Installation in overhaul depots
  - Training of personnel
  - Specs for the replacement process
    - and ancillary processes - finishing, stripping, inspection, QC, NDI [redacted]

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What else does it take to replace chrome in aircraft?

- Well-defined process that fits with OEM production and O&R system
- Approval from stakeholders
  - Weapons system owners, engineers, OEMs, airlines, NAVAIR, AMCOM
- Contract changes
- Drawing changes (thousands)
  - Single Process Initiative (JG-APP)

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Aerospace Applications

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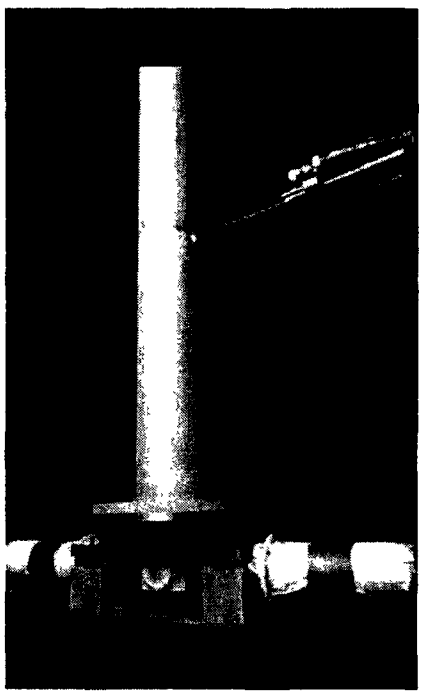
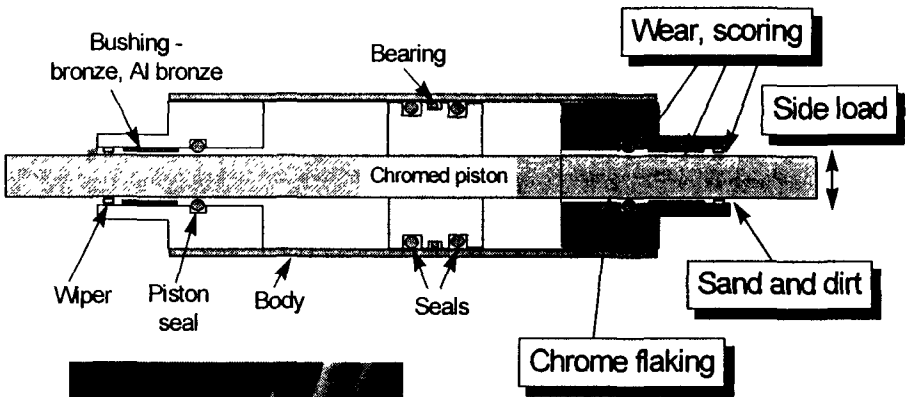
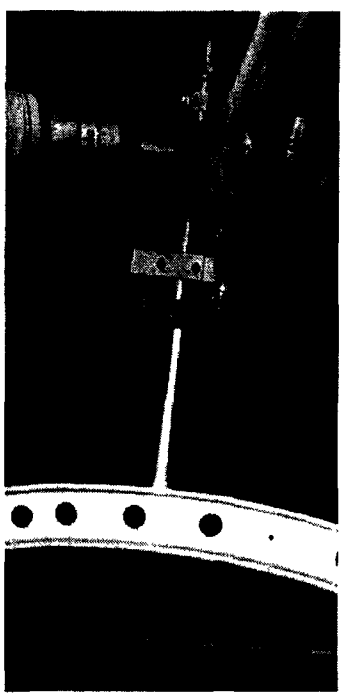


Actuators

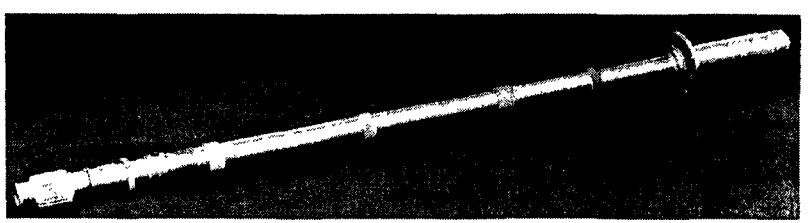


Landing gear



Slat and flap tracks

Engine shafts



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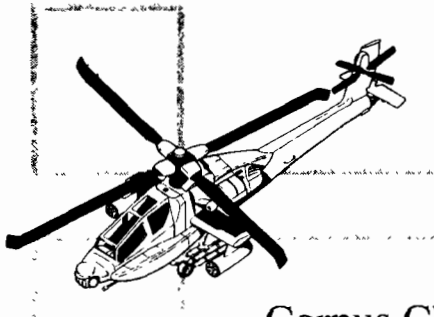
Background - HCAT

- The Hard Chrome Alternatives Team
  - Funding - ESTCP, Air Force, DARPA
  - Tri-service team
    - Depots, OEMs, laboratories, service providers
  - Applications - aerospace
  - Putting HVOF into DoD maintenance depots
    - Equipment, process/material definition, training
  - Data acquisition for process validation
    - Structure, properties, performance



HCAT Core Team

NADEP Jax
Don Parker
HVOF - Aircraft

Corpus Christi AD
Mel Avila
HVOF - Helicopters

GE Aircraft Engines
Jerry Schell
OEM HVOF - Engines
Tech transfer

NRL -Prog. Manager
Bruce Sartwell
Financial
Materials analysis

NDCEE
Eric Brooman
Stripping, training
JG-APP

NADEP Cherry Point
Robert Kestler
PVD, HVOF - Aircraft

WPAFB - Coord.
Ita Udo-Aka
Air Force support
Testing

NU/RC-Tech. Lead
Keith Legg
PVD, HVOF
Training

Ogden ALC
Grant Cheever
HVOF - Landing gear

Metcut
John Sauer
Mech. tests

Mitre Corp
Bob Cutler
Hydraulic testing
Tech transfer

Menasco Aerospace
Mike Brown
OEM - Landing gear
Canadian Team Leader

Southwest AeroService
Bruce Bodger
HVOF - Aircraft

Sacramento ALC
Elwin Jang
HVOF - Hydraulics

Boeing
Dennis Duhl
Embrittlement
and fatigue

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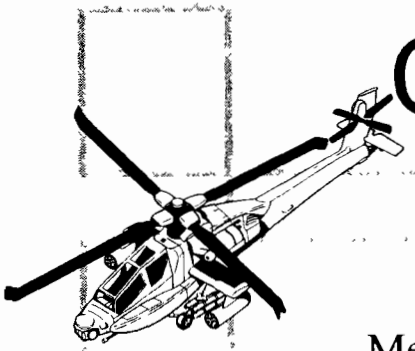
CHCAT Canadian Team



Menasco Aerospace
Mike Brown
Project Lead
Landing gear

Cametoid
Des Newman
PVD coatings

Messier-Dowty
Roger Eybel
Landing gear performance

Industry Canada
Lawrence Otupiri
Co-ordination

Heroux
Serge Labbe
Stripping, finishing

NRC
Bernard Arsenault
HVOF visualization
Testing, analysis

Orenda
Raj Thumbaraj
Testing

U. Toronto
Sanjeev Chandra

Vac-Aero
Jeff Pritchard
HVOF

Westaim
Shawn Gerrias
HVOF powders

Bombardier - de Havilland
Roque Panza-Giosa

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Requirements for replacement

- Must be able to replace chrome function
  - Wear, lubricity, corrosion, fatigue Critical!
- Fit with DoD depot maintenance
  - Well-defined and similar to existing methods
  - Large components, reasonable capital cost
  - Rebuild and strip
- Fit with OEMs

HVOF fits the bill for most OEM and maintenance needs nts

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The HVOF Process

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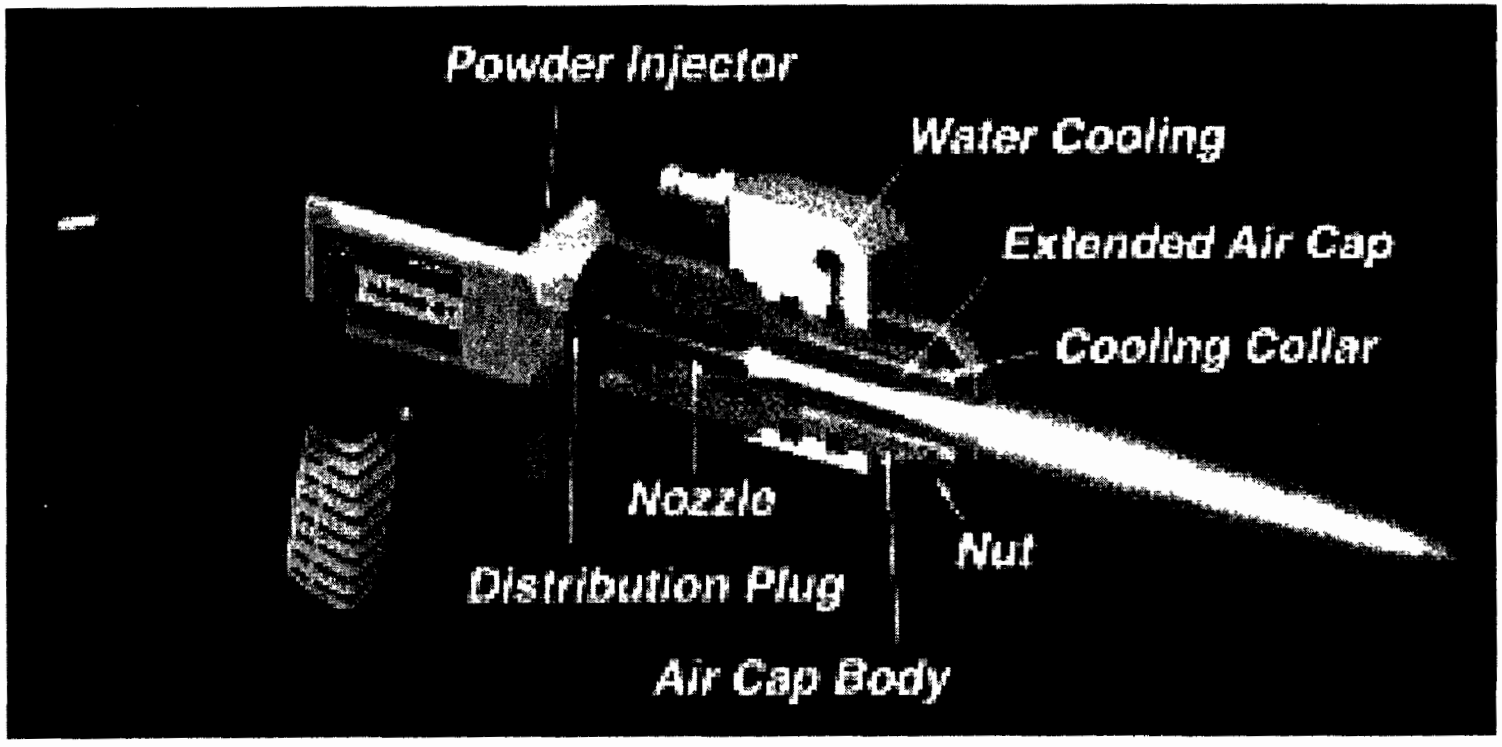
HVOF description



Sulzer-Metco Diamond Jet HVOF Gun

HVOF = High Velocity Oxy-Fuel thermal spray

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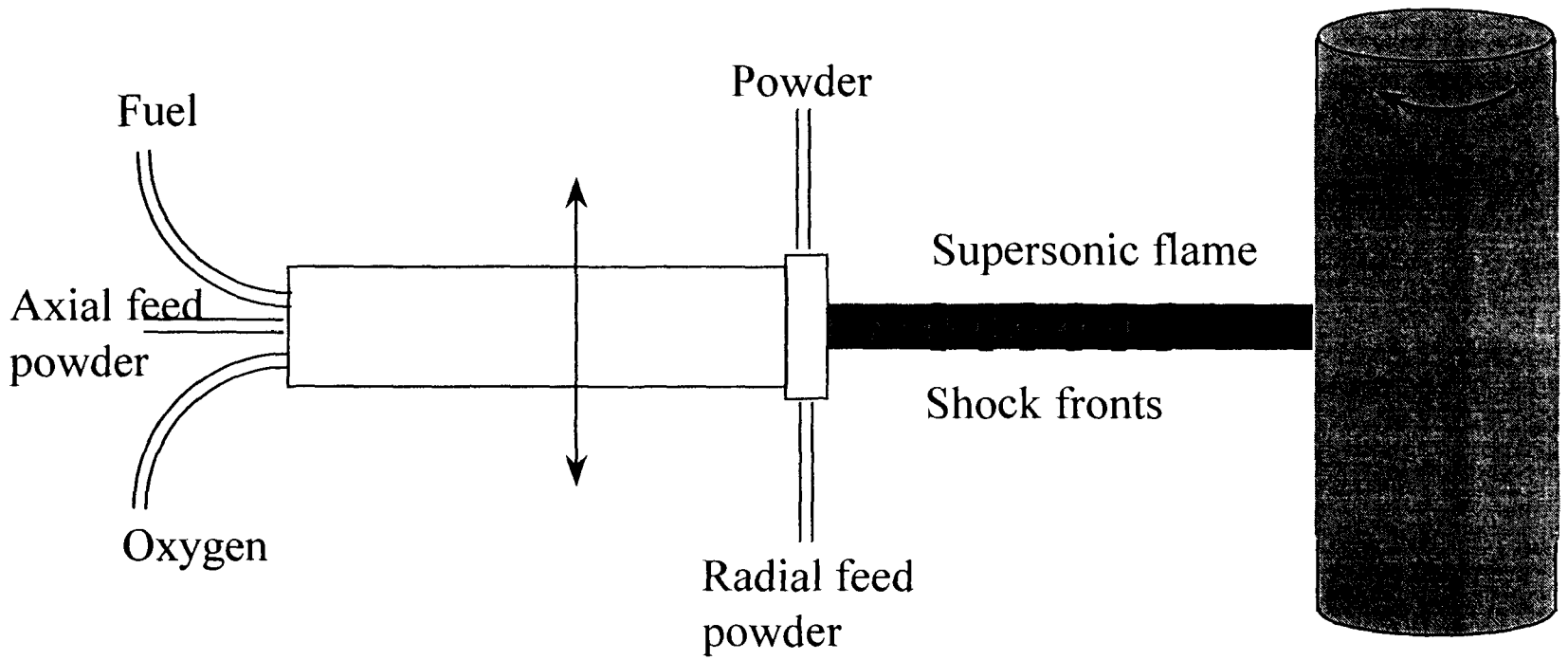
HVOF Technology



- Flame starts within gun body
- TAFA gun is radial, others axial feed

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Thermal spraying of a landing gear Southwest Aeroservice

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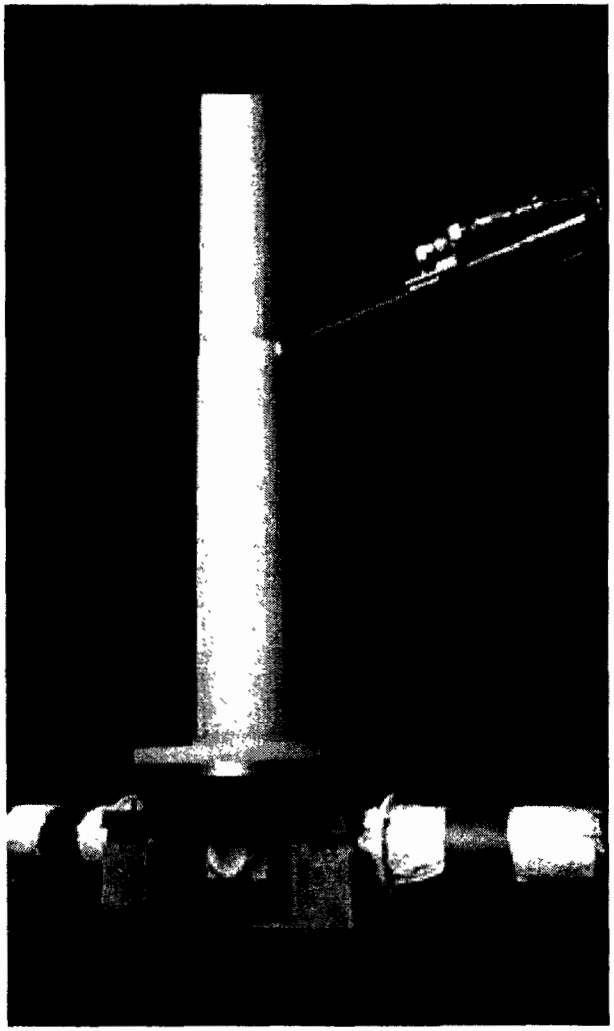

- Spins about vertical
- Length 3-8 feet
- Usual material: 300M high strength steel

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Materials

- Component materials
  - **AISI 4340** high strength steel
    - hydraulics, landing gear
  - **PH13-8Mo** stainless steel
    - helicopter components
  - **7075-T73** aluminum, **300M, Aermet 100**
    - landing gear

- Coating materials
  - **WC-Co**
  - **Tribaloy 400**
  - **WC-CoCr** (C-HCAT)

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Proving that it Meets Technical Requirements

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Testing

- QC at deposition site
  - hardness, adhesion, thickness, stress
- Material properties
  - microstructure, porosity, crystal structure
- Material performance
  - fatigue, corrosion, fretting, wear, fluids
- Component testing
  - hydraulic testing, landing gear cycling, drop tests
- Operational testing
  - flight tests

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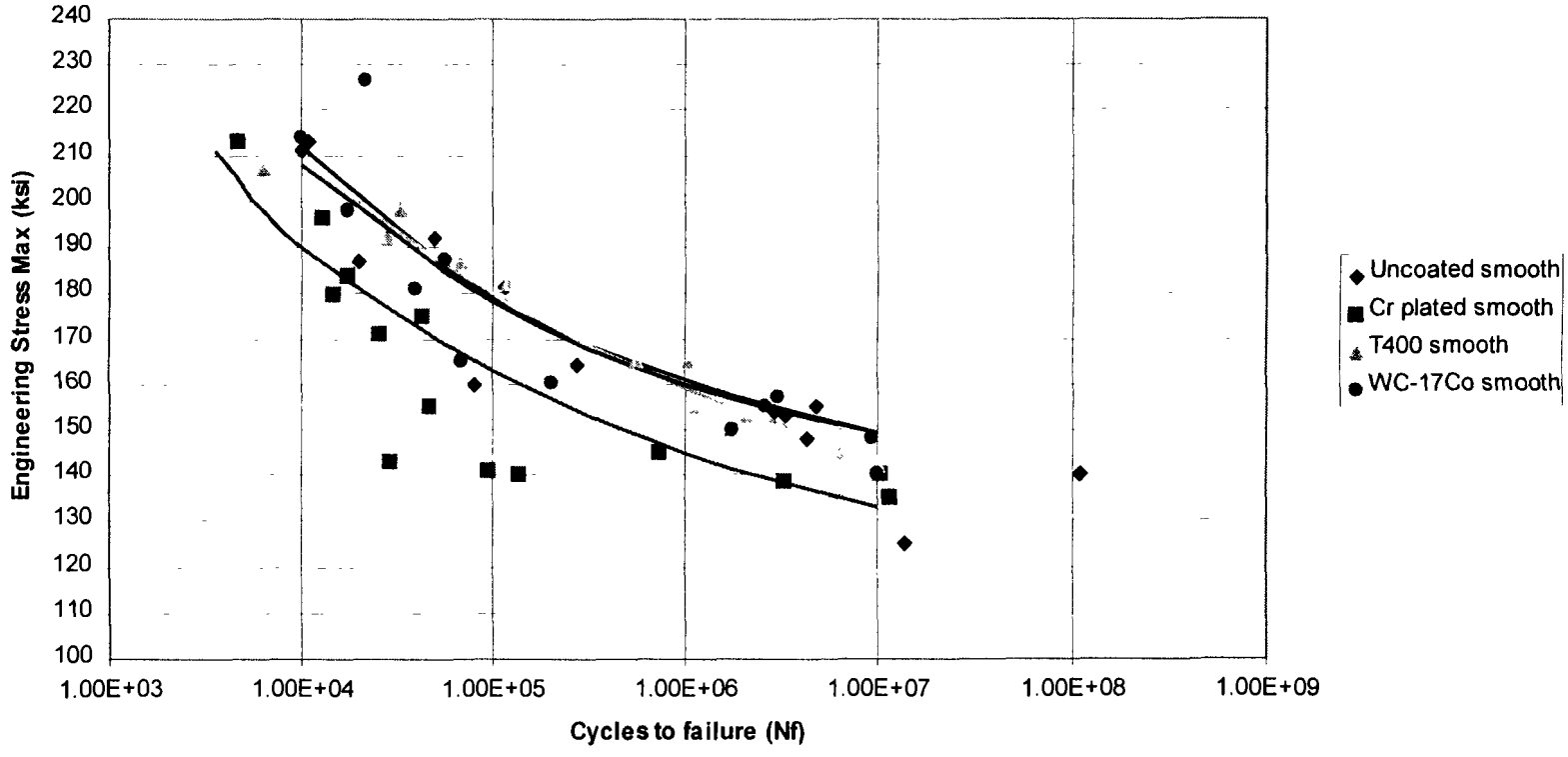
Results - fatigue



- High strength steel - no fatigue debit (chrome has large debit)

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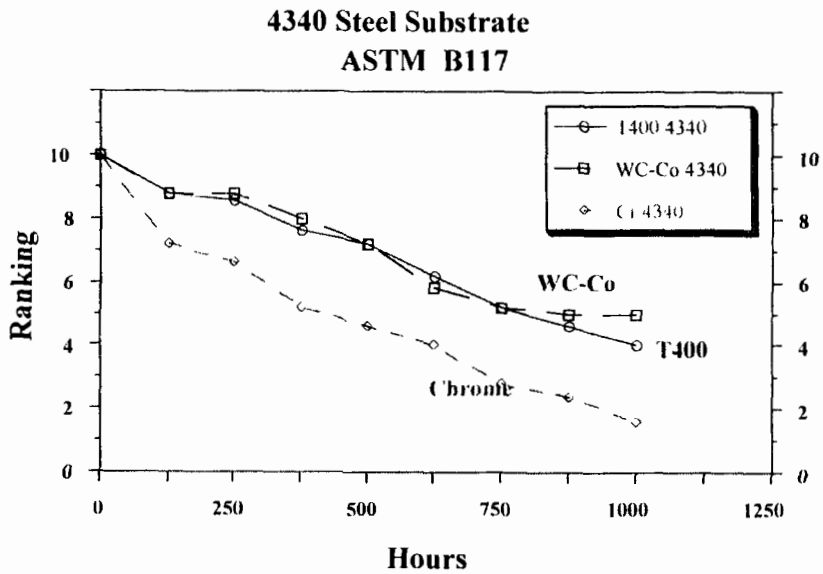
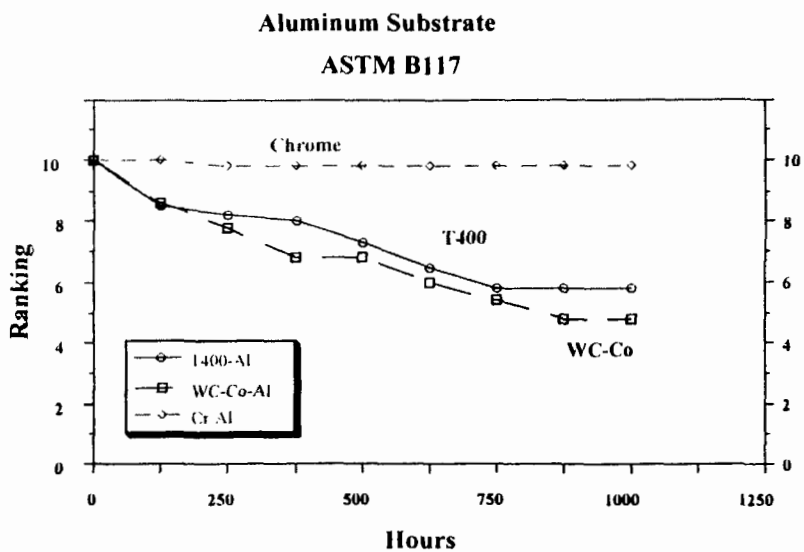
Corrosion



- Most cases, HVOF is as good as/better than chrome
  - except when platers use Ni strike



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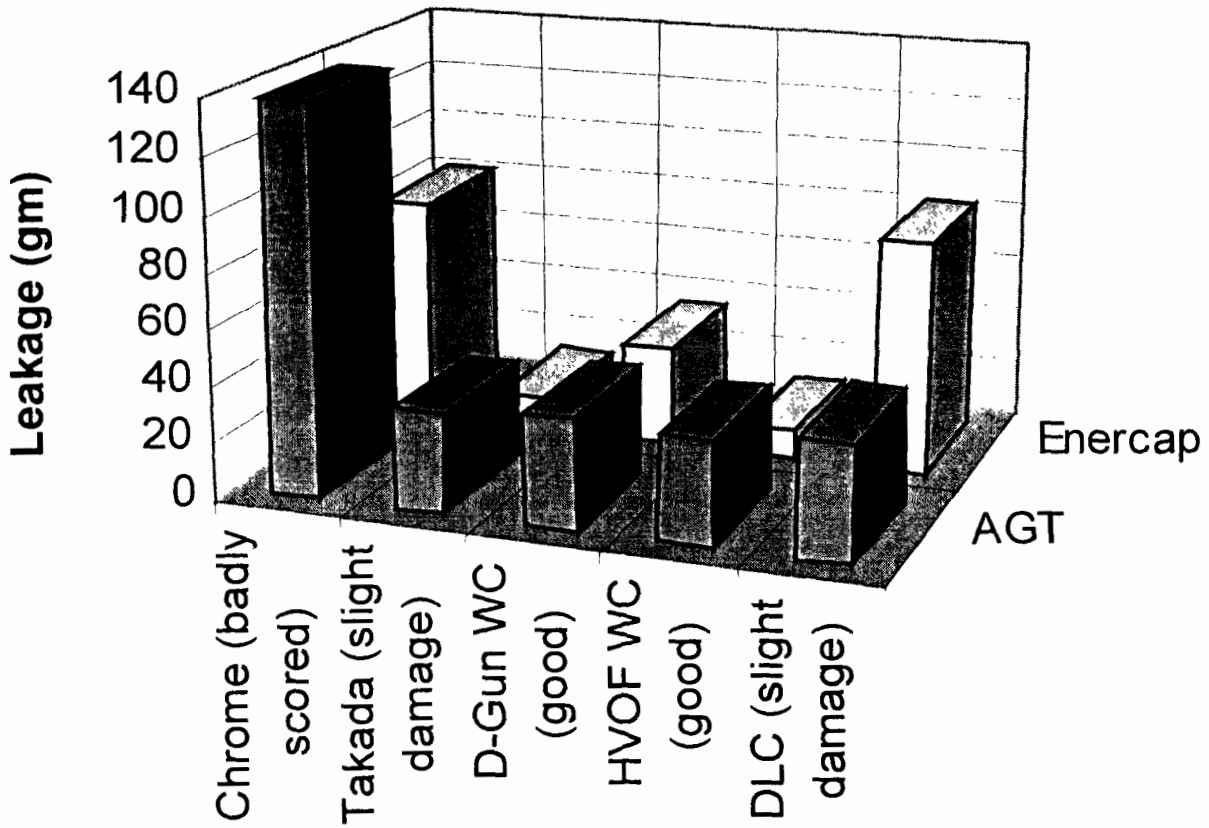
Hydraulic tests - Results



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Conclusions so far

- HVOF is better than hard chrome
  - Better wear (2 - 3 x life)
  - No fatigue debit (except on aluminum)
  - Equivalent or better corrosion (except on aluminum)
  - No hydrogen embrittlement
- HVOF is cheaper than chrome
  - Shorter production and repair cycles
  - Landing gear HVOF cost <50% EHC
  - Engine items HVOF is 1-1.5x EHC
  - Life-cycle cost lower

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HVOF Capabilities and Limitations

Capabilities

- Rebuilding to 0.020”
- Excellent for outside diameters
- Coats 1- 2 diameters into holes

Limitations

- Cannot coat internal diameters <4”
- Easily overheats thin sections, aluminum alloys, small parts

[redacted]

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Conclusions - the sale

- The real sale is not environmental
  - Better performance, lower cost
  - Lower production cost and cost of ownership
    - DoD excited about ability to rebuild more badly worn parts, repair difficult seal areas
    - OEMs like better fatigue and no H_2 embrittlement (no heat treat, less delay)
    - Airlines like faster overhaul turnaround

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Conclusions - the difficulties

- Difficulties with replacing entrenched technology
  - Conservatism, long experience
    - change is risk
    - especially aircraft - lives at stake
  - Need to prove it works better or costs less
    - to provide reason for change
    - performance must be proved that is simply assumed for the older technology
  - Specs and standards required

Critical issue

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Conclusions - other requirements

- Equal (or even better) performance is not enough - must consider all ancillary requirements
  - Stripping (to remove old or bad coating)
  - Finishing (methods and smoothness)
  - Fit with production (OEMs and depots)
  - Technology transfer and training
  - Politics is as important as performance

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Summary

- Must have strong driver for change
- Must have a truly viable technology
- Actively encourage participation of stakeholders - especially decision makers
- Consider <u>all</u> the issues
  - everything that affects how the technology really has to be used
  - have a way of actually making the change
- Specs and standards
  - including QA and QC issues

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Joseph Leonhardt

Leonhardt Plating Company

"Innovative Water Conservation at Leonhardt Plating"

BIOGRAPHY

Joseph Leonhardt CEF is the environmental manager for Leonhardt Plating Company an electroplating company in Cincinnati. He has many responsibilities including environmental, safety, quality and personal manager. He authored a pollution prevention paper that won Leonhardt Plating the Ohio Governors' Award for Pollution Prevention in 1997. He was spoken to various groups and conferences concerning the p2 activities at Leonhardt Plating. He is the current President of the Cincinnati Branch of the American Electroplaters and Surface Finishers, and he is the Events Director for the SUR/FIN convention in Cincinnati in 1999.

Innovative Water Conservation

Summary

Founded in 1950, the Leonhardt Plating Company is a family owned and operated electroplating job-shop in Cincinnati. The company provides a variety of metal finishing services, including Polishing, Buffing, Electroless Nickel Plating, Nickel and Chrome Electroplating and Electropolishing of Stainless Steel in a 20,000 square foot shop. Leonhardt Plating is committed to total quality control and promotes continuous improvement at all levels including environmental.

Over a five year period, through an innovative, continuous program of water and raw material conservation, Leonhardt Plating has dramatically reduced its water usage and embarked on a permanent pollution prevention program.

As a result of concentrated efforts at Leonhardt Plating reduced water usage from approximately 23,000 gallons a day in 1993, to 3,000 gallons a day currently. This resulted in savings of $5,000 annually on our water bill.

In addition to the savings on our water bill, we were able to change our permit with the Cincinnati Metropolitan Sewer District from continuous flow to a batch discharge. This resulted in an annual cost savings of $10,000 in discharge monitoring fees.

In June of 1993, we began brainstorming sessions aimed at reducing wastewater by making the plating process more efficient. Changes included installation of water timers, reduction in the number of rinse tanks, use of counterflow rinses, redesign of the hot water rinse, repiping of wastewater collection, and downsizing of rinse tanks.

Narrative Description

In 1993, the first duty the operator performed each morning was to turn on all the water within the plant. All rinses continued to flow all day until quitting time and the operator would close the main valve as the last duty of the day. Water savers had been installed on all the rinse tanks in an attempt to reduce water usage. However, the water savers became clogged and ultimately failed. The operators eventually drilled these water savers out to allow for more flow into the rinse tanks.

Another attempt to conserve water was posting a sign above the main valve reminding operators to close the valve during breaks and lunch. This was not successful in reducing water usage.

We were using water in three different systems. The first was bath make-up and replacement for evaporation loss in the plating tanks and their closed looped rinse tanks. This water runs through a deionized exchange cylinder to remove impurities.

The deionized water is piped throughout the shop to fill plating tanks and rinses. All the plating rinses are closed looped, and piped through a heavy metal exchange cylinder. None of the deionized water is discharged into the sewer.

The second area of water usage was the cleaning stage of the plating process. We focused our attention on this area because it accounted for over 95 percent of our discharged wastewater.

The last source of water usage was used in a continuous flow hot water rinse following the chrome rinse tank. This water was discharged into the sewer as wastewater.

The wastewater from the cleaning rinses discharged from the tanks and spilled into a trough that ran under the plating area. The trough was funneled into a sump that was pumped to a holding tank. The wastewater settled in the holding tank and discharged into the sewer.

Description of Waste Reduction Techniques

Installation of Water Timer

A water timer and solenoid valve was installed to deliver a fixed quantity of water to each rinse tank. We purchased a lawn sprinkler water timer and solenoid valves at a local home improvement store. Instead of watering the grass, our converted lawn sprinkler system feeds water to our rinse tanks.

The water lines are now piped to a central location connecting the feed for each cleaning line. A solenoid valve is installed at the beginning of each line, and wired to the water timer.

The water timer allows us to control the amount of water to each of our five plating rinses. The amount of water needed is dependent of the size and quantity of parts run, and the times that the parts are run. We found that more water is needed before breaks and lunch breaks. Less water is needed for small flat parts. Any line can be turned off or on per water required.

Counterflow Rinses

We decided that the soak rinse was the dirtiest and needed the most water. The electroclean and acid rinse wastewater were fairly clean. We decided to reuse this water by collecting it and pumping it back to the soak rinse.

The wastewater from the electroclean and acid rinses overflow into a sump barrel that is pumped back to be reused in the soak rinse. This achieves our objectives of reusing fairly clean water and also doubled the amount of flow for our dirtiest rinse tank without using fresh city water.

Redesign Hot Water Rinse

A flowing hot water rinse followed the closed looped Chrome rinse tanks. The final Chrome rinse was piped into a holding tank and pumped through a heavy metal exchange cylinder that removed the heavy metals in the water and before sending it back to the final Chrome rinse. We decided to combine the chrome rinse water into the final hot water rinse.

We repiped the final Chrome rinse through the heavy metal exchange cylinder and into the hot water heater. The water is heated and runs into the final rinse and overflows to the supply source for the earlier Chrome rinse. This is a closed looped process and none of the final rinse is discharged into the sewer.

Repipe of Wastewater Collection

Another major improvement was the piping of the wastewater directly to the collection sump for each line. Now if the pH is running high or low, we can easily test the wastewater discharge of each plating line to determine where the problem is occurring and correct it.

Rinse Tank Updated

We looked at each rinse tank to determine its size and condition. Most of these rinse tanks were steel and needed to be repaired. The replacement of tanks are polypropylene or fiberglass tanks.

The new tank size was important because the larger the volume of water, the more water was needed to keep a fresh clean tank. The tank size was judged by the smallest possible size that parts could still run. All new tanks are fitted with weirs to capture any solids or oils that floated on top of the water.

A save rinse after the chrome tank was converted to a spray rinse. The chrome is collected in the tank and added back to the chrome plating tank. This is saving us 200 pounds in the cost of chrome.

Reduction in Number of Rinse Tanks

After scrutinizing the rinse tank layout, we decided that two rinses following the acid tank were not necessary. We removed one rinse with no noticeable change in the quality of rinsing. This eliminated three flowing rinses and saved $3,000 in water cost annually.

Environmental Benefits

The reduction in wastewater has allowed Leonhardt Plating to change its current continuous wastewater discharge permit to a single daily batch tank discharge. By capturing all wastewater in a batch tank, Leonhardt Plating can avoid a potential spill discharge into the sewer. A daily record log of pH, temperature, volume, start and stop time of each discharge, and name of operator is maintained.

Batch discharge has caused us to operate more efficiently by reducing our operating and monitoring costs. We have used these cost savings to improve recycling and reduction of our wastewater. Batch discharges also benefits MSD as a result of decreased paperwork, inspector's time, and wear and tear on MSD equipment.

Leonhardt Plating has made a commitment not to generate any more wastewater. In 1995 and 1998 we installed a new electropolish process that is completely closed looped from the sewer. All the rinsewater is piped through a heavy metal exchange cylinder and reused in the process.

Economic Benefits

Over the last five years, business has doubled. This proves that pollution prevention worked for Leonhardt Plating as our costs decreased and sales increased.

We anticipate an immediate cost saving of $10,000 as a result of decreased discharge monitoring fees. In addition, we will also experience a cost saving in the amount of water we buy and raw materials we purchase.

The long term cost savings will boost the company's growth potential and long-term survival. We have reduced the company's liability and improved the company's image as one that is more socially and environmental responsible. It has helped keep and attract environmentally conscious customers. We are providing the legacy of a cleaner environment for future generation.

Tim C. Lindsey

Illinois Waste Management and Research Center

"Proven Methods for Promoting the Adoption of P2 Innovations: Case Study Examples"

Timothy C. Lindsey

Tim Lindsey has been Manager of the Illinois Waste Management and Research Center (WMRC) Pollution Prevention Program since 1994. He supervises a staff of 15 engineers and scientists that perform research on innovative pollution prevention technologiesnd provide technical assistance to industries regarding pollution prevention strategies. Dr. Lindsey began working for the center in 1991 as a Research Engineer working directly with industry personnel to define methods for reducing both the volume and toxicity of the wastes that they generate. Tim was previously employed at one of the nation's largest energy processing facilities for Exxon. He was with Exxon for a total of six years and served as an Environmental Engineer, Safety Coordinator and Proje Manager. Prior to his work with Exxon, he was employed as an environmental consultant for five years supervising contaminated site investigation and remediation projects. Tim received his B.S. (1979) and M.S. (1980) in Environmental Science from Southern Illinois University and his Ph.D. (1998) in Environmental Planning at the University of Illinois.

Proven Methods for Promoting the Adoption of P2 Innovations: Case Study Examples

Timothy C. Lindsey, Ph.D.

Manager, Pollution Prevention Program

Diffusion of P2

- P2 is diffusing far slower than it should
- How does it compare with other innovations?
- How do we speed up the process?

Myth: The Advantages of P2 are so Obvious that People will Rush to Adopt it

- Waste Reduction
- Cost Savings
- Improved Compliance
- Improved Efficiency

Reasons for Slow P2 Adoption Rate

- Preventive Innovation
- Change Agents Identity
- Emphasis on Awareness
- Optional Decision
- Individual Blame Orientation
- Innovation Characteristics

Innovation Characteristics that Affect Diffusion

- Relative Advantage over the idea it supersedes
- Compatibility with existing values, past experiences and needs of potential adopters
- Complexity -- perception with respect to difficulty to understand and use the innovation
- Observability -- the degree to which the results of an innovation are visible to others
- Trialability -- the degree to which an innovation can be experimented with on a limited basis

3 Types of Innovation Knowledge

- Principles Knowledge -- information dealing with the function principles underlying how the innovation works
- Awareness Knowledge -- information that an innovation exists
- How-to Knowledge -- information necessary to use an innovation properly

Information Requirements for Implementing P2

- Compliance and Waste Treatment
  - Require mostly external (out of process) information
  - Internal information requirements include only Quantity and Concentration
- Pollution Prevention
  - Requires mostly internal (in-process information)
  - Adds to compatibility/complexity issues

Project: Examine the Diffusion of Membrane Filtration Technology

- Technology can be used to effectively recycle (in-process) cleaners and metal working fluids
- Payback period typically ranges from 6 to 24 months
- Can drastically reduce oily wastewater emissions

Key Questions

- What factors influenced companies decisions to adopt or reject the technology?
- What did change agents do to influence adoption decisions?
- How do we apply the lessons learned to other P2 Practices?

Summary of Project Participants

Participant	Innovation Resources	WMRC Involvement	POTW Involvement	Adopt/Reject
Large Automotive	Extensive	Yes	Yes	Adopted
Large Railroad	Extensive	Yes	No	Adopted
Small Stamping	Limited	Yes	Yes	Adopted
Small Machining	Limited	Yes	Yes	Adopted
Med. Fabrication	Moderate	Yes	No	Rejected
Med. Machining	Moderate	Yes	Yes	Rejected

Daniel Marks

Progressive Recovery, Inc.

"Innovations In Solvent Recycling Systems"

Dan Marx

Screenprinting & Graphic Imaging Association International

"Screen Printing P2: An Emerging Vision"

Biography:

Dan Marx, senior associate, government affairs, has been with Screenprinting and Graphic Imaging Association International since 1991. Focusing primarily on safety and environmental issues, he has created many of the Association's training and compliance programs, and has written on safety and the environment for a number of different industry publications. His numerous articles for the Association's monthly, the *Tabloid,* and other association publications, as well as his industry speaking engagements, provide him valuable forums from which to address important safety and environmental compliance issues of the day.

Screen Printing P2: An Emerging Vision

Introduction

For more than six years (starting 1992), the Screenprinting and Graphic Imaging Association International (SGIA) has been involved in an extensive P2 effort, mainly through its involvement in the US EPA's *Design for the Environment Printing Project.* Throughout this period, SGIA staff has learned a great deal about P2 methods and practices being developed by printers, as well as industry suppliers and materials manufacturers. Emerging from this experience is a new vision – a better way for the screen printing industry – an identification of environmentally preferable alternatives at every step of the screen printing process.

This article, utilizing numerous pollution prevention case studies, presents real-world examples of P2 successes, while at the same time presenting a start-to-finish tour of the screen printing process. While examples given will certainly not represent "one-size-fits-all" solutions to this highly diverse industry (products range from T-shirts to signs; surfboards to printed circuit boards), they do present universal strategies – diving boards of thought – for the minimization of waste and the prevention of pollution.

The Traditional Process in a Nutshell

Art/Image Preparation

Traditional "pre-press" image preparation includes the creation of film positives through the use of photographic developing processes. This photographic process is quickly becoming an activity of the past in many operations. Alternatives to this traditional process are discussed later in this article.

Screen Preparation

The creation of a printing screen begins with a wood or steel frame over which mesh, (commonly monofilament polyester) is stretched to a high tension, then attached. The mesh is then coated with a photosensitive emulsion. Once this emulsion has dried, a film positive is placed on the screen, which is then exposed to intense light. After exposure, a rinse of the screen mesh displaces any areas where the emulsion was not exposed to light, thus creating a "negative image." The screen is then ready to go to press.

Printing/Ink Use

In the actual print process, ink is forced through the screen mesh onto the substrate (print surface) by virtue of hydraulic pressure initiated by the action of a flexible rubber or synthetic blade known as a squeegee. Ink is deposited in areas where the stencil allows ink to pass. The printed substrate is then conveyed either by hand or mechanically onto a conveyor transport system, which conveys the print through a drying unit. In textile printing, a light-tack spray adhesive is periodically applied to the printing platen, in order to prevent the fabric substrate from moving or distorting during printing.

Inks commonly used in screen printing are traditional solvent-based inks and ultra-violet-curable (UV) inks, both utilized in the industrial and graphic areas of the industry. The screen-printed-textiles area of the industry commonly uses plastisol inks. Water-based inks are found in both areas of the industry, though they offer little environmental benefit when compared to more preferred alternatives.

Screen Reclamation

During the process of screen reclamation, the stencil that was applied to the screen in order to define the printed image is removed, so that the screen may be reused. Within the reclamation process, all excess ink is removed from the screen for reuse. At this point, any remaining ink residue is then removed from the screen, using either water-soluble ink degradents or solvents. Next, the screen is degreased using a mild detergent. A stencil-removing chemical is then applied. After the stencil remover has dissolved the stencil, the stencil is then removed using a pressure-washer. After this step, if any emulsion is still left in the screen, a caustic "haze remover" is used to eliminate the remaining emulsion. The screen is then ready to be reused.

Alternative Methods

The information outlined below presents some of the many ways progressive screen printers are preventing pollution in their operations. Before any of these methods or techniques is discussed, however, it is important to discuss exactly from where change in our industry is emanating. Many of the developments you will read about below were not originally intended to bring about a positive environmental benefit. In many of cases, they were designed to either improve quality or reduce costs. Some changes were even driven by the protection of employee health. These myriad motivations for change are in keeping with an ongoing theme constantly outlined by SGIA: safety, the environment, and good business production practices are very often interrelated. Using a chemical safer for your employees, for instance, can have an undeniable effect on a company's environmental impact.

Art/Image Preparation

Recent changes in art and image preparation have been driven primarily by the introduction of digital and computer technologies. Design software has easily dovetailed with digital output devices designed to produce film positives quickly, easily, and without the use of photographic chemicals. These devices run the gamut of digital technology,

ranging from small-format output from a standard computer laser printer onto translucent vellum; large-format thermal setting of images onto transparent film; direct-to-screen devices that inject the image directly into the screen mesh. Benefits of these types of devices include the reduction or complete elimination of photographic chemicals, and greater control of printing variables.

Some screen printers have also found an environmental advantage by using a color digital output device to create proofs for client review. This activity can be used to finalize art and design concerns before the press is set up. Design changes after press set up would require the reclamation and re-exposure of any screen involved.

Screen Preparation

The major environmental opportunity relating to screen preparation is to prepare screens carefully at all points in the process. Substandard screen preparation work can lead to lost time, lost money and the needless waste of significant amounts of chemical product. To provide an example, screens that are improperly prepared and improperly exposed may lead to unfavorable print quality. This means the job must be set up again. First, the screens must be reclaimed, requiring the use of one or more reclamation chemicals. Next, if the screens were either underexposed or overexposed, they may require the use of even more chemicals. This situation is a prime example of quality directly effecting environmental impact.

A secondary, but interesting environmental opportunity in screen reclamation relates to the type of screen frame used. Attaching screen mesh to traditional rigid wood or steel frames requires the use of aggressive adhesives. They also require replacement of mesh when, over time or due to excessive use, it loses tension. Attaching mesh to retensionable frames, however, requires no adhesive, and the expensive mesh can be re-tightened without replacement.

Printing/Ink Use

The main environmental opportunity relating to ink choice is the substitution of UV-curable ink for traditional solvent based ink. UV ink, like plastisol ink on the textile side of the industry, is 100% solid, containing no volatile organic compound (VOC), therefore highly minimizing air emissions. It is "cured" rather than "dried." UV ink does have its limitations, however, and can not be used for certain applications. As UV ink continues to develop, however, may of these limitations may vanish. The switchover to UV ink can also be expensive, requiring the installation of a specific curing unit.

In textile screen printing operations, a number or companies are finding less expensive, less pollutive ways of applying platen adhesive than the traditional "spray can' method. Some of these options include the use of water-based adhesives or large rolls of material similar to double-sided tape.

Yet another opportunity to prevent waste, and thus pollution in the printing/ink use area, is the institution of detailed ink management guidelines and strategies. These methods can include careful ink inventory control, mixing only as much ink as is needed for the job, detailed ink mixing records, and the prompt use or blending of excess ink.

Instituting a shop rag policy can drastically reduce certain wastes that may or may not require disposal as hazardous waste. One screen printer experienced success by simply instituting a policy that rags be used as many times as possible before disposal. To provide a simple figure, using rags five times instead of once reduces rag volume by eighty percent. A basic rag management policy can be simple to create, easy to implement, effective in waste reduction.

Screen Reclamation

Screen reclamation, the process in which the stencil is removed from the screen so the screen can be reused, is the area of the screen printing process where the most environmental progress has been made. The main reason for this reality is that this area is where the industry's "nastiest" chemicals are/were used. For this reason, screen reclamation was the primary focus of the Design for the Environment Screen Printing Project.

The use of chemicals other than those considered "traditional" is gradually becoming commonplace within the screen printing industry, some companies have found interesting and surprising results from their use of alternative chemical systems: a safer workplace, better performance, less product used, improvements on the bottom line. Printers investigating alternative reclamation chemicals have also found, however, that switching chemicals is not as easy as buying a new jug of product. Challenges associated with new chemicals can include finding the right product among many, and achieving employee buy-in on the use of the new product.

Whether a company is using either traditional or alternative solvents in screen reclamation, the use of a "closed-loop" solvent application system is an easy way to ensure that cleaning solvents are used not just once, but over and over until they are no longer useful. Some companies now distill their spent solvent for even further reuse.

Another common alternative in screen reclamation is the use of high-pressure water systems to aid in reclaiming. Using this type of system, a chemical is applied to "soften" the emulsion. The rest of the process is done by the water (often in excess of 1000 psi), which literally blasts the emulsion out of the screen. In many cases, these systems are linked with filtration units that claim any particulate matter from the water. Though these systems can require a significant initial investment, companies using these systems have found they are safer for employees, use less chemical product, and make screen mesh last longer, due mainly to the fact that the mesh is not repeatedly exposed to caustic chemical products.

In a recent development, one screen printer has created a holding tank to capture used rinse water from his company's screen preparation area. This "gray water" is then used with the company's high-pressure reclamation system. The main advantage in this situation is the reuse of water.

Even in situations where a company decides to continue using "traditional" screen reclamation solvent systems, opportunities for increased environmental performance do exist by way of modified work practices. For instance, one company found that sending screens to the reclamation process immediately after the press run made the screens easier to reclaim, requiring less effort, less chemical product, and less need for the use of caustic haze removers. Relating to haze removers, one company instituted a policy that haze remover be used only where the screen is stained, rather than on the whole expanse of the screen mesh. The benefits from these simple work process changes are equally simple to understand: improved worker safety, improved environmental performance, a positive effect on quality and the bottom line.

Applying New Methods

As was mentioned in the introduction to this article, not all the methods outlined above can apply to all screen printing companies. For instance, a screen reclamation chemical that performs exceptionally when used in conjunction with plastisol ink may work horribly with UV or solvent-based ink. The methods outlined above can, however, be used by all screen printers as valuable strategies for future environmental management efforts. Another example: UV screen printing ink is used on T-shirts.

Last, this article should in no way be considered complete. Pollution prevention methods, along with the technologies around which they orbit, are in constant flux. This article should be viewed as the first incarnation of an ever-developing body of knowledge.

-End-

Joe Mattson

Industrial Towel & Uniform, Inc.

"New Solvent Recovery Technology for Launderable Printer Wipers"

NEW SOLVENT RECOVERY TECHNOLOGY FOR LAUNDERABLE PRINTER WIPERS

WHY LAUNDERABLE PRINTER WIPERS?

* *LAUNDRY, NOT WASTE*

The U.S. EPA has determined that contaminated wipers generated as a result of normal operations which are sent to commercial industrial laundries and subsequently reused are not discarded; therefore, they are not solid wastes subject to regulation under RCRA. Wipers that will be sent to a laundry or are laundered by the generator and satisfy the RCRA exclusion specified in 40 CFR 261.4(a)(1) and (2) are not subject to RCRA accumulation requirements.

* *COST*

Head to head cost comparisons prove that launderable wipers cost less than disposables. In the case of printer wipers where compliant disposal may require handling as a hazardous waste launderable wipers cost significantly less.

WHAT IS UNIQUE ABOUT ITU'S SOLVENT RECOVERY PROCESS?

* *What methods of solvent removal are available?*

- *Air Drying, not a CAAA compliant option.*

- *wringing, required additional treatment prior to reuse. Creates often hazardous, wastestream.*

- *centrifugal extraction, requires additional treatment also. Creates additional, often hazardous, wastestream.*

- *microwave technology, a time consuming process, 2-3 hours.*

- *infrared technology, unproven, slow and time consuming.*

or ITU's Solvent Recovery Process.

- *efficient, controlled, high % solvent recovery*

- *solvent is recovered for beneficial reuse*

- *no additional treatment of the solvent is required*

- *flow monitoring to record the volume of solvent recovered which can be reported back to the generator of the soiled wipers for their chemical mass balance calculations*
(overhead, attached, detailing ITU's Solvent Recovery process)

** WHAT IMPACTS ARE THE IMPENDING EFFLUENT LIMIT GUIDELINES AND STANDARDS FOR INDUSTRIAL LAUNDRIES GOING TO HAVE ON THE INDUSTRIAL LAUNDRY INDUSTRY?*

- *START TREATING: those industrial laundries without wastewater pre-treatment may choose to install equipment which enables them to treat to the new standards. (about $1.5 million)*

- *UPDATE TREATMENT SYSTEM: those industrial laundries with "just enough to get by" today will have to update their pre-treatment systems. (about $250,000 for upgrade)*

- *AVOID THE NEED TO TREAT: industrial laundries with no system now may decide not to invest in pretreatment. They may choose to sell their business or outsource a portion of their cleaning to another industrial launderer.*

- *DRY CLEAN: Industrial laundries will try dry cleaning wipers to avoid wastewater discharge problems, a process which results in product quality unacceptable by industry standards.*

- *Disposable Wipers are an alternative for the end user, but should be evaluated in light of product cost, handling, storage, RCRA, CERCLA and total risk.*

**** A FEW INDUSTRIAL LAUNDRIES, ABOUT 13%, HAVE WASTEWATER PRETREATMENT CAPABLE OF MEETING THE NEW CATEGORICAL STANDARDS. ITU is one of the 13% capable of meeting the categorical standards.***

A comparison of pretreatment standards:

Pollutant parameter	*CP-Daily Max. (mg/L)*		
	Laundries (new)	*Electroplaters*	*Metal finish*
Copper	*0.24*	*4.5*	*3.38*
Lead	*0.27*	*0.6*	*.069*
Zinc	*0.61*	*4.2*	*2.61*

ITU's SOLVENT RECOVERY PROCESS EQUIPMENT LEASE OPTION. Our estimated return for leasing and operation of the solvent recovery equipment based on an average of 5000 wipers per week.

1) value of the recovered solvent	*$8,632*
an average of 4.15 gallons/100 pound load (ITU actual).	
4,316 gallons/year @ $2.00/gallon	
2) reduced reportable air emissions	*$ 534*
4,316 gallons/year x 7.5 lbs/gal = 32,370 lbs/yr	
32,370 lbs/yr = 16.19 tons/yr @ $33/ton = $534/yr	
3) not having to purchase and operate alternative	*$8,000*
equipment, ie: centrifuge. to	*$12,000*
4) elimination of the cost of hazardous waste	*$156,000*
disposal of at least 3 drums/week at a minimum	
of $200/drum.	
5) Improved health and safety in your plant,	*$?????*
reduced fumes, less fire potential, less OSHA risk,	*$5,000+*
improved fire inspection results.	
at least	*$ 9,166*
but as much as	*$182,166*

year, it will no longer be excluded from the standards.

§ 441.21 Pretreatment Standards for Existing Sources (PSES).

Pursuant to the CWA section 307(b)(1), indirect dischargers are required to comply with pretreatment standards for existing sources by three years of [the effective date of the final rule]. For purposes of this part, indirect dischargers must comply with this part by three years after [the date of publication of the final rule].

§ 441.22 Pretreatment Standards for New Sources (PSNS).

Except as provided in 40 CFR 403.7, any new source subject to this part that introduces pollutants into a publicly owned treatment works must comply with 40 CFR part 403 and achieve as pretreatment standards for new sources (PSNS) the same standards as those specified in § 441.21 for existing sources (PSES).

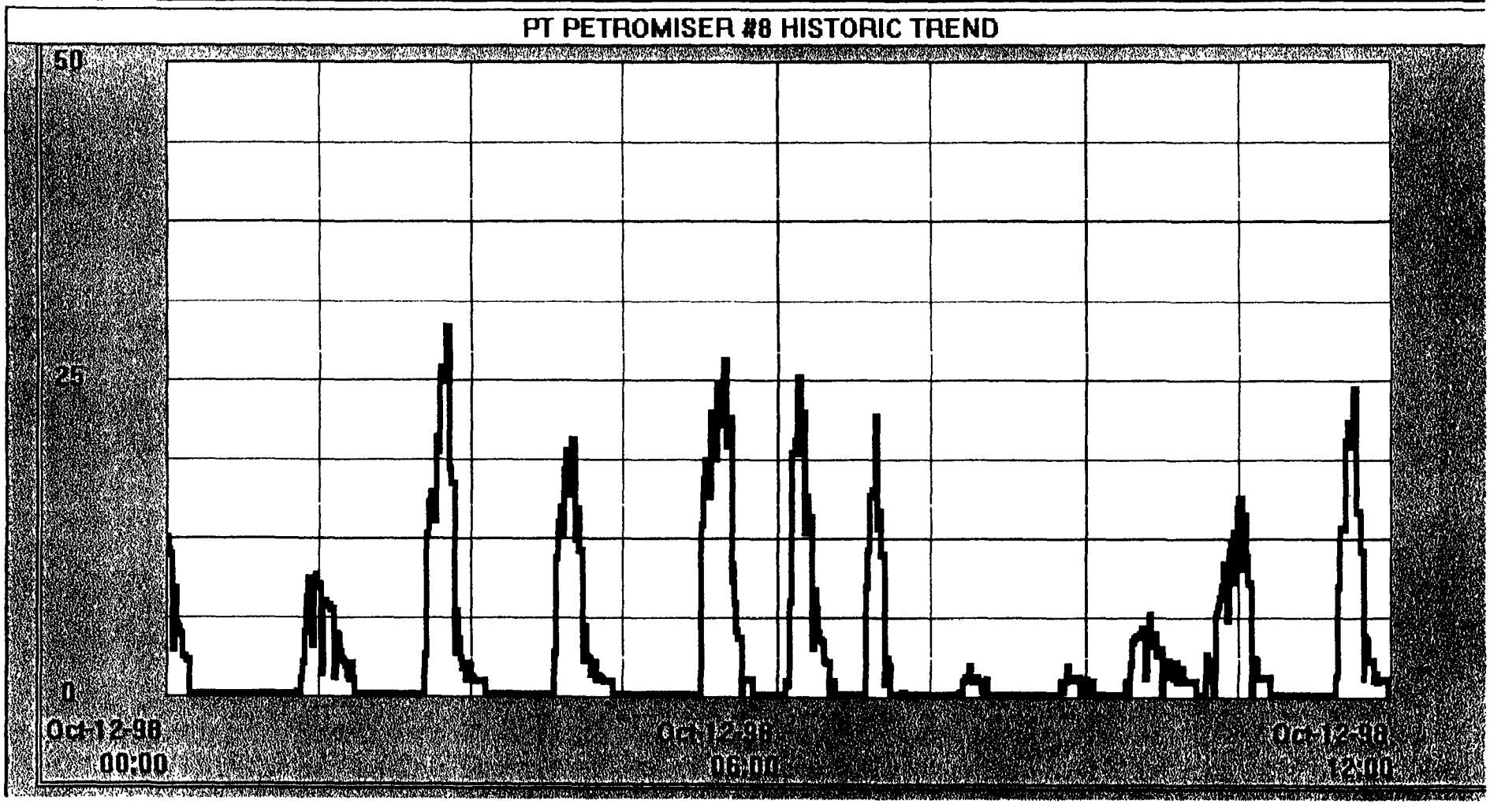
TABLE 1 TO PART 441—PRETREATMENT STANDARDS

Pollutant parameter	CP—Daily maximum (mg/L)
Bis (2-Ethylhexyl) Phthalate	0.13
Ethylbenzene	1.64
Naphthalene	0.23
Tetrachloroethene	1.71
Toluene	2.76
m-Xylene	1.33
o&p-Xylene	0.95
Copper	0.24
Lead	0.27
Zinc	0.61
SGT–HEM [1]	27.5

[1] Monthly average limitation for SGT–HEM under CP option is 15.4 mg/L.

[FR Doc. 97–30240 Filed 12–16–97; 8:45 am]

BILLING CODE 6560–50–P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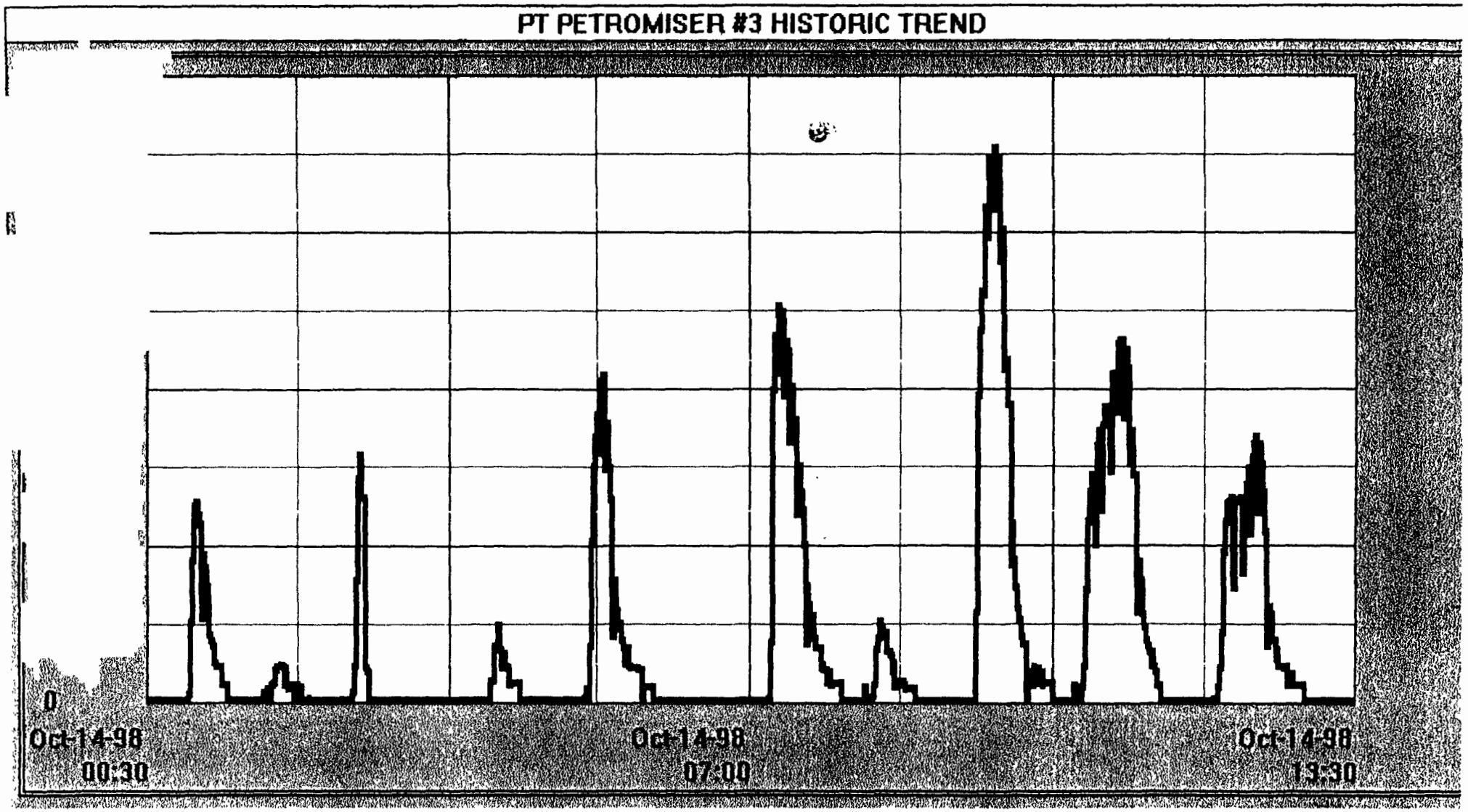
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Dan T. McGrath

Great Cities Institute, University of Illinois at Chicago

"An Empirical Evaluation of the Adoption of P2"

BIOGRAPHICAL SKETCH

Daniel T. McGrath

Professional Positions:
Research Professor, Great Cities Institute, University of Illinois at Chicago and
Coastal Economic Development Specialist with the Illinois-Indiana Sea Grant Program (1998 – present).
Research Economist, The Energy Resources Center, University of Illinois at Chicago (1996-1998).
Research Associate, The Great Cities Institute, University of Illinois at Chicago (1994-1996).
Research Associate, The Center for Urban Economic Development, University of Illinois at Chicago (1992-1994).
Assistant Economic Analyst, Argonne National Laboratory Technology and Environmental Policy Section, Argonne, Illinois (1991-1992).

Education:
Ph.D. 1996, Public Policy Analysis/Economics, University of Illinois at Chicago.
M.A.1993, University of Illinois at Chicago, Economics.
M.B.A..1986, University of Notre Dame, Finance and Management.
B.S./B.A.1983, University of Notre Dame, Mechanical Engineering/History.

Awards and Honors:
1985 Notre Dame/Clark MBA Scholarship
1992, 1993, 1994 University of Illinois/FMC Corporation Fellowship Winner
1993 UIC/Geldard Academic Award for outstanding graduate student in economics

Publications Related to the Proposed Project:
McGrath, D.T. 1998. Urban industrial land redevelopment and contamination risk. *Journal of Urban Economics*. (in review)
McGrath, D.T. 1997. Lean and green: an empirical evaluation of firm pollution prevention adoption. Report submitted to the Chicago Manufacturing Center.
McGrath, D.T. 1996. A REMI model evaluation of the contribution of the Chicago airport system to the Chicago metropolitan regional economy. Report prepared for the City of Chicago Department of Aviation through UIC's Great Cities Institute.
McGrath, D.T. 1994. An analysis of impacts to the State of Illinois regional economy related to proposed water pollution rules, R92-8. Prepared as Testimony before the Illinois Pollution Control Board. Center for Urban Economic Development (March).

Professional Activities:
Membership: American Economics Association, Midwest Economics Association, Illinois Economics Association.

Collaborators: Wim Wiewel, John McDonald, Joe Persky, Davis Jenkins, Daniel McMillen, Bonnie Lindstrom, Bernard Engel, Jonathon Harbor

Graduate Advisors:
Dr. John McDonald, Department of Economic, University of Illinois at Chicago

I. Introduction

One of the more prominent issues currently being debated within the Pollution Prevention (P2) community is why firms are reluctant to adopt a pollution prevention opportunity despite clear cost savings by doing so. A recent example of this was Dow Chemical's reluctance to adopt a program that eliminated a half million pounds of waste that saved $1 million (Greer & Van Loben Sels, 1997). Why would it not take advantage of this opportunity? The main reason given was fundamentally economic - that the P2 project could not compete with other more financially attractive capital allocation opportunities within Dow.

The P2 community seems fairly silent on the fact that adopting preventing pollution practices that fundamentally change the way a firm accomplishes its production has profound economic consequences for many stakeholders within a local economy—both positive and negative. In a recent study modeling the economic impacts of P2 on New Jersey's regional economy (Robinson, 1996), not only did firms' cost savings have a net positive effect on the State's output, employment, and personal income, but one of the direct effects of P2 was that the chemical industry lost substantial income as a result of lower chemical use. However, these negative effects of P2 adoption are similar to those that occur for any broadly adopted process innovation.

The national P2 community has been recommended to direct its research towards the development of a stronger understanding of the fundamental economics behind pollution prevention adoption. In his keynote speech at the April 1997 National Pollution Prevention Roundtable Conference, New England Regional EPA Director, John DeVillars, indicated that the adoption of P2 was linked with the economic situtation facing a firm. He went on to say that the P2 community has not clearly identified measures that help firms achieve economic and

environmental success. Mr. DeVillars' call for the incorporation of more rigorous, formal economic analysis in P2 research was echoed by a number of speakers at the NPPR Conference, the most notable being the Hon. Jackie Aloisi de Larderel of the United Nations Environmental Program. Her recommendation to the U.S. P2 Community was that a greater fundamental economic understanding of P2 be developed, which she noted is the direction that P2 is moving in Europe and that is consistent with the recommendation of the President's Council for Sustainable Development.

The general thrust of P2 adoption explanations developed by the US P2 research community are primarily organizational and managerial in nature. When confronted with the apparent failure to achieve broad technological adoption within US firms, prominent P2 researchers have responded with discussions of failures of vision, inadequacies of leadership, bureaucratic inertia, and subversive co-opting of the true definition of P2 (Hirschhorn, 1997). These qualitative perspectives may be an accurate and important commentary on management in US firms and how that impacts how firms conduct business, direct capital investments, and seek to achieve the environmental compliance mandated by federal and state law. However, this discussion does not assist in developing an understanding of the fundamental economics behind pollution prevention. Until now there has been little focused discussion or empirical analysis of P2 as process innovation - the changing of a production process to achieve improved production and/or lower costs. Most studies on the determinants of P2 adoption have been anecdotal or based on incomplete survey research analysis. The purpose of this paper is to begin this discussion—to restate the problem of P2 adoption in a way whereby the economics of process innovation might provide some insight to its adoption by firms.

In addition to the development of a process innovation framework for P2 adoption, this report presents the results of cross-sectional analysis utilizing this framework to identify the firm and industry specific factors contributing to P2 adoption from an investigation of data provided by the Industrial Technology Institute's (ITI) Benchmarking Database. Following is a broad review of literature discussing process innovation. Next is a section describing the ITI Benchmarking Database used in this analysis. The final section is a discussion of the empirical results and their implications for public policy.

II. Literature Review

The topic of pollution prevention as distinct from pollution abatement or control has yet to be discussed in any substantial way in the economics literature, though its absence has been recognized and commented on (Helfand, 1992; Robinson, 1996). Applied P2 literature discusses a number of reasons why firms might not be willing to adopt P2 opportunities despite their clear cost savings. The general view in this body of literature is that the primary limitation to P2 adoption are organizational/managerial in nature: firm managers and/or decision makers lack or are unwilling to acquire the necessary information to make a full assessment of the potential associated cost savings (Bierma & Waterstratt, 1995; Bartlett, et. al, 1995).

The first article specifically addressing the economics of pollution prevention as defined and understood by the P2 community is Helfand (1992). In this article, Helfand presents results and policy implications from a standard profit-maximizing firm model using two inputs: a polluting input (for which reduction would constitute pollution prevention) and an abating input (pollution control technology), both of which are assumed to be productive inputs. The applicability of this model to the P2 issue is that it explores the various outcome measures

(output, profits, and pollution emissions) resulting from the application of four different public policies, one of which requires firms to limit their use of the pollution input below a certain level—i.e. source reduction. Helfand's primary contribution is that, given a unchanging production function, economic theory shows that mandating source reduction will achieve optimal pollution abatement levels, but it will also result in lower economic performance of the firm. That is, profits will be lower than in the case where the firm is left to decide how it is to achieve required abatement performance standard.

In Helfand's static model, profits can only increase if the firm changes its technology. If pollution is costly to a firm, there is an incentive for the firm to pursue process innovations to reduce those costs (and pollution) in the same way that firms try to reduce other normal operating expenses. This kind of change can only be represented in Helfand's model as a change in the firm's production function; however, this is outside the scope of her paper. Although not addressing process innovation in her model per se, Helfand does recognize the fact that understanding P2 as a process of technical innovation and diffusion is an important idea that has yet to be addressed in the literature.

Helfand's paper views the question of why a firm might be unwilling to capitalize on a clear cost-saving P2 opportunity in more general terms - what limits a firm's adoption of any kind of process innovation, since there are fundamental economic reasons for not adopting technologies instantly? The speed at which process innovations are adopted can depend on the level of cost savings achieved, the cost of the investment, the level of uncertainty associated with the new process, interest rates, capital constraints, and industry demand. Additionally, acquiring new process technology can involve major human capital investments, worker and manager

retraining, and often represents a direct challenge to the inertia of a bureaucracy that may be already meeting its stakeholder expectations.

There is a large body of literature investigating the question of innovation and its role in the process of technological change. The standard text outlining the theory and empirical literature relating to technological change is Stoneman (1983). Generally, technological change is understood as a three step process. 1) Invention—the creation of a new process or product usually patented; 2) Innovation—the first commercialized application of a new invention; and 3) Diffusion—the process by which an innovation spreads across the market and is adopted by competing firms. With regard to process innovation, theory suggests that new processes are more likely to yield greater cost reductions (Stoneman,1983, p. 264). Thus, innovation and diffusion of new technology is more likely to occur when it saves on a production factor input that has a higher share in total costs than when it has a smaller share, and those factors determining the magnitude of these costs for a firm—such as the firm's output level, the factor input prices, and interest rates, are the same factors that signal innovation of new technology. A classic example is the tremendous innovative response in the U.S. following the Arab oil embargo of 1973.

Another excellent summary discussion of innovation is Tisdell (1995a). In this article, Tisdell outlines the economics of process innovation and discusses some general limitations on diffusion. Generally, competition among firms is viewed as an important determinant of R&D activity and, as such, an important determinant of innovation. Firms are in competition to gain market share by developing and innovating new cost-saving processes, and this competitive process determines winners and losers, leaders and laggards. Tisdell identifies six important

economic factors that current economic theory shows to be significant determinants of innovation[1]:

1. The greater the initial size of the market, the greater likelihood of innovation by firms in the market.

2. The greater the expected growth rate of a market, the higher the likelihood of innovation by firms in the market

3. The higher the discount rate on capital investments, the lower the likelihood of innovation.

4. The longer the firm's planning horizon, the greater the incentive to innovate

5. The higher the marginal productivity of the firm at reducing its unit costs of production the greater the likelihood of innovation by that firm.

6. The more inelastic the demand for a firm's product, the greater the likelihood of innovation[2]

II.A. *Innovation in Pollution Control*

There are a number of papers investigating innovation in pollution abatement technology, most of which are focused on the impact of different public policies on the rate of abatement technology change. Magat (1978) presents one of the first theoretical examinations of the impacts of differing environmental policy regimes—in this case an effluent tax versus a fixed effluent standard—on inducing advancement in abatement technology. Polluting firms react to both these policies by reducing the levels of production and/or changing their production process to one that is less polluting per unit of output. Environmental policy also affects the firm's investment decisions concerning the extent and type of innovations that are developed and

[1] The factors identified refer to their effects on R&D expenditures. The assumption here is that the higher the R&D expenditure by a firm, the higher the rate of innovation. The six factors are identified from an investigation of the innovation possibility frontier model developed by Dasgupta & Stiglitz (1980).

[2] When a firm has faces inelastic demand for its product, this means that large price changes for its product result is generally small changes in the quantity demanded. In this situation, given a relatively stable market, the firm is more likely to be a cost minimizer—seeking ways to reduce its costs of production.

diffused. As a result, it also affects the rate (the amount of innovation over time) and direction (advancing production technology vs. abatement technology) of technical advance, as measured by the ratio of R&D expenditures to total expenditures. Magat's results demonstrate that there are two important differences between these two policies. First, over time an effluent tax can be shown to increase the amount of effluent produced for most firms, whereas an effluent standard ensures a fixed effluent path with advancing technology. Second, and of most relevance here, the model implies that if labor substitutability is difficult, a constant effluent standard promotes an increase in the rate of advance in abatement technology whereas an effluent tax leads to a decline in the rate of abatement technology advancement.

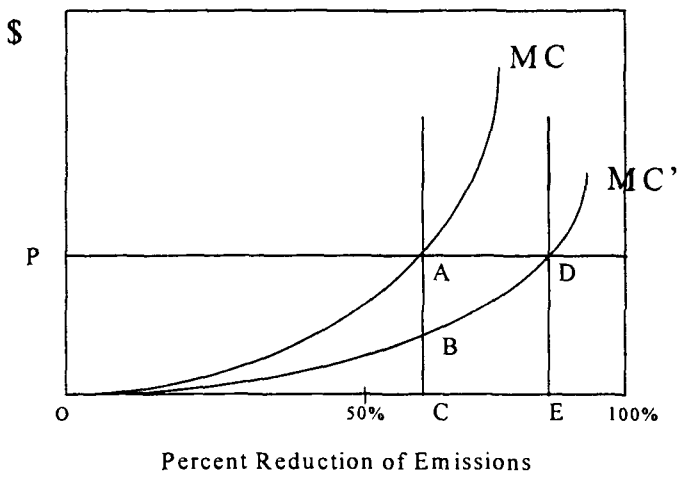
Milliman & Prince (1989), however, support a different conclusion. These authors examine the incentives to promote pollution abatement technology change under five different regulatory approaches: emission standards, emission subsidies, emission taxes, free marketable permits, and auctioned marketable permits. Their model investigates the dynamics of diffusion of technology and how these five policy approaches affect these dynamics. The authors conclude that emission taxes and auctioned permits provide the highest incentives to promote innovation and diffusion of abatement technology and are comparatively higher that the other three policy regimes.

Downing and White (1989), in theoretical analysis of the impact of various institutional arrangement on pollution control innovation, provide a simple framework for discussing the economic constraints to process innovation in pollution prevention. Applying this model, if one assumes that the environmental policy is one of command and control (the current regulatory approach in the U.S.), then the firm will pursue innovation up to the point where it meets its environmental compliance requirements. Emission standards for a given firm are depicted as a

fixed emission requirement (line AC in figure 1). In figure 1, the marginal cost of reducing emissions for the firm is curve MC. If the regulating body is pursuing social efficiency in pollution control and knows the marginal social benefit of reducing emissions, depicted as fixed benefit P, in figure 1, then the regulating body should set the emission control level at the point of social optimum. This is point A— the point where marginal benefit equals marginal cost.

Assuming that a firm is in compliance and is operating at point A on its marginal abatement cost curve, any technology that reduces the marginal cost of abatement, line MC' in figure 1, will provide the private economic benefit to the firm (area OAB). However, the firm will have no incentive to adopt the new technology and operate at point B unless the present value of the net benefits, OAB, exceeds the cost of investment in the new technology, X. Also note that there is no incentive for the firm to operate at the new social optimum, point D on the new marginal cost curve, MC', unless the governing body responds to the new technology opportunity by imposing a new, more stringent standard, line DE on figure 1. The only incentive to produce at point D is if the additional costs imposed by acquiring the new abatement technology (area CBDE) and the initial investment, X, (not represented on the graph) are less than the current abatement costs, area OAB.

Figure 1



Downing and White's simple model presents very clearly that incentives to adopt cost saving innovations in pollution control in the presence of a fixed abatement standard are fundamentally economic, and the likelihood of adoption of a new process innovation that reduces pollution is a function of the net present value of the cost savings achieved by adopting the innovation—that is the present value of the cost savings achieved by adopting the new process less the cost of the investment, X.

$$\text{Prob(P2 Adoption)} = f(\text{NPV}).$$

Fixed abatement standards provide no incentive for firms to adopt cost saving opportunities above those that bring the firm into compliance, Thus, the economic determinants of pollution prevention adoption are those factors determining the net present value of the pollution prevention opportunity. Also, for any firm, if the reduction in marginal costs resulting from adopting a new technology is not well defined or is uncertain, the likelihood of adoption by the firm is reduced even further.

II.B. ***Economic Competence***

As mentioned previously, the P2 literature discusses many valid non-economic reasons why firms may be unwilling to adopt P2 opportunities, with most of those reasons centering around the managerial ability of the firm's decision makers. If a firm lacks the ability to accurately assess cost savings in pollution abatement, this increases the uncertainty for the firm to accurately assess a net present value for any pollution prevention opportunity. This notion is not inconsistent with the idea of "economic competence" expressed in the evolutionary economics literature (see Tisdell, 1995b), which state that innovation requires not only the generation of a new cost-saving idea, but economic actors must have the capability to take advantage of the innovation. Carlsson and Stankiewicz (1991) posit that a firm's economic competence—the ability to perceive opportunities and adjust its performance accordingly—is an important determinant of the innovation process and a determinant of which innovations will survive in a competitive market. It is important to emphasize that the notion of economic competence—an idea similar to "entrepreneurial capital"—is a very difficult measure to specify; though the implication is clear - firms with greater economic competence are more likely to adopt pollution prevention opportunities. A number of researchers have provided evidence that larger firms are more likely to adopt newer, more capital-intensive technologies (Kelley and Brooks, 1991; Dunne, 1994). The argument is that larger firms have and can maintain a higher stock of human capital and are thus more capable of recognizing and capitalizing on an cost-saving opportunity. Thus, larger firms tend to be more likely than smaller firms to adopt a pollution prevention opportunity.

In a theoretical article, Teece (1994) posits that a firm's organizational structure (formal and informal structures and hierarchies within the firm), as well as the network of external linkages they possess have a direct affect on the firm's innovation activity. However, pollution

prevention opportunities cross over both of his innovation classifications—"autonomous" innovations which fit well into the existing structure and "systemic" innovations that present more direct challenges to the existing firm structure. It is not clear if any specific firm structure emerges as being the most conducive to P2 adoption, but the thrust of Teece's view is clear. Innovation can be significantly determined by firm structure and encouraging P2 must take into account the broad and complex nature of the organizational structure of small and large firms. This view of organizational structure and external linkage as a critical factor in facilitating P2 adoption is very consistent with much of the discussion in the P2 literature. Specifically, Bierma and Waterstraat (1995), in a survey investigation of P2 adoption among metal fabricators, find information linkages —particularly supplier-firm linkages—to be a critical factor in successful P2 adoption in the metal fabrication industry.

Doms. et. al. (1995) in a paper identifying the determinants of firm exits from an industry, postulate that the exploitation of advanced technologies by a firm may be proxy for unobserved managerial ability. If firms with superior management are best able to fully exploit advanced production techniques, then plants with superior management would be more likely to adopt pollution prevention opportunities. Antonelli (1993) suggests that capital investment in advanced technology correlates positively with increased productivity. Thus, firms with higher managerial ability or "economic competence" might be more likely to exhibit higher rates of productivity. If economic competence is a fundamental determinant of a firm's adoption of a pollution prevention opportunity, as is suggested in the P2 literature, then a positive relationship between P2 adoption and firm productivity would exist.

However, one must keep in mind that the adoption of a P2 opportunity, or any new technology that reduces a firm's costs, might by itself contribute to a firm's increase in

productivity. Myers and Nakamura (1980) explore the impact of fixed time schedules for pollution abatement on firm productivity. The authors develop a dynamic model whereby a firm manager has a range of choices regarding input proportions and output levels until the investment in production equipment is made. Thereafter, the firm's plant and equipment are fixed for their useful life. The implications of this model are that the imposition of pollution abatement requirements lead to accelerated obsolescence of existing plant and equipment, creating a short-term increase in labor productivity for the firm.

In sum, a firm's adoption of a process innovation that reduces pollution control costs, i.e. a pollution prevention opportunity, is a function of the net present value of the savings achieved by the adoption of an innovation. However, without the ability to directly observe a measure of this net present value for a firm, as discussed above, a number of researchers have identified a collection of industry-specific and firm-specific characteristics that might signal the magnitude of this value and, as such, signal the adoption of an innovation. With respect to industry-specific characteristics, process innovation is hypothesized to be correlated with the size and expected growth rate of the industry's market (Tisdell, 1995). With respect to firm-specific factors, those characteristics that increase the scale of the net present value of any cost-saving opportunity are hypothesized to correlate with firm P2 adoption. Larger firms are more likely to adopt newer technology and process innovations (Dunne, 1994). More capital intensive firms are likely to have lower capital costs and are more likely to replace capital with newer, more modern plant and equipment (Doms et. al. 1995), while firms with a higher share of toxic disposal costs to total costs are more likely to have an incentive to reduce those costs with new process innovation (Stoneman, 1983).

Aside from these strictly economic factors, firms with greater managerial ability or "economic competence" have a higher likelihood of identifying and responding to cost-saving opportunities and, it is hypothesized, that some measure of a firm's initial productivity might be a good proxy for this unobserved variable (Doms, et. al, 1995).

II.C. *The Model and Hypothesis*

This paper hypothesizes that the above-mentioned industry-specific and firm-specific characteristics identify underlying differences in a firm's capability and incentive to identify and reduce costs, given a hypothetical cost-saving opportunity. The empirical technique to test this hypothesis is a probit regression of the discrete dependent variable, P2ADOPT, which takes on the value of one if a firm adopts a pollution prevention opportunity and zero if it does not, and is generally of the form:

Prob(P2ADOPT) = f(industry-specific characteristics, firm-specific characteristics, firm managerial capability)

Prob(P2ADOPT) = f(market size, firm market share, industry, firm size, capital-labor ratio, toxic-waste cost share, initial firm productivity at time of innovation, vector of other variables which determine firm economic competence)

If a measure of the firm's initial productivity is a significant determinant of P2 adoption, then this lends support to the view that managerial capability is a limiting factor. Also, if other industry-specific and firm-specific variables are statistically significant in addition to initial total

factor productivity, then it is possible to separate the impact of the economic determinants of P2 adoption from the vector of factors used as a proxy to measure managerial ability.

III. Description of Data

The dataset for this study is micro-level data of firm characteristics produced by the Performance Benchmarking Service at the Industrial Technology Institute (ITI) in Ann Arbor, Michigan. The dataset consists of 1,662 manufacturing companies nationwide. These are typically smaller firms with sales of over a million dollars. The information is provided to ITI directly from the firm through questionnaires that were administered to these firms in 1996. From these questionnaires, data on firm background, general business, design and manufacturing, scheduling and delivery, workforce and quality assurance were gathered, under condition of anonymity.

Of main interest in our study on pollution prevention adoption by U.S. manufacturing companies, are the pollution prevention variables within the 1996 questionnaire:

1. Does the firm use or dispose of hazardous or toxic material through its production process?
2. Has the firm tracked the use and disposal of these hazardous materials?
3. Has it re-engineered its product(s) or manufacturing in order to reduce toxic material?
4. Does it have information on the dollar amount of disposal costs of these hazardous materials?

Most of the variables in the dataset can be categorized in 2 separate values – current value in 1996 and value from 2 years earlier (1994). This enables short-term comparisons of these variables. The total number of records that had complete data to investigate the relationship between P2 adoption and the variables identified was 312 records. Complete data for all variables is required in a probit analysis (see Appendix 1 for a discussion of the probit analysis),

and missing data was the only reason for the exclusion of a record. Of these total 312 firms, all require the use or disposal of toxic waste. With respect to the most important P2 question—whether the firm had changed their product formulation or production process to achieve a reduction in toxic use or byproduct—205 firms responded yes and 107 firms responded no.

III.A. *Discussion of Variables in Probit Model*

The dependent variable in the probit model is P2ADOPT, a dummy variable taking on the value of 1 if the firm reports a change in its production process or product formulation to facilitate the reduction of toxics use or byproduct and 0 if not. There are ten independent variables included in the probit model. The first seven of the independent variables listed here are firm-specific characteristics at beginning of two-year time period. These variables will be tested separately to produce a "predictive" P2 adoption model to identify those initial characteristics that signal P2 adoption during the 2-year period. Also, depending on the model specification, industry dummy variables will be included in the model to control for industry effects. However, not all industries are represented in the dataset. Where industry dummy variables are included, the variable INDSALES will be excluded, as there may be a strong correlation between INDSALES and the industry dummy variables.

The definitions of these variables are as follows:

1. **TRACKU94** – Dummy variable which takes on the value of 1 if the firm reported tracking its use and disposal of toxic material in 1994. If not, the value is 0.

2. **HAZRAT94** – The ratio of the firms reported total hazardous or toxic waste disposal and treatment costs in 1994 to the firm's total reported material, parts, services, and utility costs.

3. **VAPE94** – The firm's calculated value added per employee in 1994.

4. **CLRATIO** – The firm's capital/labor ratio. This variable is calculated as the firm's reported replacement value of its machinery divided by the firm's total payroll in 1994.

5. **EMPCODE** – This variable identifies the firm size as measured by the number of employees. EMPCODE takes on the value of 1 if the firm has 50 employees or less. It takes on the value of 2 if the number of employees is between 51 and 100. It takes on the value of 3 if the number of employees is between 101 and 500, and it takes on the value of 4 if the number of employees is between 501 and 1000.

6. **MKTSHR** – This variable identifies the firms market share which is calculated as 1994 firm sales divided by 1994 value of industry shipments.

7. **INDSALES** – The total value of 1994 firm industry shipments from the 1995 Annual Survey of Manufacturers (US Department of Commerce, 1995).

The next three variables are qualitative firm performance variables at the end of the two-year period. These variables have been chosen to signal those firms that may be better managed. These variables are:

8. **TRACKU96** – A dummy variable essentially identical to TRACKU94; however it identifies if the firm reports tracking in 1996—at the end of the two-year period.

9. **MODEQUIP** – A dummy variable which takes on the value of 1 if the firm reports that it had purchased new equipment or upgraded its equipment within the 2-year period, else the value is 0.

10. **ISO9000** – A dummy variable which takes on the value of 1 if the firm reports that is had received ISO 9000 certification[3] during the 2-year period.

[3] ISO 9000 is a series of quality standards (published by the International Organization for Standardization -ISO) which define a framework of minimum requirements for the implementation of quality systems to be used in contractual situations identical to the EN series of standards (EN 29000) and other national series. The ISO 9000 standards have been adopted worldwide as suitable criteria for assessment and registration of companies by independent accredited third-party organizations.

The last two variables are quantitative performance variables which have been chosen to measure firm productivity and cost-reduction performance at the end of the two-year period. These are:

11. **DELHAZCR** – The change in total real hazardous waste disposal and treatment costs in 1994$ over the two-year time period.

12. **DELRVAPE** – The change in real value added per employee in 1994$ over the two-year time period.

Separating these firms into two groups, some interesting statistics emerge. On average, P2 adopting firms when compared to non-adopters are:

1. more likely to track their use and disposal of toxic materials
2. have higher hazardous waste disposal costs and a higher share of hazardous waste disposal costs to total costs.
3. higher sales and larger number of employees.
4. lower hazardous waste disposal cost growth.
5. higher capital/labor ratio.
6. slightly lower measures of initial labor productivity.
7. higher total industry sales
8. larger market share.

The general statistics of a number of variables for these 312 firm records which have been divided into P2 Adopters and Non-Adopters is presented in Table 1.

Table 1 -- Descriptive Statistics

	Total Sample N=312		P2 Adopters N = 205		Non-Adopters N = 107	
Variable	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
TRACKU96	0.885	0.320	0.907	0.291	0.841	0.367
TRACKU94	0.795	0.404	0.810	0.394	0.766	0.425
DELHAZCR	$ 998	$ 24,322	$ 954	$ 29,751	$ 1,083	$ 5,680
HAZRAT94	0.0043	0.011	0.0056	0.013	0.0021	0.003
EMPCODE	2.387	0.666	2.493	0.661	2.186	0.631
CLRATIO	1.450	1.749	1.630	2.059	1.106	0.793
MKTSHARE	0.0032	0.0095	0.0039	0.0114	0.0018	0.0035
INDSALES	$19,522	$26,800	$ 21,825	$ 29,510	$ 15,108	$ 20,035
ISO9000	0.035	0.184	0.049	0.216	0.009	0.097
MODEQUIP	0.721	0.449	0.771	0.421	0.626	0.486
VAPE94	$ 65,830	$ 33,830	$ 64,973	$ 33,382	$67,472	$ 34,771
DELRVAPE	$ 3,938	$ 15,522	$ 4,925	$ 15,108	$ 2,049	$ 16,191

IV. Empirical Results

In this section, patterns of pollution prevention adoption and firm characteristics, qualitative outcomes which signal firm performance, and productivity measures focusing on the role of a firm's hazardous waste cost ratio in predicting pollution prevention adoption are examined. As discussed above, the approach is to estimate a set of pollution prevention adoption equations using a probit model.

Table 2 reports the results from the probit P2ADOPT regressions using the 317 plant observations from the ITI data. All the three equations include controls for industry effects by including dummy variables based on ITI's 25 industry classifications[4]. The probit results from all the 21 industry group dummy variables are not included in Table 2; however, those industry groups for which the results are significant are included. Standard errors are in parenthesis. Variables with a double asterisk identify the variable as being significant at the 5% confidence

[4] Three industry groups were not represented in the data. Also, industry group 6, metal forming and fabrication, was selected as the reference category as it was the most represented industry in the dataset. Thus, the dummy variable for industry group 6 was excluded from the probit analysis.

level. Variables with a single asterisk identify variables that are significant at the 10% confidence level.

The first column identifies the results of Model 1, which includes basic firm characteristics at the beginning of the two-year time period (which is the year 1994) in the data. This equation is essentially the "predictive" P2 adoption model, that identifies those firm characteristics reflective of the firm's cost structure and managerial performance that best predict a firm's adoption of pollution prevention measures. The probit results of Model 1 indicate that larger, more capital-intensive firms with high hazardous waste costs as a share of total costs have the highest likelihood of P2 adoption. Firm size, as identified by the number of employees (EMPCODE), the firms capital-labor ratio (CLRATIO), and the firms initial hazardous waste cost ratio are all significant determinants of a firm's P2 adoption while the signs of the coefficients are consistent with expectation. These three variables were selected as indicators of a firm's cost structure, since actual cost-savings from a firm's P2 adoption is unknown. Whether or not a firm was initially tracking its hazardous material usage (TRACKU94) is significant. However, a firm's initial productivity, as measured by the firm's value added per worker (VAPE94), is significant . However, surprisingly, its sign is negative.

Table 2
Probit Model: Dependent Variable is P2ADOPT

Variable	Model 1	Model 2	Model 3	Model 4
	N = 312	N = 312	N = 312	N = 312
Intercept	-0.568* (0.352)	-0.9896** (0.4210)	-1.717** (0.519)	-1.824** (0.529)
TRACKU94 1 if the firm tracked its use and disposal of hazardous material in '94, 0 otherwise	0.051 (0.203)	-0.034 (.228)	-0.462 (0.299)	-0.449 (0.301)
HAZRAT94 Ratio of hazardous waste disposal costs to firm total costs	40.941** (17.077)	37.610* (21.338)	40.027* (22.333)	43.196* (22.702)
VAPE94 Value added per employee in 1994	-4.623 E-6* (2.49 E-6)	-2.343 E-6 (2.78 E-6)	-3.691 E-6 (2.90 E-6)	-3.119 E-6 (2.98 E-6)
CLRATIO firm Capital/Labor Ratio	0.123* (0.070)	0.148* (0.086)	0.139* (0.084)	0.136* (0.084)
EMPCODE 1 if employees < 50, 2 if 50 < employees < 100, 3 if 100 < employees < 500, 4 if 500 < employees < 1000	0.321** (0.141)	0.445** (0.136)	0.314** (0.145)	0.324** (0.146)
MKTSHARE Firm Market Share in 1994	25.219 (19.445)	---	---	---
INDSALES Total value of firm's industry shipments in 1994	6.958 E-6* (3.661 E-6)	---	---	---
TRACKU96 1 if the firm tracked its use and disposal of hazardous material in '96, 0 otherwise	---	---	1 279** (0.454)	1.276** (0 458)
MODEQUIP 1 if the firm purchased new equipment or upgraded its equipment between 1994 and 1996, 0 otherwise	---	---	0.374* (0.195)	0.374* (0.198)
ISO9000 1 if the firm had received ISO9000 certification between 1994 and 1996, 0 otherwise	---	---	0.977* (0 572)	0.900 (0.573)
DELRVAPE Change in real value added per employee in 1994$ over 2-year period	---	---	---	1.11 E-5* (6.07 E-6)
DELHAZCR Change in real hazardouse waste disposal costs	---	---	---	-4.98 E-6 (5.58 E-6)
Significant Industry Group Variables				
INDGRP8 Heat Treating, Coating, & Plating	---	---	1.216* (0 634)	1.245** (0 630)
INDGRP12 Computer, Communications, & Electronics Parts	---	1.256** (0.606)	1.240** (0.621)	1.352** (0 629)
INDGRP14 Automotive and Heavy Trucks	---	---	0.680* (0.400)	0 696* (0.405)
Log Liklihood	-180.114	-171.382	-163.454	-161.370
Liklihood Ratio Index	0.116	0.146	0.185	0.196

Note Probit models 2, 3, and 4 include 21 Industry Group control variables Only significant industry groups are shown
The liklihood ratio index measures goodness-of-fit analogous to Rmeasure in OLS Regression models (Greene 1990)
Standard Errors are presented in parentheses * signals significance at 10% level ** signals significance at 5% level

As previously discussed, these latter two variables were chosen as signals of a firm's performance, i.e. testing whether better-run, more productive firms might be more likely adopt a pollution prevention opportunity. The data show the opposite. It appears that firms with lower initial economic performance are the one's more likely to adopt a P2 opportunity. This result might be indicative of firms that utilize environmental cost savings as ways to stay competitive in the market and do so only when productivity is low compared to peer firms. Also, consistent with theory, the size of the industry, INDSALES, as measured by the magnitude of industry sales, is a significant determinant of P2 adoption. The larger the industry market in terms of sales, the more likely the firm is to adopt P2. However, the firm's market share, MKTSHARE, is not significant.

Model 2 is similar to Model 1; however, specific industry dummy variables were included to control for industry effects. Because of this, the industry variables, INDSALES and MKTSHARE, were removed.[5] The results of Model 2 are generally consistent with those of Model 1; however, the measure of initial firm productivity (VAPE94) is no longer significant, though its sign remains the same. Additionally, firms in Industry 12 (computer/electronics manufacturers) appear significantly more likely to adopt P2 opportunities compared with all other industry groups. Thus, without knowing any other performance/quality outcomes from the 317 firms in the dataset, consistent with innovation theory, those initial firm characteristics indicative of high hazardous waste disposal costs, rather than those initial firm characteristics indicative of better firm management performance, are strongest indicators of P2 adoption.

The third column identifies probit results for Model 3, which adds additional qualitative performance outcomes to the original predictive model, Model 2. Specifically, whether or not the firm modernized its plant and equipment over the 2-year period (MODEQUIP), whether the

firm reported tracking it hazardous material usage at the end of the 2-year period (TRACKU96), and whether or not the firm obtained ISO 9000 certification during the 2-year period (ISO9000). These variables were chosen to signal those firms that may have more progressive management teams. The results of Model 3 indicate that all three of these variable are significant. With regard to the TRACKU96, this result support the assertion that requiring hazardous material tracking improves the chances of a firm adopting a P2 opportunity. It is important to emphasize that the inclusion of these qualitative outcome variables in Model 3 increase the significance of the firm's hazardous waste cost ratio versus that in Model 2, thereby strengthening the view that, although it may be the case that more progressive management exhibit a higher likelihood of P2 adoption, it is still the firm's cost structure that is the most important component in predicting process innovation. Lastly, in Model 3 a significant positive correlation of industry groups 8, 12, and 14 (coating & plating, computer/electronics manufacturers, and automotive/heavy truck manufacturers) and P2 adoption is exhibited.

The fourth column identifies probit results of Model 4 which adds to Model 3 two quantitative performance variables, the change in real hazardous waste costs (DELHAZCR) and the change in real value added per employee (DELRVAPE). These variables were added to test whether P2 adoption is correlated with measurable quantitative improvements in the firm's performance while maintaining significance of variables identified as significant in Models 2 and 3. The variable DELHAZCR is not significant. This result should not be interpreted as that P2 adoption did not achieve cost reductions for these firms, as it could be the case that the adoption of a P2 opportunity slowed a rapid growing cost for the firm. Unfortunately, there is no statistical evidence that, among this group of firms, P2 adoption is correlated with measurable reductions in a firm's total real hazardous waste disposal costs. The significance of the change in

[5] MKTSHARE was not significant when included in Models 2, 3, and 4.

real value added per worker, DELRVAPE, however, provides evidence that P2 adoption is correlated with improved firm labor productivity as measured in changes of real value added per worker. It is important to emphasize here that one cannot infer the direction of causality between these two variables. This result is consistent with the theoretical result identified by Myers and Nakamura (1980) that shows adoption of a process innovation can result in a short-run improvement in labor productivity. It is not clear whether P2 adoption is the cause of these improvements in productivity or whether the better-run, more productive firms are the ones more likely to adopt P2. A separate analysis of a regression model with a measure of the firm productivity gains as the explanatory variable would be required to provide a more systematic answer to this question. However, the preservation of the significance of the predictive and qualitative outcome variables is encouraging evidence that supports the assertion that P2 adoption improves firm financial performance. Additionally, the significance of industry groups 8, 12, and 14 is preserved. Industry group 3, printing, is almost significant. Model 4 is able to accurately predict P2 adoption 46% and P2 non-adoption only 7% of the time, for a total of 53% predictive accuracy. The predictive power of this model would be much greater had a variable identifying the specific cost savings for each P2 opportunity been available.

The primary contribution of these results are that they identify robust variables that are correlated with P2 adoption, and that these relationships are consistent with expectations and economic theory concerning process innovation. The variable with the most explanatory power is the firm's initial hazardous waste cost ratio (HAZRAT94) which accounts for about 4% of the models total 20% explanatory power[6]. The firm's number of employees (EMPCODE) has the

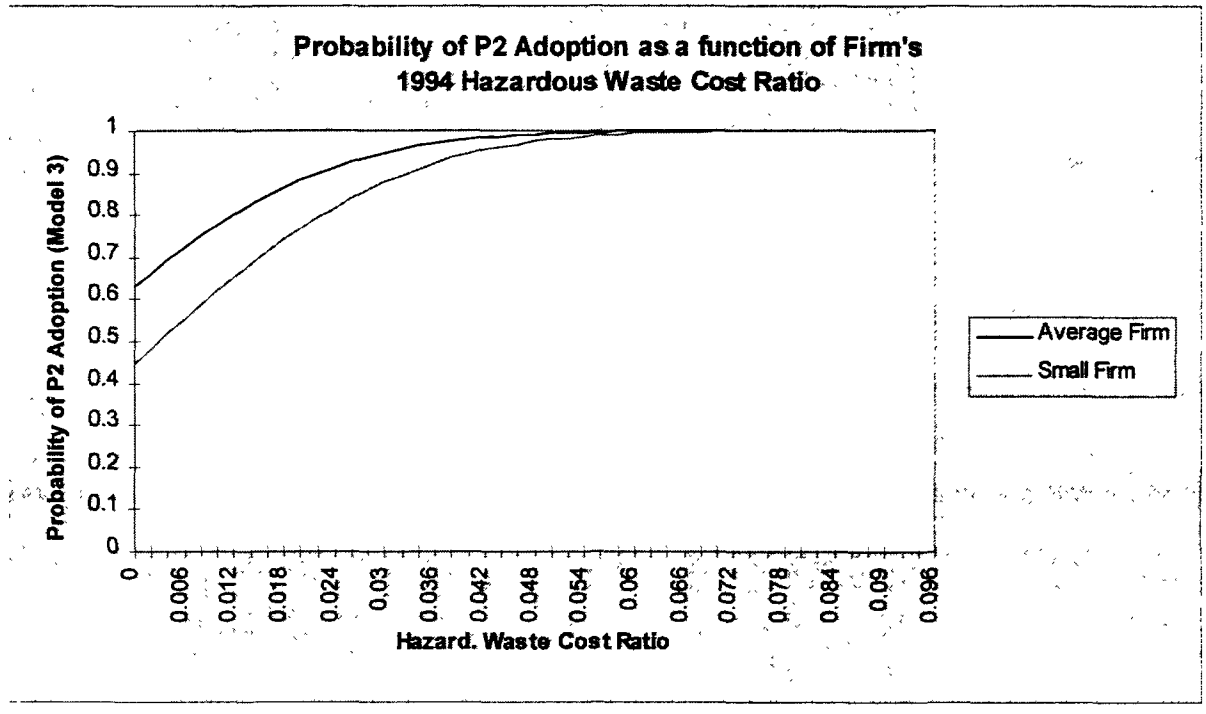
[6] The overall explanatory power of Model 4 is about 20%, which is very good for a probit model. The log liklihood ratio index, a measure for a probit model that is similar to the R2 statistic for a ordinary least squares regression model, is 0.196 for Model 4.

second-most explanatory power, accounting for 3%. The addition of the industry group variables contributes 7.5%.

Looking more closely at the difference in labor productivity between the two groups of data, firms that adopted P2 within the 2-year period show, on average, an increase in real value added per employee $4,900 (25.6% greater than the average). Firms that did not adopt P2, exhibited increases in real value added per employee on the order of $2,000 (44.4% below the average and 59.2% below P2 adopters). This is a significant difference. However, from the probit model, the marginal relationship between changes in real value added per employee and P2 adoption is slight. The predicted increase in the probability of P2 adoption from the non-adopter DELVAPE mean of $2,000 to the adopter mean of $4,900 is an increase of only 1.6%. Thus, the contribution of this variable to the model's explanatory power is relatively low.

Figure 2 shows the relationship between the probability of P2 adoption as predicted by Model 4 at the mean value for all the variables. The probability of P2 adoption at a hazardous waste disposal cost of zero—analogous to eliminating the variable from the model—produces an average probability of about 70%. This is mostly determined from the fact that P2 adopting firms are a majority in the dataset. Nonetheless, the probability of P2 adoption approaches 90% at a cost ratio of about 2.2%. Converting this percentage to a dollar value, on average, this 2.2% represents approximately $164,000 in hazardous waste costs or about $1,200 dollars per employee for an average firm of 140 employees. However, the relationship of P2 adoption and the firm's initial hazardous waste cost ratio is much more pronounced for small firms (50 employees or under). This relationship is also presented in Figure 2. The model predicts that for a firm to have a 90% probability of P2 adoption the cost ratio needs to approach 3.2%. In the dataset of 312 observations, there are 25 firms that represent this categorization, four of which

reported being P2 adopters. This ratio represents for this group, on average, only about $21,600 in hazardous waste costs. However, on a per employee basis, this figure represents about $1,660 per employee for an average small firm of about 13 employees. Thus, the model predicts that the incentive threshold to adopt P2 is much higher for small firms than for the average firm when viewed on a per employee basis.



V. Conclusion

The results of an empirical analysis of firms that reported adopting and not adopting P2 opportunities show that large, more capital intensive firms with high hazardous waste cost are more likely to be P2 adopters. The variable that is the most significant determinant of P2 adoption is an economic variable: the share of the firm's hazardous waste costs to its total costs. On average, firms with a hazardous waste cost ratio of 2.2% or higher have probabilities of P2 adoption 90% or greater. However, the results also provide evidence that there are qualitative

differences among firms that signal P2 adoption. Firms that have purchased new or upgraded their production equipment, or have obtained ISO 9000 Certification are more likely to adopt P2. This is loose evidence to support the view that perhaps more progressive, better managed firms and those whose managers have a higher level of education are more likely to be P2 adopters. Additionally, analysis of the predictive model provides a scale for possible financial incentives to facilitate the adoption of pollution prevention opportunities by smaller firms. The results of the probit model predict that small firms that have hazardous waste cost ratios on the order of 3.2%, or on average about $1,660 per employee are 90% likely to adopt a P2 opportunity.

A second important result is that there is evidence showing a positive relationship between P2 adoption and increases in firm labor productivity. It must however be emphasized that, at least at this point, the direction of causality is uncertain. After controlling for those firm characteristics that identify higher firm hazardous waste disposal costs and that might signal better, more progressive management, real increases value added per employee is a significant determinant of the probability of P2 adoption. Within the dataset of 312 firms, P2-adopting firms have increases in labor productivity well over double those firms that reported not adopting P2.

In the majority of reports within the P2 literature identifying P2 barriers in small firms, the primary barrier generally is identified as the firm's measurement of its true hazardous waste costs. The results of this study support this view. Increasing a firm's capability to accurately assess its true environmental costs will likely increase the firm's adoption of P2, if the institution of better environmental accounting increases the firms environmental cost to total cost ratio. There is an awareness among P2 practitioners that more accurate accounting of environmental costs may not be enough to bring a firm to adopt P2. Better environmental accounting will not

ensure that a given project will be profitable or provide enough cost savings to pass a firm's innovation cost threshold.

In addition to encouraging better environmental accounting within the industrial community, P2 practitioners should investigate the importance of firms obtaining the appropriate market signals with regard to their environmental waste costs. It is generally accepted that the market costs of hazardous waste to a firm is less than the true cost that the hazardous waste imposes on society and on ecosystems. If the market price the firm faced in hazardous waste disposal more closely reflected the true societal cost, the proper innovation response by firms would be more swift. There is strong support for the view that a firm's innovation response is driven primarily by the cost structure it faces. The P2 community should investigate its role as not only one of promoting policies that encourage process innovation through better environmental accounting and management education, but also one of the promotion of financial and economic policies that provide incentives for firms to innovate.

This research is also the first empirical study to identify evidence of a direct relationship between P2 adoption and increases in firm labor productivity. As such, it provides some support for the view that developing policies that create economic incentives for P2 innovation might, in addition to accomplishing the environmental goals sought by the P2 community, produce improvements in firm productivity. This will in the long-run help to make US industry more globally competitive. Certainly more research needs to be done to clarify how P2 adoption might improve firm productivity, and clear evidence of this connection would provide convincing justification for the development of financial/economic incentives and instruments to facilitate P2 adoption in the U.S.

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Marcia Mia

U.S. EPA, Office of Compliance

"P2 in Rulemaking"

Marcia Mia has been employed as a chemical engineer with the Environmental Protection Agency for eight years. She is currently with the Chemical Industry Branch of the Office of Compliance where she specializes in air issues relating to the chemical industry. Before joining EPA, Marcia worked as an environmental engineer and a process engineer in the cutting tool and electronics industry, respectively. Marcia has her BS in chemical engineering from Clemson University and her MBA from the Babcock School of Management, Wake Forest University.

Pollution Prevention in Rulemaking

Marcia Mia
Office of Compliance
US EPA

P2 in the PhRMA Mact

- Existing sources only

- Tanks
- Process Vents
- Wastewater streams
- Equipment leaks

Option 1

Production - Indexed Consumption of HAP reduced by 75% of baseline

Production-Indexed Consumption of HAP

Kg of HAP consumed/kg of HAP produced

Option 2

50% Reduction in production-indexed HAP consumption factor

+

Additional amount of add-on controls to achieve overall HAP reduction of 75% from baseline

Additional Restrictions

- Any reductions in HAP that also reduce VOC must have a equivalent reduction in the production-indexed VOC consumption factor

Additional Restrictions

- Any reduction in production-indexed HAP achieved by reducing a HAP that is not a VOC cannot cause an increase in the production-indexed VOC consumption factor

Additional Restrictions

- O/O that PRODUCE HAPs may also qualify for the P2 option, provided the HAP emissions GENERATED at the PMPU are reduced to the levels required by the rule.

Baseline Production-Index

- Based on consumption and production values averaged over the time period from start-up of the process until present
  - OR
- The first 3 years of operation
  - whichever is less

P2 Demonstration Summary

- To be submitted with Precompliance Notification Report

Minimum P2 Demonstration Requiremetns (63.1257(f))

- Description of methodologies and forms used to measure and record daily consumption of HAP compounds
- Descriptions of methodologies and forms used to measure and record daily production of products included in the standard

Minimum P2 Demonstration Summary Requirements

- Supporting documentation for the previous descriptions including operator logs sheets and copies of daily, monthly and annual inventories of materials and products

Calculation of Annual Factor Continuous Processes

- Calculated for every 30 days for the 12 month period preceding the 30th day (30-day rolling average)

Calculation of Annual Factor Batch Basis

- Every 10 batches for the 12-month period preceding the 10th batch (10-batch rolling average).
- OR
- Every 5 batches if the number of batches less than 10 for the 12-month period preceding the 10th batch and every year if the number of batches is less than 5 for the 12 months preceding the 5th batch.

Demonstration of Compliance

- Annual kg/kg factor is equal to or less than 50% of the baseline factor
- Yearly reduction kg HAP/yr associated with add-on controls is equal to or greater than mass of HAP calculated using equation 52
- Demonstration that criteria are met accomplished through description of control device and material streams entering and leaving control device

Demonstration of COmpliance

- Annual reduction achieved by add-on controls quantified

Eric Olander

EPI Electrochemical Products Inc.

"Alkaline Non-Cyanide Plating, Silver & Copper Processes"

BIO for Eric Olander

- **EPI**, nine years, Sales & Vice President
- Present member of AESF
- Past President Milwaukee AESF branch

ALKALINE NON-CYANIDE PLATING

COPPER & SILVER

PROCESSES

Plating of silver has been utilized for jewelry, electronics, and other functional uses for many years. The traditional complexing/chelating agent for silver plating has been potassium cyanide.

Cyanide is utilized in bronze, cadmium, copper, gold, silver, and zinc plating. It is a workhorse for the plating industry.

Waste minimization, through EPA Common Sense Initiative (CSI), is asking all metal finishers how they can finish their parts through alternative processes that eliminate cyanide, generate less hazardous waste, recycle rinse water, recycle sludge, and lower energy consumption.

In the plating industry, zinc alternatives (acid zinc and alkaline zinc) have worked in place of cyanide zinc for the last 20 years and proprietary alkaline non-cyanide copper has been utilized in the last seven years. Companies that only have copper cyanide can switch to these alkaline non-cyanide copper baths, thereby eliminating cyanide from their facility resulting in enjoying the advantages of eliminating cyanide. The challenges for some metal finishers is that they have cyanide copper and other cyanide processes such as brass, cadmium, and silver. Until acceptable alternatives for brass, cadmium, and silver are developed, metal finishers will continue using cyanide.

Recently, a new alkaline non-cyanide silver bath began production at four beta sites last February. All of the beta sites are working with excellent results and the companies now have working production baths.

Progress Report Findings on New Alkaline Non-Cyanide Silver versus Cyanide

- Eliminates the need for a silver strike tank; plates directly to substrate - saves space and process time.
- Adhesion is superior to cyanide silver.
- Plates faster than cyanide silver.
- Present formulation is bright eliminating separate brightener additive resulting in an organic-free silver plate.
- Color is brilliant white.
- Cost is equivalent in running cyanide process.
- Better throwing power.

New Process versus Existing Non-Cyanide Copper Process

- More cost effective because it plates out of silver anodes rather than solution.
- Anodes do not polarize – excellent anode corrosion.
- Plates faster than other processes.
- Easy to maintain with single maintenance addition.
- Superior color to competitive processes.
- **E-Brite 50/50** has not required a carbon treatment of any bath. Other existing non-cyanide systems utilize more organics that require carbon treatments every 3 – 6 months.

Bath Parameters

	Rack	Range	Barrel
E-Brite 50/50 concentration by volume	50%	40 – 60%	50%
Silver metal oz/gallon	2.0	1.5 – 2.5	2.0
pH	9.0	8.5 – 9.5	9.0
Temperature	68°F	60 - 75°F	68
Cathode Current Density	5 – 20 ASF		5 – 10 ASF
Anode Current Density	2 – 10 ASF		2 – 10 ASF
Agitation	air agitation of anode, plus cathode rod agitation		

Equipment & Operation

Anode	Pure Silver
Anode/Cathode Ratio	2:1
Filtration	Continuous filtration with 2 micron carbon filter
Tank	All plastics (polypropylene) tanks

Plating Additives

E-Brite 50/50:	liquid bath concentrate and silver replenisher
E-Brite 50/51:	liquid concentrate of electrolyte replenisher
E-Brite 50/52:	anode corroder
E-Brite 50/55:	pH adjusting salts (increase)

Bath Maintenance

pH meter
Silver metal titration
Electrolyte analysis by **EPI** – amp/hour basis

Plating Procedures

Substrate: Steel, copper strike in alkaline non-cyanide copper is necessary

Post Rinsing

- Silver dragout
- Rinse
- 10 – 20% sulfuric acid
- Rinse
- Chrome tarnish inhibitor – B.P.A. electrolytic
- Triazole compound – **E-Tec 529**
- Warm rinse
- Dry

Now the silver and copper platers have a method to eliminate cyanide from their facility with the recent development of an alkaline non-cyanide silver that works as well or better than cyanide.

On-going Test at Rockwell (Allen-Bradley)

- Hardness Brinnel	100 – 110
- Electrical Resistivity	Under study at this time
- Purity SME Analysis	
	% by weight
Silver Ag	99.99

TECHNICAL PAPER

FC97-199

Copper Plating

author

ERIC OLANDER
Vice President
Electrochemical Products, Inc.
New Berlin, Wisconsin

abstract

Copper plating is the building block process for metal finishing in many industries. This paper includes details of four different copper plating processes with emphasis on the newest technology—alkaline non cyanide copper. Also included are details of plating aluminum and how the newest copper process alkaline non-cyanide copper gives the plater of aluminum the opportunity to plate aluminum substrates without using cyanide.

conference

FINISHING '97
May 19-22, 1997
Rosemont, Illinois

terms

Plating
Electroplating
Aluminum
Aluminum Coating

Society of Manufacturing Engineers
1997
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Society of Manufacturing Engineers
One SME Drive • P.O. Box 930 • Dearborn, MI 48121
Phone (313) 271-1500

INTRODUCTION

Copper plating processes are being used as the first step in many plating applications, from truck bumpers to printed circuit boards. Today you will find four types of copper plating - acid copper, alkaline non-cyanide copper, alkaline cyanide copper and electroless copper. The acid copper process is used for printed circuit boards and decorative applications. This process is microthrowing meaning that it levels. The alkaline non-cyanide copper process is new to the industry and is used to replace cyanide copper for environmental reasons. Cyanide copper, a work horse for the plating industry, is used as a strike plate, heat treat stop off, and EMI shielding. Cyanide copper cleans the substrate being plated and has the largest operating window and is the easiest to use. The alkaline non-cyanide copper and the cyanide copper are macro throwing, meaning it will not level. Electroless copper is an autocatalytic immersion copper process that is utilized in plating on plastics and printed circuit boards. In the search for environmentally friendly processes and the pressure to reduce cyanide, we will focus on the newest copper plating technology - alkaline non-cyanide copper process.

Alkaline non-cyanide copper processes include: copper pyrophosphate chemistries and proprietary copper chemistries. Pyrophosphate chemistry is used today, but with some limitations because of adhesion factors and break-down product called orthophosphate. The orthophosphate is formed from the hydrolis of the pyrophosphate into orthophosphate (see equation 1 below).

$$P_2O_7^{-4} + H_2O \rightarrow 2HPO_4^{-2}$$

undertaken and achievements accomplished during the reporting period to reduce the volume and toxicity of the waste generated. By eliminating cyanide copper, a generator can show good faith in meeting this regulation's requirements even though he may still be doing cyanide silver, cyanide gold or cyanide brass plating.

It has been difficult to replace cyanide in alkaline copper plating baths because of the need for a high metal compound concentration while maintaining a low metal ion concentration in the bath. The high metal compound concentration furnishes a reservoir for the copper throughout the solution and also stops polarization of the anodes as they are dissolved. On the other hand, a low metal ion concentration is required to produce small crystals at the cathode to produce a bright plate. A low metal ion concentration also increases coverage and throwing power. A high metal compound concentration with a low copper ion concentration in a bath is accomplished with a common anion such as sulfate with sulfuric acid and copper sulfate in an acid copper plating bath, and with cyanide in alkaline baths with copper cyanide and sodium cyanide. With cyanide as a common anion in the bath, the bath can contain an excess of cyanide to control anode corrosion and cathode efficiency. In addition, cyanide breaks down into relatively harmless by-products of ammonia and carbonate, which are not detrimental to the operation of the bath. That is, the carbonates are not really detrimental until they reach a concentration of 16 ounces or more per gallon of the bath. In searching for a common anion to replace cyanide as a complexer it has been an important consideration to find a common anion which does not break down into undesirable by-products and at the same time does not have a negative effect on present waste treatment operations. Therefore, strong chelators such as EDTA and NTA cannot be used.

A non-cyanide alkaline copper plating bath has been developed and is being used in heavy production for over 6 years with excellent success. The bath will plate directly on iron and steel, brass and copper, zincated aluminum, diecast zinc, stainless steel and white metal castings in both rack and barrel operations. The process consists of a liquid concentrate which contains the copper and all the chemistry required in the process. The liquid concentrate is used at a volume of 40 to 60% in D.I. or soft water to charge the bath initially. Thereafter, only one primary addition agent, the electrolyte, is used to maintain the bath as the copper is dissolved from the anodes. In addition, there is a high current density booster additive. A bath charged at 40% by volume will have a copper concentration of 1 ounce per gallon. The bath can be operated very successfully at this level of copper, but there are instances where a faster plating speed is desired in which the anodes are dissolved until a concentration of 1.5 to 2 ounces per gallon of copper is reached. It is very important that the electrolyte additive be added on a daily basis while the copper anodes are being dissolved. Once the preferred level of copper is determined for a particular installation, the anode area and anode current density required to maintain the optimum copper concentration in the bath are determined.

The pH of the bath is monitored and will increase as the bath is used. When the pH exceeds 10, it is reduced by adding dilute sulfuric acid. The bath has proven to be easy to use and maintain with only the copper metal and pH being monitored.

A review of the benefits of a non-cyanide alkaline copper plating bath would include:

- Eliminates the inherent dangers of cyanide in the workplace and improves employee health and safety.
- Eliminates the concern for catastrophic accidental acidification of cyanide.
- No carbonates to be treated
- No carbonate sludge containing cyanide to be treated or waste hauled.
- No cyanide in F006 sludges.
- No danger of cyanide if a fire occurs in a plant.
- Reduces waste treatment costs for destroying cyanide.
- Eliminates the use of hazardous chlorine and sodium hypochlorite to treat cyanide
- Accidental drag-in of non-cyanide alkaline copper plating solution poses no toxic problems with the subsequent acid copper solutions.
- Reduces fire and liability insurance premiums.
- Easily installed in existing plating lines.
- One bath serves as both a strike and plate bath.

BATH CONTAMINANTS

Organic Contamination - remove with batch carbon treatment. Sometimes hydrogen peroxide is added to remove the organics.

Iron - Can absorb up to 2000 ppm iron. Remove the iron through high current density dummy plating.

Lead - Can absorb up to 50 ppm of lead. Remove with high current density dummy plating.

Calcium - Will destroy the copper - complexor bond and more complexing product is necessary. Switching to DI or softened water alleviates this problem.

Chrome - Up to 10-15 ppm limit. Chrome reducer does work, but use sparingly.

One of the applications of plating alkaline non-cyanide copper is plating onto zincated aluminum surface with this copper process. A typical plating process for aluminum can include approximately seventeen steps - cleaning to copper plating. Plating aluminum requires more steps than other substrates such as steel, brass and zinc diecast. The main reason for more steps is that copper cannot be directly plated onto aluminum. It needs the proper pre-plate cycle to be successful. To determine the pre-plate process, the aluminum alloy, type of aluminum - casting or extrusion, and existing condition of aluminum - stamping, polished/buff, or machined must be known before the pre-plate cycle can be determined. In the past steps 9 and 13 utilized a cyanide base zincate with a cyanide copper plate. With alkaline non-cyanide processes available, metal finishers can now use non-cyanide zincates

creating an entire non-cyanide process for aluminum. With recent development of new non-cyanide zincates, they meet or exceed cyanide base zincates in performance.

Another application for the non-cyanide process is the replacement of stannate process for aluminum and the cyanide bronze. The non-cyanide zincate will directly replace the stannate process. The typical stannate process is an immersion alkaline tin process - sometimes electroplated tin. The non-cyanide zincate process costs less to use versus the stannate process because of its ease of use, and wider operation window and cost of zinc versus tin.

The zincate process utilized to ASTM B-253-68 (1) will meet the service condition specifications adhesion and corrosion of the SAE J207 (2) specification. The stannate process is losing favor to the zincate process with the need to eliminate cyanide since the typical stannate process uses a cyanide bronze process. Some experimental work on using the immersion tin with the alkaline non-cyanide process is being investigated. The manufacturers (platers) of aluminum bus bar are investigating alternatives to the stannate process. Included in the alternatives is zincated aluminum with the alkaline non-cyanide copper process.

CONCLUSIONS

Platers of aluminum have a new environmentally friendly process for plating aluminum without the use of any cyanide zincate or cyanide copper plate. The key to the process is the alkaline non-cyanide copper. The proprietory alkaline non-cyanide copper process has better throw than the cyanide process, low copper metal concentration, more stable chemistry than copper pyrophosphate chemistry, and reduces waste treatment costs eliminating chlorine/bleach from the waste treatment area.

Lee Paddock

Minnesota Attorney General's Office

"Valuing Environmental Performance"

LeRoy C. (Lee) Paddock

LeRoy C. (Lee) Paddock is Director of Environmental Policy and Manager of the Agriculture and Natural Resources Division for the Attorney General of Minnesota. Lee is also a member of the Executive Committtee for the Attorney General's Office. As Director of Environmental Policy he is responsible for environmental legislation, development of new environmental enforcement programs, liaison work with U.S. EPA on enforcement issues and advising the Attorney General on environmental policy. A significant emphasis of his work has been finding cooperative solutions to environmental problems. Lee also manages a 23 person Division that represents the Minnesota Department of Agriculture and the Minnesota Department of Natural Resources.

Lee joined the Minnesota Attorney General's Office in 1978. He served as Senior Environmental Counsel for the National Association of Attorneys General in 1985 and 1986. In addition to his other responsibilities, Lee is a participant in the Aspen Institute's series on The Environment in the 21st Century, was a Liaison Member of the Eco-Efficiency Task Force of the President's Council on Sustainable Development, participated in the work of the Enterprise for the Environment Dialogue, serves on the Board of Directors of the Minnesota Environmental Initiative and on the Advisory Board for the University of Minnesota's Center for Environment and Health Policy.

Lee is a 1977 graduate of the University of Iowa Law School and served as a law clerk for Judge Donald Lay of the U.S. Eighth Circuit Court of Appeals.

Lynn Persson

Bureau of Cooperative Environmental Assistance, Wisconsin DNR

"Wisconsin's Innovative Environmental Initiatives"

Wayne Pferdehirt

Printers' National Environmental Assistance Center
(PNEAC)

"The Printers' National Environmental Assistance Center: Your Partner in Compliance and Waste Prevention"

Bio: **Wayne P. Pferdehirt, P.E., AICP**

Mr. Pferdehirt is Co-Director of the Printers' National Environmental Assistance Center (PNEAC). PNEAC assists printers and organizations that help printers, by providing easy access to current, practical accurate information and resources that can guide environmental compliance and waste prevention efforts by printers.

Mr. Pferdehirt participates in PNEAC through the University of Wisconsin's Solid & Hazardous Waste Education Center (SHWEC), where he helps Wisconsin businesses and local governments improve financial and environmental performance through the application of cost-effective waste prevention strategies. Mr. Pferdehirt is also a Program Director in the University of Wisconsin-Madison's Department of Engineering Professional Development, where he leads professional development courses in environmental management systems, ISO 14000, "green" product design and the design of solid waste facilities. Wayne received his B.S. in civil engineering from Carnegie-Mellon University, and his M.S. from Northwestern University. Wayne is a member of GATF, NAPL and IAPHC.

The **Printers' National Environmental Assistance Center (PNEAC):** Your Partner in Compliance and Pollution Prevention

EPA Region 5 Pollution Prevention Conference
Chicago, IL

Wayne Pferdehirt
Co-Director, PNEAC
University of Wisconsin

What is PNEAC?

- A Unique Partnership between University-Based Technical Assistance Organizations & Printing Trade Organizations
- Designed to Complement Existing Service Providers
  - Increasing Access to Best Info & Expertise
  - Pushing Edge of Envelope
- For All Types of Printers and Printing Technologies
- One of Initial Four Small Business Compliance Assist. Centers Funded by EPA

PNEAC

Who Does PNEAC Serve?

- "Wholesale" Level
  - Technical Assistance Providers
  - Regulators
  - Industry Trade Associations
  - Graphic Arts Educators

- "Retail" Level
  - Printers
  - Print Industry Vendors

PNEAC

PNEAC Operating Partners

- $ EPA Office of Enforcement and Compliance Assurance
- IL Waste Management and Research Center (WMRC)
- U. of WI Solid & Hazardous Waste Education Center (SHWEC)
- Graphic Arts Technical Foundation (GATF)
- Printing Industries of America (PIA)

PNEAC

PNEAC Advisory Council

- National Association of Printers and Lithographers (NAPL)
- International Association of Printing House Craftsmen
- Gravure Association of America (GAA)
- Screenprinting and Graphic Imaging Association (SGIA)
- Flexible Packaging Association
- Flexographic Technical Association (FTA)
- Clean Air Act Small Bus. Assist. Programs
- Association of Small Business Development Centers (SBDCs)
- National Pollution Prevention Roundtable
- National Institute of Standards and Technology
- Envir. Defense Fund (EDF)
- Council of Great Lakes Governors

PNEAC

How Can PNEAC Help You?

- If You Are A Printer:
  - Increase access to printing-specific, understandable compliance information
  - Give you practical, tested suggestions on how to reduce wastes and associated costs
- If You Help Printers:
  - Improve your understanding of printing and environmental challenges facing printers
  - Improve your access to the best technical and training resources to support your work with printers
  - Help you connect with experts and peers working with printers

PNEAC

What Has PNEAC Been Up to So Far?

- Established World-Wide Web Site
- Established Printech and Printreg E-Mail Listserves
- Broadcast "Green and Profitable Printing" Videoconferences 5/96 and 12/97
- Conducted Focus Groups with Client Groups
- Prepared Strategic Plan
- Established Advisory Committee
- Conducted Training for Regulators and Technical Assistance Providers
- Established 888-USPNEAC hotline for fact sheets and technical assistance

PNEAC

PNEAC Listserves

- Printech: Focuses on P2 technical issues; over 190 subscribers
- Printreg: Focuses on regulatory Issues; over 160 subscribers
- Participants primarily include technical assistance providers, trade associations, and regulators
- Questions from printers referred from assistance providers or PNEAC World-Wide Web site
- Dialogues archived at PNEAC World Wide Web site.
- To subscribe, contact Wayne Pferdehirt (608/265-2361 or pferdehi@epd.engr.wisc.edu)

PNEAC

PNEAC World-Wide Web Site

www.pneac.org

- Hot News
- Ask PNEAC
- Printech & Printreg Archives
- Fact Sheets & Case Studies
- Compliance Info & Contacts
- Info on Federal and Regional Printing Initiatives
- Links to Other Printing-Specific Web Resources
- Calendar of Workshops & Conferences
- Completely Searchable

PNEAC

Green and Profitable Printing '96 and '97 Videoconferences

- Reached over 3,000 participants at over 100 sites in U.S. and Canada
- In survey conducted 14 months after '96 videoconference:
  - 92% of surveyed printers reported improved environmental compliance
  - 97% said they had since adopted 1 or more waste reduction strategies featured in videoconference
  - 97% said they would recommend videoconference to other printers

PNEAC

December 1998 Screen Printing Videoconference

- Live broadcast December 2, 1998; 9:30 -11:30 Central
- PNEAC provides first-rate professional, practical program, for use by state, local and industry hosts
- Will focus on screen reclamation and digital pre-press
- Co-sponsors with PNEAC:
  - Screenprinting and Graphic Imaging Association (SGIA)
  - EPA: OECA and DfE
  - PETE
- Call SHWEC (608-262-0910) for more info

PNEAC

Coming Attractions

- Videoconference for Screen Printers; 12/2/98
  - For current list of downlink sites, see www.pneac.org
  - Sign up now to host a downlink site
- Updated Chemlog, at Reduced Price
- Expanded Vendor & Supplier Listings
- Environmental Benchmarking Tool

PNEAC

Coming Attractions (continued)

- Environmental Compliance and Waste Prevention Checklists
- Additional Case Studies
- Additional Fact Sheets

PNEAC

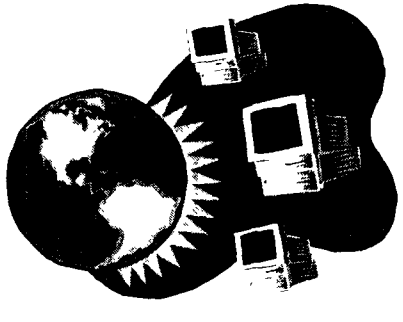
PNEAC Toll-Free Hotline

- 1-888-USPNEAC
- One Call Can Get You:
  - Live technical assistance @ GATF
  - Fax-back documents
  - Referral to other helpful, available resources
    - » trade associations
    - » technical assistance providers

PNEAC

Contacting Printers' National Environmental Assistance Center (PNEAC)

- Toll free at 1-888-USPNEAC
  - Live technical assistance at GATF
  - FAX-back documents



- Via World Wide Web at:

  www.pneac.org

PNEAC

Roger Price/Robert P. Briggs
(see Robert P. Briggs for paper)
STV Inc.

"An Employee Driven Waste Minimization P2 Study at a Specialty Chemicals Plant"

Roger L. Price

Roger L. Price, P.E. is a Senior Environmental Engineer with STV Incorporated. He received his Bachelor's Degree in Civil/Environmental Engineering from Cornell University in 1975 and his Master's Degree in Sanitary Engineering from The Pennsylvania State University in 1977. Mr. Price has over 20 years of diversified environmental experience in a broad range of industrial, commercial and governmental projects. His experience includes preparing and auditing environmental management systems and environmental compliance programs. Mr. Price has prepared and conducted over 170 professional training sessions on pollution prevention, spill prevention and response preparedness, environmental management systems and regulatory compliance. In 1992, Mr. Price was appointed to serve on an Advisory Committee for the President's Commission on Environmental Quality, Pollution Prevention Model Demonstration Project.

N. Rajagopalan

Illinois Waste Management & Research Center

"Putting the Squeeze on Metal Working Fluids"

Biography: N. Rajagopalan

Dr. Rajagopalan is currently responsible for oversight of the pollution prevention technology development and demonstration activities of the Illinois Waste Management & Research Center. He has several years of experience in process development and project management in the food, chemical, and metal finishing industries. His research interests include novel separation processes with particular emphasis on membrane based separations. He is the recipient of numerous grants from both industries and public agencies and has several peer reviewed technical publications.

WMRC Pollution Prevention Program

Putting The Squeeze On Metalworking Fluids

Kishore Rajagopalan

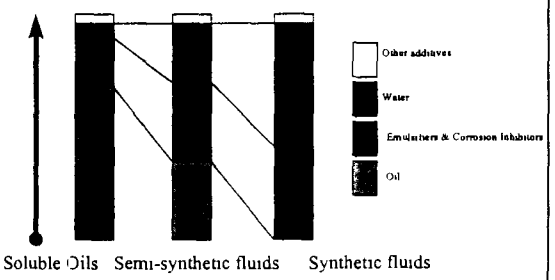
Metalworking Fluids

Fluids that facilitate metal shaping processes

Benefits

Functional		Performance
Cooling	→	Extend Tool Life
Lubrication		Control Surface Finish
Chip Removal		Dimensional Control
		Reduced Power Consumption

Metalworking Fluid Types



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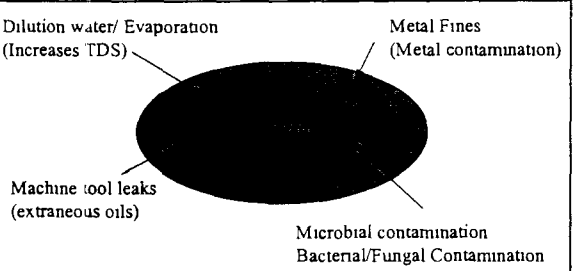
Machine Tool Agile Manufacturing Research Institute

Degradation Of A Coolant



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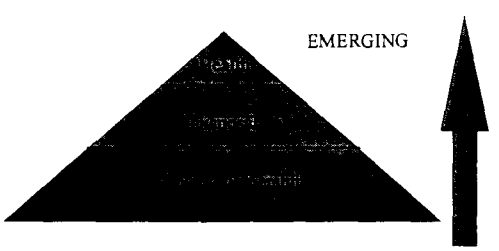
Economic & Environmental Issues



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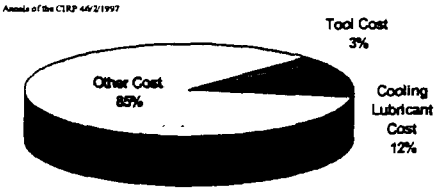
Cost Of Ownership

German Automotive Industry Survey

Annals of the CIRP 46/2/1997



Lubricant cost >>> Tool Cost !!!!

Disposal

- High Oil & Grease
- BOD
- Synthetics/Semi-synthetics hard to treat

US discharge volume ~1-2 billion gallons/yr

Metal Products & Machinery Rule (proposed)

Health & Safety

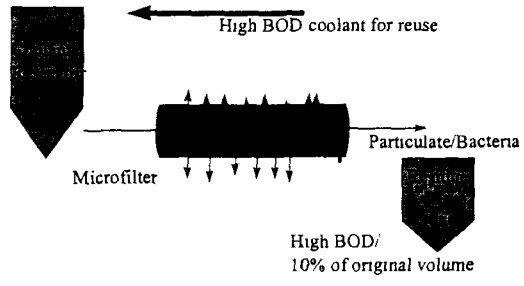
- Bacterial contamination
  - respiratory diseases (e.g., HP)
  - contact dermatitis
- Biocides
  - Toxicological problems
- Mists

NIOSH 1998 Criteria for a recommended standard Occupational exposure to metalworking fluids

Research Goals
WMRC-MTAMRI Partnership

- Reduce volumes of metalworking fluids discharged
  - through improved recycling methods
- Address health & safety issues
  - alternative microbial control
  - (reduce/eliminate) biocides

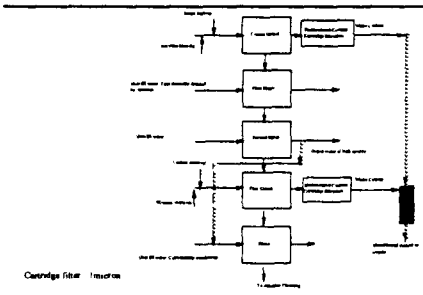
Crossflow-microfiltration concept



Case Study-Particulate Removal
Recycling Grinding Fluid

- Manufacture of Aluminum Discs
  - Highly polished surface
  - Large volumes of coolant used
  - High BOD

Grinding Process



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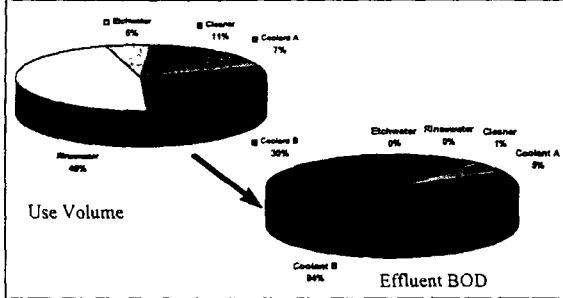
Effluent



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Problem Solving

- Process Substitution
  - Substitute coolant
  - Reduced BOD 71%
  - Estimated BOD (mg/L) -1724
- Recycling through microfiltration
  - Volume reduction ~80%
  - BOD reduction ~50%

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Product Useability

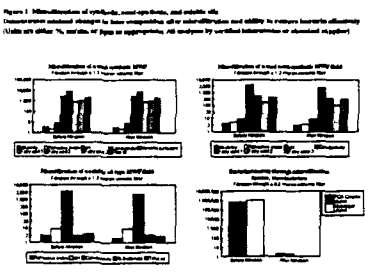
Coarse Grinding
- Re-used directly up to 3 cycles
- 1% fortification required after 3 cycles

Fine Grinding
- Needed fortification

Projected Cost-Benefits

- Coolant Savings- 260,000 US $
  - Through substitution/recycling
- Annual Equipment Operating Costs
  - 85,000 US $
- Equipment Capital Costs
  - $ 300,000

Other Coolants/ Microbial Control



Critical Data Gaps

- Microbial Issues
  - types, growth rates, acceptable levels, endotoxins
- Metalworking fluids
  - components, physical characteristics,chemistry, functionality, contaminant levels/tolerance
- Microfilters
  - optimal surface, pore size, operation mode

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Current Status

Microfiltration as a means of extending coolant life is very promising

- particulate control relatively easy
- microbial control- promising/critical gaps remain- on-going research
- synthetic coolants easiest to microfilter
- semi-synthetics & soluble oils more challenging
- additional research required to map boundaries of applicability

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On-Going Research

[redacted]

MWF Characterization	Recycling Technology Development Evaluation
Functional properties	Engineering
Chemistry ⟷	Effectiveness
Contamination rates	Residuals
Contaminant characterization	Economics

Waste Management & Research Center
Machine Tool Agile Manufacturing Research Institute

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Dr. Veera Boddu
Ms. Teresa Chow
Mr. Steve Skerlos

Paul M. Randall/Dr. W. J. van Ooij

U.S. EPA, National Risk Managment Research Laboratory/University of Cincinnati

"Evaluation of Silanes to Replace Chromates in Metal Pretreatment Prior to Painting"

Evaluation of silanes to replace chromates in metal pretreatment prior to painting

Paul M. Randall
U.S. EPA
Cincinnati, OH 45268
Tel. (513) 569-7673
randall.paul@epamail.epa.gov
and
Dr. W.J. van Ooij
University of Cincinnati
Cincinnati, OH 45268
Tel. (513) 556-3194
wvanooij@uceng.uc.edu

USEPA Region 5 Waste Minimization/P2 conference
December 14-16, 1998

Acknowledgments

- EPA (Cincinnati Lab)- Funding 1994-1997
- Brent America, Inc. (Lake Bluff, IL)- Testing, in-kind support
- Univ. of Cincinnati, MS&E
  - Dr. Van Ooij- Principal Investigator
  - Nie Tang- Galvalume Work
  - Jun Song- Al Work(painted)
  - Wei Yuan- EGS and HDG work
  - Chunbin Zhang- CRS Work
  - Vijay Subramanian- Al Work (unpainted
- SSAB, Sweden- Collaboration in Galvalume Project

rious Effects of Properties of ane Films

- Cleaning of Metal Substrate
- Silane Concentration
- Solvent
- pH of Silane Solution
- Aging of Silane Solution
- Dipping Time
- Temperature of Silane Solution
- Drying of Silane Film
- Rinsing of Silane Film
- Aging or Heating of Silane Film

Outline

- *Introduction*
- *General approach*
- *Silane process*
- *Results*
- *Conclusions*

Objectives

- Developing new pretreatment rinses for metal surfaces which are currently treated by phosphate or chromate-containing processes both prior to painting.
- Metals considered include: cold-rolled steel(CRS), electrogalvanized steel(EGS), hot-dip galvanized steel(HDG), Galvalume® and aluminum(Al).
- Optimization of laboratory-tested rinses with dilute aqueous solutions containing organofunctional silanes.
- Publish papers and a final report.

Partners

- U.S. Environmental Protection Agency
- University of Cincinnati
- Brent America
- SAAB

General Approach

- Select metal
- Study interaction between various silanes and metal surface
- Vary deposition conditions and test stability of film
- Test the performance with and without paint coatings
- Salt spray test at Brent America; GM test at UC
- Study paint-metal interface by EIS
- Report on results

Silane process

- Hydrolyze 10% aqueous (or water/alcohol) silane solution (1-24 hours); adju pH with acetic acid
- Adjust concentration to 2-5 vol. %; adjust pH again
- Clean metal thoroughly (alkaline + solvents)
- Dip metal in silane solution(5 s - 30 min) (or spray,wipe,brush)
- Drip dry or blow dry with air
- Dip in second silane solution(optionally)
- Drip or blow dry; optionally heat at 60-200 ^{0}C for immediate cure.
- Perform corrosion test(one silane) or paint (1 or 2 silanes) and then test.

amples of Silanes Used on Metals

- **H2N-CH2CH2CH2-Si(OC2H5)$_3$ γ -APS Fe, Al**
- **H2N-O=C-NH-CH2CH2CH2-Si(OCH3)$_3$ γ-UPS Zn**
- **(H5C2O)$_3$-Si-CH2CH2-Si-(OC2H5)$_3$ BTSE Fe, Al**
- **H2C=CH-C6H4-CH2NHCH2CH2NHCH2CH2CH2-Si(OCH3)$_3$ SAAPS Galvalume**
- **H2C=CH-Si(OCH3)$_3$ VS Zn**

Where do Silane Treatments Work?

Painted Systems

- Painted cold-rolled steel(BTSE + γ-APS
- Galvalume® coil paint lines(2-step; edge creep)
- Painted hot-dip galvanized steel(vinyl silane)
- Painted electrogalvanized steel(γ -UPS)
- Cast aluminum wheels(BTSE; filiform corrosion)
- Automotive steel sheets (various)
- Electrogalvanized steel staples(vinyl silane)
- Coated aluminum beverage cans(BTSE + γ -APS)
- Painted Al 3003 sheets (BTSE + γ-APS; filiform corrosion)

Advantages of New Silane Treatments

- Process flexible: can be optimized for the metal and applications
- Process and materials are environmentally compliant
- Corrosion performance of treated metals superior to that of currently used chromate and phosphate systems.
- Treatments can provide excellent corrosion resistance even witho paint coating
- Chemicals are commercially available and relatively inexpensive
- Costs of the silane treatment is of the same order as existing treatments or less

Silane Film Analysis and Characterization

- Film Thickness
- Film Homogeneity
- Structural Analysis of Silane Films
- Surface Energy Properties of Film
- Electrochemical Properties

Advantages of New Silane Treatments(Cont'd)

- Treatment involves fewer steps than phosphating, viz., cleaing, dipping, and optionally dipping in a second silane. There are no rinse steps. Drying at roo temperature.
- Two-step process provides improved adhesion to polymers and paints
- Two-step process allows optimization of the process for a particular polymer o paint system
- Several different forms of corrosion are improved by the silane treatments:
  - Underfilm corrosion(scribe creep) in painted systems
  - Edge corrosion
  - Atmospheric corrosion
  - Pitting corrosion(Al)
  - Filiform corrosion(Al)
  - Galvanic corrosion

Where do Silane Treatments Work?

Unpainted Systems

- White Rust inhibition of HDG steel(vinyl silane)
- Al 2024 aircraft alloys(BTSE; salt immersion)
- Weathering of TiZn roofing sheets (vinyl silane)
- Al 386 handles of kitchen knives(BTSE)
- Wrist watch bezels(BTSE)

Scribe creep in mm in PU-powder painted CRS panels

No.	Treatment of CRS	14 Days GM Scab	25 Days SST*
1	Alkaline-cleaned only	30.0 ± 1.2	51 ± 24
2	Iron Phosphate	14.5 ± 0.8	23.2 ± 0.9
3	Iron Phosphate + Chromate	5.0 ± 0.5	2.2 ± 0.3
4	Optimum silane treatment**	2.5 ± 0.3	2.5 ± 0.5

*salt spray test, ASTM B-117

**2 min dip in 2% BTSE of pH= 6 followed by 0.5 min dip in 5% γ-APS of pH= 10.5

Performance of BTSE on Al 2024

No.	Treatment	Salt Immersion (Hours)	Corrosion Rate, mpy	E_{corr} , mV
1	None	10	5.3	-445
2	Chromate	170	.004	-700
3	BTSE, 1 dip	80	0.2	-450
4	BTSE, 2 dips	200	.01	-500
5	BTSE, 2 dips cured (2x)	> 250	.004	-500

Note: Continuous immersion in aerated 3% NaCl

Hours: time when corrosion became visible at waterline

Cure o fBTSE: 15 min at 125 C

BTSE: 2%, 1 min, dip, pH= 4

Mpy= corrosion rate in 3% NaCl in mm per yhear determined from polarization data, E_{corr} = corrosion potential of sample va Ag/AgCl in 3% NaCl

Scribe creep in mm in PE-powder painted EGS

No.	Treatment of EGS	6 weeks GM scab	5 weeks SST
1	Alkaline-cleaned only	16.2 ± 5.9	24 ± 19
2	Standard zinc phosphate	3.3 ± 2.0	2.7 ± 0.9
3	Optimum silane treatment *	3.1 ± 2.2	1.3 ± 1.0

*2 min dip in 2% γ-UPS of pH= 8

Scribe creep in mm in Powder-painted HDG

		4 weeks GM Scab		2 weeks SST	
No.	Treatment	PE Paint	PU Paint	PE Paint	PU Paint
1	Cleaned only	23 ± 12	18.8 ± 10.1	52 ± 21	57 ± 12
2	Zinc Phosphate	11.0 ± 6.2	9.9 ± 2.5	4.0 ± 1.2	12.0 ± 4.2
3	Silane*	1.1 ± 1.0	1.3 ± 0.8	1.1 ± 0.6	1.3 ± 2.0

*2 min dip in 5% VS solution of pH= 6

White Rust Performance(stack test) of silane-treated HD

No.	Treatment	Percent White Rust(14 days)
1	Alkaline-cleaned only	100
2	Standard temporary chromate	50
3	5% VS of pH= 6(2min dip)	0

Conclusions

- Silanes can provide outstanding corrosion performance of painted CRS, EGS, HDG and GVL.
- Optimum treatments have been determined for CRS, EGS, HDG, and GVL
- BTSE does not work well with zinc
- Optimum silane is metal specific; concentration and pH also have to be optimized.
- Film thickness is determined by concentration and not by immersion time
- HDG treated with 5% VS gives excellent white rust inhibitiion; the film can be painted.
- More R&D is needed to develop silane treatments into robust industrial processes.

Conclusions

- A new, promising technology will soon be available fo replacing chromates in metal finishing industries
- The processes are flexible and can be adapted to substrate and coating
- Various forms of corrosion can be protected, with or without pain coatings
- The silane-based sysems often outperform existing systems
- More R&D is needed and is currently being done by Brent International

J.J. Rao

G.E. Medical Systems, NB-913

"Recycling & P2 at G.E. Medical Systems"

RECYCLING and POLLUTION PREVENTION
at
GEMS

Dennis M.Hussey, CIH,CHMM (1)
Paul E. Neumiller, NREP,CEA (2)
J.J.Rao, PE,CHMM (3)

General Electric Medical Systems (GEMS) is headquartered in Waukesha, Wisconsin for its international business in medical diagnostic equipment. Several of GEMS manufacturing/service facilities are located in the greater Milwaukee area. GEMS manufactures, installs and services a wide range of medical diagnostic equipment such as CT Scanners (CT), Magnetic Resonance Imaging systems (MR), mobile X-Ray equipment (X-Ray), Ultrasound equipment (US), Positron Emission Tomography equipment (PET) and special cameras. GEMS is also the largest manufacturer of X-Ray tubes at its Milwaukee plant on Electric Avenue. The X-Ray targets are manufactured in Cleveland, Ohio (Target plant) and the magnets for the MR systems are manufactured in Florence, South Carolina (Florence plant). The targets and the magnets are then shipped to the manufacturing plants in the Milwaukee area. The repair of major equipment is carried out at the Trout facility (Trout), the digital boards used in the electronic controls are repaired at another facility (DBR).. All of the GEMS manufacturing is covered under the Standard Industrial Code # 3788.

GEMS is unique in the medical diagnostic equipment business having established eight years ago a product take-back and recycling program for the old diagnostic equipment replaced in the field by GEMS. The recycling program offers return of any obsolete component or an entire diagnostic system to the Recycling Center (RC) in Milwaukee, even if it is not an original GEMS equipment, from the field by GEMS service personnel for all the customers. The equipment received at the RC is then individually reviewed and disassembled manually to separate the components into three broad streams. These three groups are the salvageable parts for reuse, the recyclable parts through third party recyclers and the disposable parts. The salvageable parts are then tested and verified for reuse in the exchange pool/parts service program. The Recycling operations are classified under the standard Industrial Code # 5093

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1: D.M.Hussey, Manager - Global Environment, Health and Dafety, GEMS
2: P.E.Neumiller, Manager- Recycling Center, GEMS
3: J.J.Rao, Manager- RCRA Compliance/Pollution Prevention, GEMS

GEMS has an Environment, Heath and Safety (EHS) management system for all of its facilities and the service personnel who operate in the field. These efforts are further supported and guided by General Electric's (GE) Corporate Environmental Programs (CEP) headquartered in Fairfield, Connecticut. As a result of this Environmental Management System (EMS) Recycling and Pollution Prevention (PP) efforts are part of the on going activities to reduce pollution and seek continuous advancements towards Sustainable Development through a multitude of efforts. The EHS group at GEMS is responsible for managing the progress and to maintain the momentum to meet the changing needs in the environmental arena. A summary of the past programs, a brief description of the present efforts and a glimpse of the future are discussed here to portray the ongoing Recycling and Pollution Prevention (R & PP) programs at GEMS.

The implementation of the R & PP is accomplished through the EMS by a group of trained environmental professionals with the assistance of pertinent outside support services as well as professionals. The training and continuous education of these individuals is certainly the key factor in the management of the programs in conjunction with the measurements of the various performance parameters on a regular basis. The regulatory required training of other non- environmental professionals and a system to incorporate their input is the other essential element that has been recognized as the key to overall success in such environmental work. The foundation for GEMS R& PP programs may be summarized to consist of:

* **Education and training**
* **EHS Measurements**
* **Forum for environmental communications**
* **Management and review of the results**

The EMS provides the impetus to start and implement environmental programs to promote recycling and achieve pollution prevention at each facility. These programs are, therefore, operationalized at the each of the sites by customizing the site specific issues relating to the programs introduced. The site specific programs that have been successfully implemented and being carried out are:

* **POWER (Pollution, Waste, Emission Reduction)**
* **EPA's 33/50 (33% reduction by 1992 & 50 % reduction by 1995 of any of the seventeen groups of chemicals) program**
* **Pulse / Power(GEMS environmental audit programs)**
* **Chemical Management program**
* **Pollution Prevention Plan**
* **An EHS council at each manufacturing facility**
* **Design for Environment and integration of EHS with design and manufacturing methodology**
* **Scorecard / Trotter Matrix (GEMS measurement/rating program)**

It is important to note that these programs at each of the manufacturing or repair facilities were established in harmony with the design engineering, manufacturing and

service operations with changing/growing trends in the diagnostic business. As such the entire process of Recycling and Pollution Prevention must be viewed as a part of a dynamic system which calls for flexible response due to changing circumstances and environmental regulations. This shall, perhaps, be more evident as the steps involved and the chronological events are described.

Recycling at GEMS:

The recycling operation was started in February 1989 as part of the Service Operations to replace a less formal " Salvage" operations at the Electric Avenue plant. These initial operations involved disposing the used oils for burning without detailed scrutiny of the process or the results and sale of the old equipment to salvage dealers with no control on the final disposition of the parts as they sometimes ended in the hands of third party vendors. This was partly due to limited industrial or commercial recyclers offering recycling services or salvage value for recoverable materials, minimal regulations to restrict the generators/transporters/waste handlers in the disposal of industrial wastes. There were limited sources of state or federal information bureaus that provided technical guidance in such matters on a structured basis. The formal establishment of the Recycling Center helped to analyze the used equipment being returned for disposal in a more technical manner and persistent efforts to improve the salvage value led to better management of these wastes. One such example was the GEMS practice at Electric avenue plant of mixing metal turnings/chips into one lugger box costing over $8 /ton for disposal. An experiment on one shift with the help of an interested supervisor led to segregation of these waste metals and ability of the RC management to negotiate a salvage value for the waste metallic waste streams. The salvage value ranged from about $0.35 to $6.50 per pound to yield a net income of about $100,000 annually. Further analysis of the incoming waste equipment streams through concentrated efforts led to the realization that with the investment of manual labor at the RC many of the complex equipment could be disassembled into valuable salvage components like copper from wires, silicon chips from the computers, precious metals from electronic components/printed circuit boards, recyclable plastics from equipment covers, glass from ancillary control components and disposable batteries used as power back-up or alternate power sources etc. The additional investment made in the employment of personnel strictly dedicated to disassembly and segregation of wastes by their disposal destination created a substantial increase in the salvage revenues. In the meanwhile the service business appreciated the ease and convenience of returning the diagnostic equipment replaced in the field to a known and fixed destination through reliable transportation services managed by the RC personnel. Another benefit has been a better control of the quality and security issues in servicing the GEMS equipment. GEMS does provide used diagnostic equipment to customers by using salvaged parts. A method to separate those parts that passed the preliminary checks as reusable parts are then shipped to the relevant facility for testing and manufacturing. This yielded further encouragement to **product recycling** efforts at the RC. As a result of the progress made an arrangement was made to establish

another recycling program that involved the return of defective or unusable manufacturing components considered as waste items at the various manufacturing facilities. Since there are five major facilities in the Milwaukee area the return of manufacturing waste streams was augmented by establishment of a shuttle service by Ace Worldwide Van Lines (Ace) for pick up of such wastes on a daily basis. The result was a steady and rapid increase in the weight/volume of materials recycled through the RC with expanded efforts on all fronts to better manage the waste generation, its segregation and the condition in which they were shipped.

One such management focus was to bring to light the cost and efforts in disassembly of the returned equipment with an aim to improve assembly design features that would make disassembly easier. The other aspect was the introduction of Design for Environment (DfE) concept to the design /manufacturing engineers to avoid **environmentally unfriendly** actors in the product to afford less expensive disposal options as Resource Conservation, Recovery Act (RCRA) promulgated more stringent regulations in the 1990s. These efforts to manage the recycling business in a more cost effective manner led to introspection of our products by the design engineers at the New Product Introduction (NPI) stage and consequently the creation of a formal document that integrated Environment, Health and Safety issues into a document called Phase Review Discipline (PRD). PRD calls for a step by step approach for launching new products with a system of checks and balances to avoid the glitches suffered earlier in the recycling program. Some of the positive outcomes have been:

* Reduction in the number of fasteners used in equipment assembly
  (Result: Reduction in the direct manufacturing costs and the assembly time)
* Reduction in the type of fasteners used on a specific component/sub-assembly
  (Result: Reduction in the type of tools required to assemble /disassemble and thereby the associated costs)
* Use of fasteners other than bolts and nuts where possible
  (Result: Reduction in the direct costs while improving manufacturing techniques)
* A review of some of the key components used in the equipment and making the design environmentally more friendly.
  (Result: Reduction in the amount of hazardous waste handled at the manufacturing as well as the recycling stage.)
* Innovations in the shipping of our equipment to the customers using returnable/ reusable steel dollies instead of disposable lumber/ large quantities of packing materials etc.
  (Result: The job of field personnel made easier who receive the new equipment in a manner conducive to field installation and as the old equipment is dismantled in stages from the customer site it is loaded onto to the returnable dollies for shipment back to the Milwaukee RC. Most of the packaging

materials are returned from the installation sites back to the RC. Usually health care facilities do not lend themselves to easy removal of the old equipment with construction type activities that leave behind a debris to upset the CLEAN ROOM image. Furthermore disposal of unused shipping materials can pose problems for the field personnel while installing large diagnostic equipment shipped in sections.)

* The field returned equipment is conveniently unloaded, most of the times, from the dollies in a familiar pattern and the dollies returned to the manufacturing facilities for reuse. (Result: Save costs, space and labor associated with lumber/shipping skids etc. that would otherwise be incurred and the inefficiencies associated with preparing new shipping skids on a continuous basis and its disposal problem faced by the field personnel at the health care facilities.)

Apart from the recycling of the diagnostic and ancillary equipment the RC also handles all the cans/bottles/plastics/computers and other such items disposed from the various GEMS Milwaukee area sites with over 4,500 employees contributing the recyclable items. Revenues from these operations and any usable computer items are donated to charitable organizations. Such activities are sometimes coordinated with the other GE businesses who seek such items for non-profit community organizations. At CT facility the cardboard received in the incoming shipments is shredded by third party vendor employing the physically challenged personnel and returned for reuse as a cushioning material instead of the more prevalent plastic materials that become nuisance when computer/delicate electronic items are unpacked.

The Target facility recycles its production waste and product waste consisting essentially of Tungsten and Molybdenum through recyclers who reuse it in the manufacture of specialty steels. In 1995 more than 36 tons of these metallic wastes were recycled. The wastes from the Magnet plant essentially consisting of permanent magnets are also recycled through special recyclers though the waste is minimal due to the special controlled application of these super size magnets in the MR imaging systems.

The RC presently occupies about 35,000 Sq. Ft. facility leased in the Ace Industrial Park on College Avenue with more than fifteen Ace contract employees and less than six GEMS employees who supervise the recycling operations with EHS training and education. The Ace trucking provides the local shuttle service to pick-up non-hazardous materials for recycling from the local facilities and thereby making recycling/proper disposal of many routine items very manageable for all the facilities involved. This certainly contributes to pollution prevention and cleaner facilities being maintained without each facility making individual attempts to handle these common issues. The Ace service also facilitates the return of scrap from production and repair operations carried out by GEMS parts vendors. This provides another cost

effective measure for disposal of solid wastes from the vendors who have been prescreened to serve GEMS customers' needs.

The RC is now feeling the constraints of space, the need to introduce technical processes in the future to make recycling activities more amenable to automation and special services for the anticipated return of the existing products in service at the end of their life or due to their obsolescence in the next decade. This is particularly so in view of the sophistication taking place in the recycling business and industry specific specialists who cater to a narrow range of the recycling niche.

Pollution Prevention at GEMS:

Pollution Prevention has been a goal at GEMS with General Electric Company's corporate policy 20.3 on Environment, Health and Safety :

* **100% Compliance with regulations**
* **Zero Hazardous Products and Processes**
* **Zero Accidents and Injuries**
* **GEMS recognized as a Good Corporate Citizen**
* **Everyone involved in EHS**

GEMS is committed to EHS excellence as part of the aforementioned policy goals for these reasons:

* **It is the Right Thing To Do (Integrity) !**
* **The Law requires it!**
* **It is a commitment to our employees !**
* **It saves us money**
* **It is good management practice !**
* **Our employees, neighbors and customers expect us to do it!**

A brief introduction to the range of chemicals used by GEMS may be covered by stating the chemicals used without quantitative reference or an explanation of their application. The chemicals are:

Acids	-	Nitric, Hydrochloric, Phosphoric and Sulfuric
Alcohols	-	Ethyl, Isopropyl, Methyl
Alkali	-	Sodium Hydroxide
Glycols	-	Ethylene/propylene
Metals	-	Steel/ Stainless Steels, Molybdenum, Tungsten, Nickel, Cadmium, Copper, Lead, Titanium, Silver, Gold, several Rare Earth metals/Oxides
Solvents	-	Acetone, Methylene Chloride

Miscellaneous - A variety of lubricants/oils, transformer oil, water treatment chemicals, detergents /Aqueous Cleaners,epoxresins/hardeners, contact cements and glues, Refrigerants for comfort cooling, sodium carbonate and other common chemicals used in cleaning and maintenance.

In the environmental management of wastes it is certainly true that what gets measured is likely to get reviewed and controlled. GEMS has been carrying out internal audits of its entire EHS practices facility by facility on an annual basis since 1980. The self-realization of the facts facing GEMS waste generation and disposal has therefore been very crucial to making improvements in the field of Pollution Prevention. GEMS manufacturing involves the use of many diverse chemicals, electronic components/computers and vendor supplied sub-assemblies. The initial efforts were control and command of the areas of manufacturing generating the wastes and avoiding undue waste streams created due to overflow, leaks, lack of timely problem solving and such recurring incidents. Once the frequency of recurrence and the number of such incidents at a given location were minimized the focus shifted to solving the pollution problems on a more permanent basis. Such an approach was based on the Waste Pyramid principle of maximum benefit in the pollution prevention strategy is derived from substitution of hazardous materials with non-hazardous materials. The next best alternative was to find less toxic or less dangerous materials being substituted to reduce the risk and the severity of the environmental pollution. The next higher section of the waste pyramid called for increased recycling efforts to maximize the life span of the raw material and reduction in the use of non-renewable resources involved. The non-renewable resources indirectly affected were fossil fuel used as energy sources in converting such raw materials from the native form to the industrially useful form. Such benefits of pollution prevention are difficult to quantify, document and record in terms of tangible cost savings.

The less desirable option available when substitution and recycling are not feasible is treatment of the waste prior to disposal through applicable permits and release within compliance limits. GEMS has minimal treatment at any of its facilities and has no wastewater treatment plants, no on-site hazardous waste treatment and minimal equipment for treatment of air emissions with only one facility covered under Title V permit program in the entire U.S. The least favorable option in the waste pyramid is disposal and this option is almost unavoidable to a certain extent. However the total quantity sent for disposal is tracked and is being minimized annually in spite of increased production and growth in the business.

The implementation of the waste pyramid strategy combined with the review of audit findings provided the correct background to embrace an in-house GE program called POWER as mentioned earlier. This program was introduced in 1989. Reduction in emissions of Volatile Organic Compounds used as solvents and in wipe-clean operations were achieved along with a reduction in the quantity of the waste

generated due to better management, simple tools like issuing smaller solvent containers per use, tracking the usage by the department and investigating any practices that led to excessive use and other measures based on person to person campaign by all those who responded to the change in culture required at the time. Many reductions were just accomplished through simple administrative controls and revised procedures for approval and purchasing of such pollutants. There were two major programs that boosted the POWER philosophy. The first one was GE's acceptance of Environmental Protection Agency's (EPA's) invitation to voluntary reduction of 17 priority pollutants under the 33/50 program. GE's leadership by Jack Welch called for 60% reduction by 1994 stretching the EPA goal for GE businesses to meet.

The 33/50 program efforts led to elimination or a major reduction in the use of solvents like 1,1,1 Trichloroethylene and Trichloroethane, Methyl Ethyl Ketone, Methyl Isobutyl Ketone, Methylene Chloride, use of Lead as a counterweight metal in mechanical design, any oils that contained minute amounts of Benzene or Toluene or Xylene. Freon 113 was eliminated under the POWER program. The reduction in the use of the 33/50 list of solvents was essentially accomplished by substituting aqueous cleaners and aqueous cleaners used with deionized water. This was specially true with the purchase of new washers equipped with ultrasonic cleaning mechanism to work with de-ionized water to improve the effectiveness of the aqueous cleaners. The installed cost of such washers were in excess of $100,000 to $250,000 depending on the part and quality requirement in a manufacturing process. The capital investment had a good payback of less than one -two years due to elimination of the hazardous waste solvent disposal issue and the labor associated in managing the EHS program guidelines. This was endorsed by the design and production engineering personnel making it a standard practice in the newer installations that followed. The momentum was thus not only maintained in achieving the basic policy goals but increasing the pace to strive for excellence as the facility leaders welcomed the cost reductions and reduced environmental risks. The maintenance and production personnel also welcomed the improved health and safety aspects of not dealing with large quantities of toxic &/or flammable solvents.

The second boost to the POWER program came from the implementation of Chemical Management program in GEMS in 1993. This program involved a formal procedure to purchase any chemical by anyone from janitorial custodians to experimental research staff along with the bulk users in production with signed permission from the EHS manager. A list of approved chemical was created and is maintained up to date based on a close scrutiny of the application of the chemical/its environmental rating in terms of safety/disposal issues and applying the POWER and waste pyramid strategy. The approval was based on the chemical being used in a particular work area (zone) in limited quantities with engineering controls in place prior to the purchase. A chemicalapproved for one particular zone is not to be used in any nearby or distant location unless specifically pre-approved through identical procedure. This reduced the proliferation of commonly used solvents/ lubricants /

oils/alcohols/cleaners etc. and provided a feedback on the consumption patterns by the location. This facilitated the control and efforts to reduce unauthorized or undue usage to afford major cost savings. The program was instituted by bringing in a chemical management company from outside to serve GEMS exclusively on a contract basis with reduction in chemical costs and consumption tied to a performance incentive for achieving positive results. The procedure now tracks all chemical requests through a single channel no matter who originates the chemical requests from any of the facilities. Any sudden shifts in the consumption patterns are now easily traceable and quantifiable. This data helps EHS management to commend the positive trends and pass the information to others as the BEST PRACTICE to create similar success elsewhere within GEMS. Any negative trend is investigated and resolved to control detrimental effects long before they become unmanageable. Chemical Management plan has provided excellent tool from the driver's seat to look ahead and plan the response for adequate control of the raw materials that are likely to become pollutants.

Each GEMS facility prepares a Pollution Prevention plan whose essential elements are:

* Reiteration of the GE EHS policy
* Plant management support statement
* Name of the site PP coordinator
* Site specific goals for Reduction, Elimination and Recycling
* Previous year PP accomplishments
* PP team members for the site
* Tracking and measurements
* PP opportunity assessment
* PP technology transfer commitments

The PP is annually updated with the relevant statistics from the previous years duly incorporated to provide a sense of accomplishment and motivation as EHS personnel change in the course of time and continuity in all these programs is crucial to the overall GEMS success.

It has been evident in the management of environmental systems at any industrial facility that just as regulators achieved very limited success with the command and control philosophy and methodology to assure environmental excellence, the industrial successes were limited if the environmental concept was not operationalized through the work force. Either a single environmental professional or a group of such personnel could not 'police' and achieve environmental goals for the entire facility. Training, education and personal involvement of the general work force is a vital ingredient for success. GEMS has established and nurtured very carefully the concept of EHS council that has contributed very significantly to the success of EMS. The EHS council at each facility consists of the EHS professional, the plant manager and a group of concerned employees from all ranks from

production associates, maintenance, administrative/clerical and other technical persons in non-supervisory or managerial positions and with or without union affiliations. This team of individuals essentially hold meetings from 1 to 4 times a month dividing responsibilities/sharing goals to document, review, discuss, resolve and initiate action to solve Environment, Health and Safety issues ranging from accidents/injuries to spills and environmental compliance problems. The minutes of the meeting are published for review by others and pending issues are gradually pushed for resolution or intervention by others to provide a continuous momentum for achieving better results in preventing accidents, injuries, spills, pollutant releases and waste generation. Since the EHS council usually comprises of people with diverse backgrounds and priorities there is little stagnation and a lot of fresh ideas to motivate reaching of EHS goals. There are both simple and formal methods to recognize the success of these teams at any time of the year which provides recognition and encouragement to the existing as well as new members. EHS council also provides a very cost effective tool to implement changes that are proposed, planned and supported by the employee team. Their success seems to be contagious and provides an excellent return on the time invested away from the prescribed duties. Once again the benefits are difficult to quantify but the results are evident just as the cool breeze brings relief from hot weather though it is invisible.

GEMS has guidance documents for introduction of new products and these integrate the EHS issues in the development stages called Milestones. The document is called Phase Review Discipline (PRD) handbook and the process is termed New Product Introduction (NPI). EHS concerns are documented in the milestones and this provides an excellent tool to integrate the environmental concerns of the future in the new products based on the present knowledge of the existing problems &/or anticipated regulatory changes. An EHS questionnaire has been developed to review and control the introduction of environmentally unfriendly elements entering the GEMS product lines in pre-finished/pre-tested sub-assemblies and product components purchased for direct use.

The PRD process is supported by the EHS group which provides Design for Environment(DfE), Design for Disassembly(DfD) and Design for Assembly (DfA) seminars. The RC offers excellent real life examples of the past mistakes, the problems encountered by the field engineers after installation during repair and obstacles faced in cost effective disposal of certain components. One such item is the fiberglass used in the protective/decorative cover used on many diagnostic equipment that remains intact in a health care facility. These covers cannot be recycled through black-top pavement contractors being in very limited in quantity and in non-crushed state. Similarly the thermoset plastics are difficult to reuse. These two items are, therefore, landfilled even when they are hardly damaged from the day of purchase.

The concept of sustainable development as the extension of DfE motto is now being reemphasized in light of the ISO 14000 development and the global nature of GEMS business. The environmental planning and management to continue the pro-active

role and support the business growth into a sustainable development phase is the challenge that has been undertaken to meet the environmental demands of the future and provide GEMS with a cost effective method to enter the twenty-first century. GEMS has established and continues to establish manufacturing and service operations abroad on all the continents and the other challenge is to carry these successes to achieve an environmental standard that excels even where the standards are less stringent and the vehicles for Recycling and Pollution Prevention efforts are not available.

The EMS at GEMS has another measurement tool that maintains a constant vigil at monthly progress called SCORECARD. This is a system of providing a numerical score for each line item of Environment, Health and Safety issues listed on the Scorecard by the site EHS Specialist. The score is a reflection of the level of satisfactory performance in a variety of EHS issues including compliance and PP issues. The Scorecard is presented to the facility manager/Business Team Leader for the site for review and resolution. The Scorecard also enables each site to be rated on a scale of 0-5 for the month, with 5 for excellent EHS management and results. A one page comparison summary of such a score on a 0-5 scale for each GEMS site is called Trotter Matrix. This matrix gives a one glance comparison of general EHS performance and this is transmitted to CEP for review in comparison with other GE businesses. The monthly generation of such performance data on compliance, spills, accidents and injuries provides a very meaningful review of the indirect correlation that exists most of the times between Pollution Prevention efforts and other EHS measurements. A trend can usually forewarn or indicate continued improvements in the R & PP goals. Such measurements are annually reviewed by the Facility Managers/ Business Team Leaders with the CEO of GEMS along with CEP personnel in a "state of the EHS at the site" type of meeting called Session E. These formal appraisals of the annual EHS audit findings and monthly scores on EHS performance certainly keep the focus on continued improvements in changing business and environmental factors.

The Pollution Prevention efforts have also been extended to maintenance of outdoor areas in view of the Storm Water permitting program. A concentrated effort was made in late1994/ early1995 to form Storm Water Pollution Prevention Team at each site, collect storm water samples on a voluntary basis. Then site specific Storm Water Pollution Prevention Plans (SWPPPs) were developed at all the Wisconsin sites. The Wisconsin Department of Natural Resources issued Tier II permits initially to these sites according to the general storm water permit program and then after due scrutiny of each site and additional revisions to some of the SWPPP issued a lower permit status. These efforts led to formal issuance of a Storm Water Pollution Prevention policy statement in GEMS to add another dimension to the PP efforts.

The proof of the pudding certainly lies in the final results achieved rather the actions performed or intended to be performed in the field of Recycling and Pollution Prevention. The data to follow has been compiled using the information available from the major manufacturing sites and the RC. It is not a comparison of success at each site but a focus on the type of success achieved at each site in the recent years.

The results achieved in GEMS may be summarized with the following data:

RECYCLING CENTER

YEAR	TOTAL EQUIPMENT WASTE RECYCLED	REVENUE
1993	7,086, 486 lbs.	More than $1M, < #2M
1994	8,496,740 lbs.	More than $2M, < $3M
1995	10,049,724 lbs.	More than $4 Million
1996	11,500,000 lbs.	Approx $4 Million
1997	13, 000, 000 lbs.	Approx. $4.5 million

POLLUTION PREVENTION
leading to
Hazardous Waste Reduction (lbs.)

YEAR	CT	X-RAY	TROUT	EA	MR@	FLORENCE#	TARGET^
1990	4,838	-	-	- -	-		69,345
1991	3,422	9,010	12,908	>900,000	16,150	+16,000	36,656
1992	2,700	6,562	11,925	833,143	4,525	+14,750	16,884
1993	2,476	1,467	9,969	339.178	9,600	+11,600	2,320
1994	2,344	2,869	6,885	307, 596	12,000	+ < 1,000	675
1995	2,332	4,097	< 1,000	289,250	12,755	+ < 750	0
		Solvent used in 1996			*0*	*+0*	*0*
1996	2,980	1,289	919	211,733	1,591	31,700*	1,116**
1997	1,203	907	775	153,439	638*	25,666*	733**

@: The use of Methylene Chloride is shown here and its use was eliminated in November 1995.

#: This shows the estimated combined usage of TCA, MIBK, Toluene and Methylene Chloride.

^: This column shows the reduction in the use of 1,1,1 Trichloroethane.

* Total Hazardous Waste
** Waste Methanol

\+ Quantity of Waste acetone, Waste Petroleum Naphtha & other flammable solid waste generated in the past years.

Lee Sanders

Honda Transmission Manufacturing (HTM)

"After the Party-The Real Value of ISO 14000 Certification"

Ariel G. Schrodt

Dover Industrial Chrome, Inc.

"Elimination of Fume Emission in Hard Chromium Plating Through Use of A Perfluorinated Surfactant"

Ariel G. Schrodt Biographical Information

Dr. Schrodt has been President and owner of Dover Industrial Chrome, Inc. since 1976, acquiring TVJ Electroforming in 1989. Before entering the electroplating industry, Dr. Schrodt was employed primarily in the field of nuclear radiation measurement instrumentation and radioisotope applications He received his M S. degree in Inorganic Chemistry in 1949, and was then employed in the radioisotope laboratory of Eli Lilly & Co for two and a half years before returning to his doctoral research Dr. Schrodt received his Ph D in Physical and Nuclear Chemistry from the University of Chicago in 1954, under the direction of Dr. Willard F. Libby. He then served as a 1st Lt. in the Army Medical Service Corp. Department of Biophysics at the Walter Reed Army Institute of Research until 1957. From 1957 to 1963 he was employed by Nuclear Chicago Corporation as Director of Detector Development and Radiochemistry In 1963 Dr Schrodt founded Mitec Engineering Laboratories which he owned and directed until 1973. Dr. Schrodt also served as Scientific Director of the Packard Instrument Co. 1964 until 1971 Dr. Schrodt served as Executive Vice President of Nuclear Systems, Inc. 1973 to 1975 He served as a consultant to the Diagnostics Division of Abbott Laboratories 1975 to 1976
Dr Schrodt is a member of the American Chemical Society, the American Physical Society, the American Electroplaters and Surface Finishers Society, the American Society for Metals, the Chicago Metal Finishers Institute and the Experimental Aircraft Association. He is a pilot and a classical pianist.
Dr Schrodt has served as a Trustee of Kendall College in Evanston since 1960.

Presentation by
Ariel G. Schrodt, Ph.D., President and Owner of Dover Industrial Chrome, Inc.

Elimination of Fume Emission in Hard Chromium Plating through use of a Perfluorinated Surfactant

Dover Industrial Chrome, Inc., also know as Dover/TVJ, is a small electroplating and electroforming business. The hard chromium plating facility was established at the present location in 1945. The TVJ electroforming business was acquired and moved to the same location in 1989. Dover specializes in hard chromium plating of rollers and cylinders of small to medium size. TVJ electroforms objects of art, components for industrial, medical and aerospace applications, and unique devices for scientific research. Current research and development activities include plating of aluminum-manganese alloys from molten salts and electroforming of microstructures in patterns generated by x-ray lithography.

The chrome plating facility has seven tanks, with volumes ranging from 400 to 2500 gallons, situated within a retention basin and vented through a common underground tunnel. The tanks have exhaust slots along or around their top edge, which open to a plenum in turn connecting to the main tunnel. This tunnel is vented through two connecting tunnels by two 25,000 cfm blowers, exhausting through stacks on the roof. The tanks have flat plate heat exchangers which are employed in small volume loops to effectively isolate the tank coils from steam or cold water sources, permitting recycling of steam and water. There are seven rectifiers with a total maximum output of 25,000 amps. Current chrome plating operations are accomplished with about 15 million ampere hours per year.

Until the use of perflourinated surfactants was adopted, chrome fumes were troublesome in a number of ways. Air quality in the plant was acceptable to OSHA, but still irritable. Air emissions were better than for plants with more direct exhaust ducting -- the underground tunnel system served to strip chromic acid from the air stream -- but we were generating a waste stream from the accumulation in the tunnels and blowers. The blowers corroded and were short lived. Plastic balls were tried as a tank cover but were troublesome and quickly abandoned. Hydrocarbon surfactants were tried, but proved to be too short lived. Even a totally enclosed, fume recycling system, such as had been patented in Finland in the1970s was contemplated, but was deemed too difficult and too expensive to establish for all of our tanks. Air baffles, positioned directly above the cathode, were sometimes used to deflect the fumes towards the exhaust slots; these did help to improve air quality in the plant.

It was in July 1989 that we received information and technical data on perfluorinated surfactants from Dr Cornelia Dorzbach-Lange of the Mobay Corporation, a Bayer U.S.A. Inc. company. Dr. Dorzbach-Lange also visited Dover in 1989 to further acquaint us with their Fluorotensides FT 248 and FT248 R, which were being used successfully in hard chromium plating operations in

Europe. While not revealing the exact composition of these products, their technical literature used sodium perfluouro-octane sulfonate as an example representing this family of products. The information supplied stated that to minimize consumption, the surface tension of the bath should be maintained below 30 dynes/cm. and that to acheive 99.9% elimination of chrome from the hydrogen gas escaping, a level of 25 dynes/cm would be required. (Our recent experience has indeed confirmed this). In spite of the impressive results obtained with use ot the Fluorotensides by platers in Europe, and expertly presented to us, we did not immediately choose to apply the surfactants at Dover.

In the fall of 1993, Atotech made a major promotion to the chrome plating industry, for their Fumetrol (R) fume suppressants. Some of the illustrations in that promotional literature and references to German usage led me to the conclusion that Atotech was marketing the Mobay (Bayer) products that I had learned about four years earlier. By this time I was ready, accepting of the idea, and totally convinced that the way to proceed was to keep the chrome in the tanks and not to let it escape and then have to clean it up somewhere else. I immediately requested a sample quantity to try in just one tank . While the trial sample quantity was insufficient to achieve the optimum surface tension in that tank, the effective fume reduction was so dramatic, so readily observable without use of instrumentation, with no detectable change in the chrome deposit quality, that I immediately ordered Fumetrol 140 to place in all of the tanks.

Before making the additions to all of the tanks in January 1994, we invited members of the Basic Industry Research Laboratory (BIRL) of Northwestern University, who were participating in a federally funded project on waste minimization, to come to Dover to make observations of our use of Fumetrol 140. BIRL personnel made measurements of surface tension and set up air samplers with intakes only a few inches above the chrome plating solutions. Measurements were made before and after initial surfactant additions. Surface tension was measured by BIRL using a ring tensiometer. From a limited number of measurements, it was concluded that fume reduction of at least 98% resulted when the surface tension was brought to a level of 28 dynes/cm.

Early in the use of the surfactants at Dover, the decision was made to maintain surface tension at a level of 30 dynes/cm or less, in view of the recommendations found in the Mobay literature. Stalagmometers, purchased initially for their economy, have been used for routine surface tension measurements, although the lab at Dover is now equipped with a ring tensiometer, used as a check and for comparisons.

With experience and reference to records for each tank, surfactant additions can be made based on ampere hours of usage and an experienced operator can judge the need for surfactant additions by observing the tank

surface characteristics, such as foam blanket distribution. The cleanliness of a white paper held just a few inches above the tank solution where the gas is rising from the cathode is also a reliable way to demonstrate the efficacy and sufficiency of the surfactant.

Except for a brief period in 1994, in which some pitting problems occurred in tank # 2, primarily when plating chrome on nickel, we have had an entirely satisfactory experience with our use of perfluorinated surfactants. Since this problem was peculiar to only this one tank, it was believed due to some contaminant inadvertently introduced, or to some impurities already in the tank being released to float to the surface where they might cling to a part being introduced to the tank. The problem was eliminated by removal of the solution surface layer and cleaning of the tank walls. BIRL made independent plating tests on a portion of the solution and did not find any pitting problem.

It should be noted that in mid 1994 the use of flouride catalysts in all of the hard chrome plating tanks was stopped so as to reduce the corrosion of lead (6% antimony) anodes and the formation of lead chromate sludge waste. All tanks are now maintained with 100:1 ratio of chromic acid to sulfate.

A report on the Dover experience with use of perfluorinated surfactants for fume elimination was made in a paper presented to the fall meeting of the American Chemical Society in 1995. Benefits experienced were outlined and surfactant usage relative to ampere hours of plating was illustrated.

With price increases by Atotech and the availability of other perfluorinated surfactant compounds on the market, in 1995 we decided to evaluate alternatives such as the Rin, Inc. / Accurate Engineering Laboratories offering of Lo-Mist M/R. Lo-Mist products are believed to be from the 3M family of Flourad (TM) surfactants which includes FC-95 and FC-98, containing potassium perfluoroalkyl sulfonates and FC-99, which contains amine perfluoro alkyl sulfonates. After testing in our #3 tank with entirely satisfactory and equivalent results, in 1996 we began using, and have continued to use, Lo-Mist M/R exclusively in all of our tanks. With only minor variations due to tank surface area and average current employed, maintenance of surface tension at a level of 30 dynes/cm typically requires addition of one gallon of Lo-Mist M/R per 750,000 ampere hours.

We have found that the use of the perflourinated surfactants does not place any limit on the thickness of chromium that can be deposited, nor does it have any

effect upon hardness. Important benefits to be noted are:

*Elimination of a significant waste stream from ventilation tunnel and blower clean out.

*Greatly extended blower lifetime.

*Easier rinsing over the tanks with less water required.

*A truly remarkable purity of air in the shop, such that visitors often comment on it.

Some questions remain regarding the ultimate fate of the added surfactant. Evaporation and electrolysis have been suggested. Early research in Germany showed no evidence of fluoride ion build up in the bath, but there may be some breakdown of the surfactant molecules into volatile lower molecular weight species.

On July 11, 1997, Scientific Control Laboratories of Chicago conducted tests on the two Dover stacks that exhaust chromium emissions simultaneously. Both stacks, one cylindrical and the other rectangular, had been temporarily modified in length to meet the criteria for an acceptable sampling point. The tests were performed while plating was being done in six tanks with current applied at the highest level appropriate for the work available in the shop for each tank. Total ampere hours during the testing period amounted to 103,592., about 1.7 times the average for normal working days. Surface tension in all baths was within the range between 25 and 30 dynes/cm. Calculations from the test measurements showed emission for the east stack at 0.0088, 0.0103 and 0.0261 mg/dscm, and for the west stack at 0.0147, 0.0171, and 0.0170 mg/dscm, compared with the emission limit for existing small sources of 0.03 mg/dscm.

With this result being accomplished with perfluorinated surfactants as the only means of control, it is almost needless to say that Dover highly recommends the use of perfluorinated surfactants in hard chromium plating processes.

Notes: The correlation of surfactant usage with ampere hours will be shown in view graphs at the presentation.

A brief (3 min.) videotape showing typical tank surface appearance during plating, rinsing over the tanks, and a white paper fume test, will be part of the presentation.

Mary Setnicar

U.S. EPA Region 5

"Partners for Environmental Voluntary Program"

Mary Setnicar
United States Environmental Protection Agency

Mary Setnicar has been with the US Environmental Protection Agency since 1985. During that time, she has served in the Office of Policy, Planning and Evaluation in EPA Headquarters; and here in Chicago in the Great Lakes National Program Office, and in the Regional pesticides and toxic substances program. In her present capacity as the chief of the Pollution Prevention and Program Initiatives Section, Mary manages the Regional pollution prevention, municipal and industrial solid waste, medical waste, and waste minimization programs. Before joining the EPA, Mary served 6 years on Capitol Hill as a legislative assistant to a Member of Congress. Mary earned her Master's degree in political science from the University of Chicago, and her BA from Marquette University.

PARTNERS FOR THE ENVIRONMENT

Today nearly 7,000 businesses, trade associations, citizens groups, state and local governments, and universities are volunteering to improve environmental performance in a timely, cost-effective way through an array of EPA partnership programs. These efforts are not just good for the environment. They make good business sense and prove that pollution prevention pays—the total annual cost-savings from participation in 1996 was $852 million

Based on the latest annual estimates, these efforts make quite a difference. In 1996, partners also:

- reduced over 5 million tons of solid waste.

- reduced more than 750 million pounds of toxic emissions.

- saved 199 trillion BTUs of energy

- conserved more than 1 billion gallons of water.

- prevented nearly 25 million metric tons of greenhouse gas emissions.

Known collectively as Partners for the Environment, these programs complement traditional regulatory approaches to environmental protection. Partners set practical, meaningful goals to improve and better protect the environment-from conserving water and energy to reducing hazardous emissions, waste, and pesticide risks.

To find out more, check the partnership programs of interest in this brochure and mail it back to EPA. Or contact the programs directly On the Internet, go to <http://www epa.gov/partners>.

AGRICULTURE

AgSTAR
Promotes cost-effective methods for reducing methane emissions at dairy and swine operations through improved manure management. 202-564-9041

Pesticide Environmental Stewardship
Promotes integrated pest management and reduces pesticide risk in agricultural and nonagricultural settings
800-972-7717

Ruminant Livestock Efficiency
Reduces methane emissions from ruminant livestock operations
202-564-9043

AIR QUALITY

Indoor Environments
Promotes simple, low-cost methods for reducing indoor air quality risks. 202-564-9733

ENERGY EFFICIENCY AND GLOBAL CLIMATE CHANGE

Climate Wise
Reduces industrial greenhouse gas emissions and energy costs through comprehensive pollution prevention and energy efficiency programs. 202-260-4407

Coalbed Methane Outreach
Increases methane recovery at coal mines. 202-564-9168

Energy Star
Maximizes energy efficiency in commercial, industrial, and residential settings by promoting new building and product design and practices 888-STAR-YES (782-7937)

Landfill Methane Outreach
Reduces methane emissions from landfills by installing products to capture gases and produce electricity, steam, or boiler fuel. 202-564-9768

Natural Gas STAR
Encourages natural gas industry to reduce leaks through cost-effective best management practices. 202-260-9793

Transportation Partners
Assists communities in reducing reliance on single occupancy vehicles and promoting more environmentally sound transportation alternatives. 202-564-9793

State and Local Outreach
Reduces greenhouse gas emissions from states and local communities by empowering officials with information and technical assistance 202-260-4314

Voluntary Aluminum Industrial Partnership
Reduces perflouorocarbon gas emissions from aluminum smelting 202-564-9044

POLLUTION PREVENTION

Design for the Environment
Helps businesses incorporate environmental considerations into the design of products, processes, and technical and management systems. 202-260-1714

Environmental Accounting
Increases business understanding of environmental costs and

incorporation of these costs into routine operations. 202-260-3844

Green Chemistry
Promotes the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances 202-260-3960

REGULATORY INNOVATION

Common Sense Initiative
Develops sector-based environmental management strategies tailored to the auto manufacturing; computers and electronics; iron and steel metal finishing; petroleum refining; and printing industries. 202-260-3413

Environmental Leadership
Recognizes and rewards facilities that demonstrate strong environmental performance and commit to go beyond compliance with existing requirements. 202-564-5081

Project XL
Allows companies to test alternative approaches that achieve cleaner and cheaper environmental results than would be realized under existing requirements. 202-260-4297

WATER CONSERVATION

WAVE
Promotes water efficiency in hotels, schools, universities, and office buildings. 202-260-7288

WASTE MANAGEMENT

Waste Minimization National Plan
Reduces persistent, bioaccumulative, and toxic chemicals in hazardous waste. 703-308-9402

WasteWise
Reduces business solid waste through prevention, reuse and recycling. 703-308-7273

EPA'S REGIONAL PROGRAMS

In addition to the national programs described above, EPA's ten regional offices have set up voluntary programs aimed at addressing specific regional environmental priorities.

Region 1 (CT, ME, MA, NH, RI, VT)
CLEAN, StarTrack, Partners for Change, Environmental Merit Awards. 888-EPA-7341

Region 2 (NJ, NY, PR, VI) 212-637-3764

Region 3 (DE, DC, MD, PA, VA, WV)
Business Assistance Center, Chesapeake Bay Program, Green Communities, Chemical Safety Audit Program, Voluntary Initiative for Pollution Prevention. 800-438-2472

Region 4 (AL, FL, GA, KY, MS, NC, SC, TN)
Life Cycle Management, Southern Appalachian Mountains Initiative, Urban Initiative for Sustainable Communities, Chemical Safety Audits. 404-562-9610

Region 5 (IL, IN, MI, MN, OH, WI)
Beneficial Landscaping, Great Printers Protect, PCB Phasedown, PCB Used Oil, Clean Sweep, US Auto Project, Waste Minimization Opportunity Assessments, Chlor-Alkali Industry Mercury Reduction Project. 312-353-4669

Region 6 (AR, LA, NM, OK, TX)
Streamline delisting process, P2 permitting pilot, Regional Administrators Environmental Excellence Awards. 800-887-6063

Region 7 (IA, KS, MO, NE)
Pollution Prevention Awards for Environmental Excellence 800-233-0425

Region 8 (CO, MT, ND, SD, UT, WY)
Air Quality Initiative through Western Governor's Association, Environmental Technology Program, Children in their Earliest Years, EMPACT, Mining, Urban Livability Initiative, Utah 2002 Olympics, American Heritage Rivers, Oil Pit Initiative 800-227-8917

Region 9 (AZ, CA, HI, NV, AS, GU)
Agriculture Initiative, Green Business Recognition Program, Merit Partnership for Pollution Prevention, South Phoenix/Los Angeles Metal Finishing Project. 415-744-2149

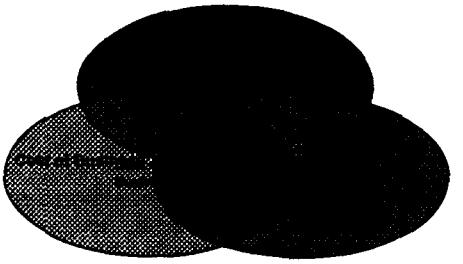
Region 10 (AK, ID, OR, WA)
The Evergreen Award honors leaders in the business community who demonstrate that pollution prevention is a sound business practice. 206-553-4072

Partners for the Environment

EPA's Partnership Programs

September 1998

A NEW WAY OF DOING BUSINESS



Through an array of partnership programs called *Partners for the Environment*, EPA is demonstrating that voluntary commitments achieve timely and cost-effective environmental results.

September 1998

2

Benefits of Being a Partner

- Why partner with EPA?

September 1998

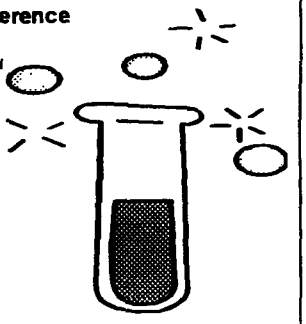
3

Partners for the Environment Makes a Real Difference

→ In 1997, our partners reduced toxic emissions by 750 million pounds;

→ Eliminated 7.6 million tons of solid waste from entering our landfills;

→ Reduced greenhouse gas emissions by preventing 79 million metric tons of CO_2 emissions.



September 1998

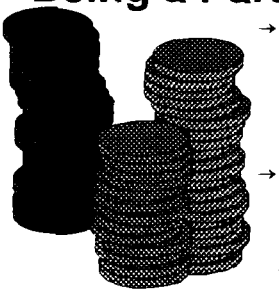
4

- These programs don't just reduce pollution they also save energy.
- Over 8,000 partners from every major sector of the economy, from Fortune 500 companies to small shop owners.

September 1998

5

Being a Partner Pays



→ *Partners for the Environment* are good for the environment and makes good business cents!!

→ Collectively Partners saved 1.6 billion (up from $852 million in 1996); and expect to save $4.6 billion annually by the year 2000.

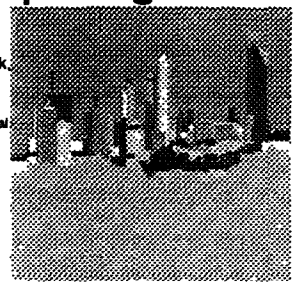
September 1998

6

Partnership Programs

→ Reduce indoor air pollution & pesticide risk.
- Indoor Environments Program
- Pesticide Environmental Stewardship Program (PESP)

→ Conserve water and energy;
- Water Alliances for Voluntary Efficiency Program (WAVE)



September 1998

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Recognition for Achievements

EPA's partnership programs has conducted or was present at 250 recognition events that was attended by 15,000 participants.

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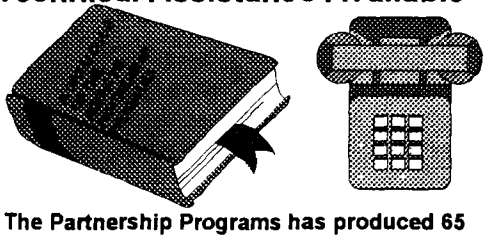
Technical Assistance Available



The Partnership Programs has produced 65 informational and technical partnership program documents, and more than 900 media articles (Journals, Newspapers, etc.)

September 1998

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Partners Measures of Success

MEASURES	1997	Projected 2000
Toxic reduced (pounds)	759 023,490	Over 750,000,000 (Goal met in 1997!)
Waste reduced (tons)	7.67 million	8.3 million
CO_2 prevented (million metric tons)	78 mmt	216 mmt
Energy saved (trillion BTU's)	1,028	935 (Goal exceeded in 1997!)
Water saved (1 million gals.)	5.8	7.2
Number of partners	9,939	13,655
Money saved (billion $)	51.8	54.4

September 1998

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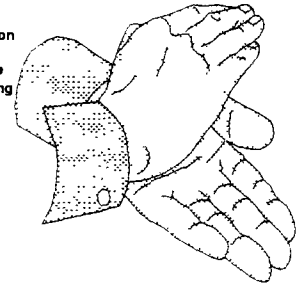
CLOSING

- Our success shows pollution prevention is becoming a central consideration in the private sector's way of doing business.
- Our partners are achieving measurable results more quickly and with lower voluntary efforts.
- Reduced environmental pollution and health risks through regulatory approaches.



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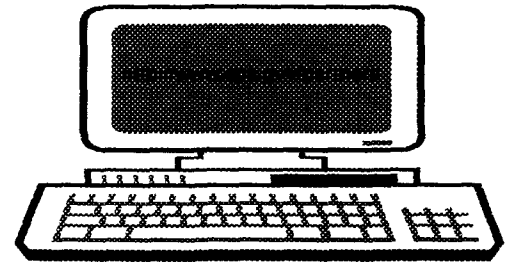
INTERNET ADDRESS

CHECK US OUT ON THE INTERNET AT:



September 1998

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Linda Sharkey

AERC/MTI

"Mercury in the Environment"

Biography

Linda Sharkey is National Accounts Manager for Advanced Environmental Recycling Company (AERC), a leader in the mercury recycling industry. She has responsibility for the development, coordination and implementation of lamp, battery and other mercury recycling programs for several Fortune 500 clients nationally. Ms. Sharkey has been employed with AERC for more than five years. She previously worked in project management for an energy conservation company. Ms. Sharkey graduated from Kent State University in 1989 with a BA in Journalism.

Mercury in the Environment

Introduction

What do fluorescent lamps, sphygmomanometers, thermostats, old paint and dental amalgam have in common? Mercury.

Mercury is a vital part of a great number of household and industrial products (Attachment I). While its unusual characteristics have made it one of the most widely used applications, mercury's neurotoxicity and its presence in the environment, have led to recent efforts to eliminate it from many applications.

Characteristic and Effects of Mercury

Mercury, also known as quicksilver, or Hg (for hydrargyrum), is a metallic, silvery, heavy, toxic liquid at room temperature. For years, mercury was mined from the earth in the solid form as the ore cinnabar (HgS), and was converted to metallic mercury by roasting or heating it in the presence of air or lime. Today, mercury is sourced domestically from secondary suppliers, with over 400 tons being produced and sold back into the marketplace annually, according to the US Geological Survey, Mineral Commodity Summaries (1997).

Mercury's unique properties have made it useful worldwide, as evidenced by many different applications in hospitals, schools, laboratories, industry and the home. The quality most often employed is that mercury is the only metal which exists as a liquid at room temperature. It vaporizes at low temperatures (as low as 10 °F). One of the most common applications for mercury is in lighting devices such as the fluorescent or mercury vapor lamp. These devices contain a typical range of 10 mg to several grams of mercury per lamp, depending on the type of lamp and the manufacturer.

Although useful in many applications, the toxicity of mercury makes it necessary to keep it contained and controlled from releases and spills. Colorless and odorless, mercury vapor provides no exposure warning properties. Mercury is toxic by inhalation, ingestion and skin absorption with acute and chronic exposure effects including central nervous system and kidney damage. Acute exposure includes nausea, blurred vision, painful breathing, excessive salivation and pneumonitis, while chronic or longer term exposure ncludes memory disturbance, hypertension, vision problems, hallucinations, tremors and personality changes.

Once mercury is released into the environment, it can be converted by microorganisms into methylmercury. Methylmercury bioaccumulates in the flesh of fish and can move up the food chain. Bioaccumulation of mercury within the aquatic food chain has been well documented. In response to the risks posed by mercury, health advisors in more than 35 states have warned the public about consuming mercury-tainted fish.

Waste Management Practices

Improper disposal of mercury-containing devices and contributes to the levels of mercury in the environment. It has been assumed that the largest man-made sources of environmental mercury comes form coal-burning plants, primary smelting, trash burning and the landfilling of mercury-wastes like fluorescent tubes and devices. Mercury is now viewed by government officials as "the acid rain of the 1990's" with global levels increasing two-to-three fold over the past century.

In response to the potential risks posed by mercury, various policies have been enacted by different levels of government.

Federally, elemental mercury, devices and compounds may be considered hazardous waste. Disposal options of these items is limited by EPA under the Resource Conservation Recovery Act to the treatment and management options outlined in 40CFR 260-279. Since it is possible for mercury to enter the environment is waste is incinerated or landfilled, many municipal landfills have limited have acceptance of mercury materials. The incineration of solid wastes has been discouraged since mercury is not destroyed when heated. In addition, OSHA and DOT have established exposure limits and handling guidelines because of mercury's toxic characteristic. DOT considers metallic mercury a corrosive hazard with mercury salts also being considered poisonous.

The Universal Waste Rule, promulgated in May 1995, includes mercury thermometers among the wastes that are "universally" generated and require proper disposal. If recycled, Universal Waste may be managed under less burdensome record keeping and transportation requirements.

Many states have adopted additional initiatives to encourage the recycling of lamps, batteries and other broadly used mercury containing devices.

New Jersey, Florida, and Wisconsin, to name a few, have facilitated the development of county lamp collection programs. The Universal Waste Rule, once adopted at a state level, can be amended to include other mercury-bearing wastestreams. In October, Region V announced is hoping to improve the awareness of small generators. The partnership between the EPA and private sector, is named " Cook County Cleansweep ." The educational training program focuses on mercury and PCB pollution prevention.

Treatment Options

When any product containing mercury reaches the end of its useful life, every attempt should be made to keep the mercury out of the solid wastestream. A well established and growing mercury recycling industry provides opportunities for households, businesses and industries to recycle their spent devices. In addition, many devices may be replaced with mercury-free alternatives.

Consumers should take their spent mercury-containing wastes to a household hazardous waste collection site, if one is available in the area. These sites may be maintained continuously or periodically, depending on the county. Homeowner should contact their local Office of Solid Waste Management for details. If a government sponsored program is not available, the homeowner should check with the product supplier. Some retail chains are offering take back programs for batteries, lamps and thermostats.

Industrial and commercial generators should contact their waste management company to discuss disposal options. Technology and costs differ greatly. When considering outlets, the generator should look to work with companies that maximize the quantity of recovered material and minimize their liability through the utilization of best available technology and safe management practices.

AERC was formed in 1990 to respond to the needs of industry, commercial businesses, schools and homeowners to safely manage and recycle mercury and to minimize widespread environmental releases. AERC uses a series of proprietary separation, hydrometallurgical and retort technologies for the safe removal and recovery of mercury in these wastes. All processes are designed and operated with stringent safety and industrial hygiene requirements to eliminate emissions of mercury into the environment, thereby reducing pollution while providing full service recycling of this extremely toxic substance.

Since 1992, AERC has processed over 6 million pounds of mercury containing devices and over 10 million fluorescent lamps. This has resulted on over 13 million pounds of mercury waste being diverted from landfills and incinerators.

Attachment I
Typical Products Containing Mercury

Thermometers	Sphygmomanometers (Blood Pressure Gauges)
Analytical Lab Solutions and Compounds	Mercury Salts
Alkaline Batteries (older types)	Athletic Shoes w/ Flashing Lights (Before 1997)
Non-electronic Thermostats	Fluorescent Lamps
Mercury Vapor Lamps	Neon Lamps
High Pressure Sodium Lamps	Metal Halide Lamps
Circuit Board and Electronic Switches	Automotive Headlamps
Gas Flow Regulators	Clothes / Curling Irons with Auto. Shut Off
Antibacterial Sprays / Ointments	Eye Tincture / Some Contact Lens Disinfectants
Latex Paint Before 1990	Some Oil Based Paint
Dental Amalgams	Manometers
Barometers	Vacuum Gauges
Some Packaging Inks	Chemistry Sets
Toys and Games (Older)	Industrial Catalysts

Some Switches in Sump Pumps, Chest Freezers, Clothes Washers, Automotive Hood and Trunk Lights

Mercuric Oxide Batteries (Can be Found in Some Children's Books and Watches)

Thermostat Probes Found in Some Gas Ranges, Ovens, Clothes Dryers, Water Heaters, Furnaces, Space Heaters

James Sherman/Tom Barnett
(see Tom Barnett for paper)
Ispat Inland Inc.

"Magnetic Separator Usage in Steel Processing Alkali Cleaning Solution Applications"

Jim Sherman

Mr. Sherman is currently a Technical Consultant within the Central Engineering Dept. of Ispat Inland Inc. Jim has been in the engineering dept. for more than 30 years with projects and project responsibilities ranging from design and engineering management for installation of various sheet steel and bar product rolling mill facilities to design, engineering management and installation of wastewater treatment plant operations. Mr. Sherman was the individual primarily responsible for design, installation and implementation of the alkali cleaning solution magnetic separator project being presented at this conference.

Jake Smith

Hennepin County
Dept. of Environmental Services, Environmental Protection Division

"Promoting P2 Activities for Hazardous Waste Generators in Hennepin County"

BIOGRAPHY

Jake Smith

Jake Smith is an Environmentalist in the Environmental Protection Division of Hennepin County Department of Environmental Services. The Environmental Protection Division regulates businesses that generate hazardous waste. Jake is currently the project manager of a grant to promote pollution prevention activities for businesses that generate hazardous waste. He is responsible for the division's generator outreach and training program, and has worked as a hazardous waste inspector. His prior experience includes 15 years in the leather tanning, air pollution control, and dry cleaning industries, working as both a research director and an environmental manager. Jake has a B.S. in Chemical Engineering from the University of Massachusetts at Lowell and is a Certified Hazardous Materials Manager.

Promoting Pollution Prevention Activities for Hazardous Waste Generators in Hennepin County

The Environmental Protection Division is responsible for enforcing the Minnesota hazardous waste regulations for businesses in the county. All businesses generating hazardous waste are licensed by the county and subject to periodic inspections by county staff. The county licenses about 4500 businesses and inspects about 2300 businesses annually.

The division has developed an extensive outreach program to ensure that businesses generating hazardous waste are aware of the regulations and know what is required to be in compliance. The outreach program consists of monthly training sessions, daily telephone assistance, fact sheets, semi-annual mailings and a semi-annual newsletter. During inspections staff is able to answer regulatory questions, provide information, and ensure compliance.

In 1997 the division received a grant from the Minnesota Office of Environmental Assistance to assess existing waste minimization efforts and pollution prevention activities of businesses and to determine outreach activities that could be used to increase awareness of pollution prevention opportunities. This presentation will review assessment results and present examples of outreach materials being developed to integrate pollution prevention into existing county programs.

Sue Sommerfelt

Iowa Waste Reduction Center

"Taking Automotive P2 on the Road: Mobile Outreach for P2"

Biographical Information for Sue Sommerfelt

Sue Sommerfelt is a Waste Reduction Specialist at the Iowa Waste Reduction Center. The center provides hands-on waste reduction and pollution prevention assistance to Iowa's small businesses. She is also the coordinator of the Mobile Outreach for Pollution Prevention (or MOPP) project where she travels extensively throughout the U.S. and Iowa. Sue has a bachelor of arts in Science: Environmental Planning from the University of Northern Iowa and is currently studying for a Masters in Public Policy.

Taking Automotive P2 on the Road:
Mobile Outreach for Pollution Prevention

The Mobile Outreach for Pollution Prevention (MOPP) is a 34-foot motor home customized to exhibit commercially available equipment useful in waste reduction efforts. The MOPP is geared toward waste streams commonly generated from the vehicle maintenance and automobile body repair industry. The MOPP is based on a pilot project conducted in a five-county area of Northeast Iowa in 1992 called "Solutions for Rural Waste Management." The Iowa Waste Reduction Center, at the University of Northern Iowa, established the newest demonstration unit in January, 1995.

The pilot project gathered information on wastes generated by small businesses in the area. Automotive waste streams were identified as a focus for continuing efforts, from the survey data. The final evaluation of the study area also revealed that *recycling and reuse of hazardous wastes increased by 74% and that the use of on-site, illegal incineration of wastes decreased by over 50%.*

Since the pilot project, the nine-step implementation plan for a mobile demonstration unit has been refined by working with diverse groups of partners throughout the nation. The MOPP was initially funded through a grant from the Northwest Area Foundation. Current efforts are sponsored through a cooperative agreement with the Environmental Protection Agency. The MOP is currently touring its home state by working with partners at the county level. Out-of-state demonstrations were conducted in Georgia, Idaho, Kansas, Maryland, Minnesota, Missouri, Nebraska, Pennsylvania and Wyoming.

The Idaho MOPP partnership was the most extensive demonstration tour to date. The partners included state agencies, tribal governments, and educational institutions. The MOPP spent eight weeks touring the state of Idaho, traveling 3,000 miles and visiting 34 communities.

Minnesota and Nebraska each hosted a week-long tour. The Minnesota partners focused on one specific area, the Lake Superior Basin. Nebraska chose to spread out, touring across the entire state by placing an emphasis on the educational aspect of the demonstration unit the first year. The demonstrations were hosted by community colleges with automotive programs. In the second year, the Nebraska Department of Environmental Quality partnered with the Nebraska Public Power District and others. The two weeks of demonstrations were hosted by the power plants in conjunction with the Keep America Beautiful affiliates throughout the state.

Each MOPP demonstration is conducted at a central site within a community. Vehicle maintenance, automobile body shops and metal manufacturers are invited to attend, usually through direct mail and personal contact from the partnership members.

Businesses attending are given a hands-on demonstration with antifreeze recycling equipment, a solvent still, paint gun wash unit, spray painting techniques and alternative parts washing options. At the demonstration a regulatory expert is available to discuss specific requirements in a non-threatening environment. The MOPP also houses a display of waste reduction manuals, regulatory summaries, and lists of vendors providing the recommended service or equipment.

Christopher Start/Scott Wells

Energy, Environment, Health and Safety Services
Michigan Manufacturing Technology Center

"MEDS: A Technology Division Support Tool for Industrial Job Shops"

Christopher L. Start

THE AUTHOR

Christopher L. Start is the MEDS Project Manager, and an Environmental Engineer with MMTC's Energy, Environment, Health & Safety Department, 2901 Hubbard Rd. P.O. Box 1485, Ann Arbor, MI 48106-1485; Phone: (734) 769-4413; FAX: (734) 213-3408; E-mail cstart@mmtc.org. He has a BA in Biology from the Virginia Military Institute (Lexington, VA), and a MS in Hazardous Waste Management from Wayne State University (Detroit, MI). He is a Certified Hazardous Materials Manager (CHMM), and has taken ISO 9000 Certified Auditor Training. He has taken additional training in hazardous waste operations and emergency response through OSHA and the U.S. Department of Transportation.

MEDS:
A Technology Decision Support Tool for Industrial Job Shops

ABSTRACT

The Manufacturing Efficiency Decision Support (MEDS) program is a web-based decision support tool that provides users with information on the performance, cost, energy, and environmental implications of alternative manufacturing technologies, so that more realistic comparisons and evaluations of technology options can be made.

The MEDS decision support tool is designed to improve decision-making by expanding the range of alternatives considered. Using "what if?" analyses on several essential variables such as budget constraints, MEDS provides objective and detailed information on the costs and benefits of technology alternatives. The program is designed to work within a typical job-shop environment. Designed for specific manufacturing industries, the tool will save the user time in researching the multitude of possible manufacturing and pollution prevention solutions for small-medium sized manufacturers in the following areas:

- Fabricated Metals (Plating, Coating, Stamping, Machining)
- Plastics
- Electronics and Computers
- Plant Utilities (Energy, Environmental and Parts Washing Systems)

The product is World Wide Web-based for ease of access and updating. The MEDS tool integrates energy, environmental, and manufacturing aspects of a technology application. The MEDS tool provides the user with a good framework and an initial set of data to begin with, while more in-depth information will be provided via links to other established web sites. MEDS provides a user-friendly interface for novice as well as veteran Internet users to allow for more efficient use of time. Intended users include NIST/Manufacturing Extension Partnership (MEP) centers' field agents, DOE Industrial Assessment Center engineers, P2 technical assistance providers, as well as industry personnel and management.

MEDS allows the user to focus on solutions that have the highest probability of success. It does this by providing five key information areas for each technology:

- Background Information (including a photo)
- Case Study
- Economic Feasibility
- Technical Feasibility
- Vendor Information

KEYWORDS

The MEDS web site is located at: http:\\meds.mmtc.org, or you can use any of the popular search engines to locate the site on the World Wide Web. The following are just a few of the keywords that can be used: "MEDS", "NIST-MEP", "Manufacturing Technology", "Energy Equipment", and "Environmental Equipment".

INTRODUCTION

The World Wide Web can be an excellent research tool because of the wide range of organizations that promote their ideas, missions, and products through web sites. Web content has grown as the number of users has grown. Nearly 100 million people now search for entertainment, commerce, and news. A recent Business Week/Harris poll found that 50% of users conduct web research. However, the majority of web content, especially manufacturing related, is non-interactive or static text while the web's features allow much more interaction with the user. A new web site called Manufacturing Efficiency Decision Support (MEDS) has been developed to provide an interactive manufacturing technology assessment tool.

DISCUSSION

There are many valuable sites for manufacturers and manufacturing consultants. For example, The Thomas Register of American Manufacturers, a product, service, and vendor listing catalogue, has a web site which, in addition to providing information currently in the Thomas Register book, also links to vendor sites. The Gas Research Institute's web site offers applied and basic research reports, and gas industry and product news. Federal government agencies such as the Environmental Protection Agency, Department of Energy, and Department of Commerce, as well as State governments, have excellent sites that provide regulatory information, technical reviews, databases, current event information, and descriptions of government services. Many of these sites have some interactive components such as keyword search engines, online discussion groups, and, in the vendor sites, forms to submit requests for product quotes.

In general, however, most manufacturing related web content is static. In other words, a user visits the site, reads the material, perhaps prints it and then moves on to another site. Contrast this to other industries that take advantage of interactive web features and benefits such as two-way communication, immediate update of information, and inexpensive distribution of programs and material. A good example is the financial services industry, which has been revolutionized by the web. Online banking and trading is now readily available.

Manufacturers can benefit from web based tools that use more of the web's features. Industrial Technology Institute's MEDS web site (http://meds.mmtc.org) provides traditional static information on the performance, cost, energy, and environmental implications of alternative manufacturing technologies. It also has interactive components that allow users to conduct technical and economic "what if?" analyses with their facility's parameters. MEDS is designed to work within the realities of manufacturing, which include partial cost, performance and technology information, as well as budget and time constraints.

Manufacturers frequently face technology feasibility questions such as "Should I install capacitors to eliminate my power factor charge?", "Is there a good alternative to solvent based metal parts cleaning systems?", and "Are there alternatives to chemical treatment of my cooling tower water?" There are many different criteria on which to base the decisions and there are often several technically and economically feasible solutions.

Let's say a plant manager faced the last question above: "Are there alternatives to chemical treatment of my cooling tower water?" Typically, the problem is segregated into separate issues such as: What are the technical constraints in my facility? What are the implementation costs, savings, and payback periods for alternatives? What are the regulatory issues? What process modifications will be required? And, will the new system require extensive retraining of my employees?

Traditionally, these questions are answered by talking to industry peers, hiring consultants, researching the problem independently, and talking to vendors. However, each of these methods has a downside. Industry peers are not necessarily experts, and often base their recommendations on their own facility's limited experience. Consultants can be expensive if they have to invest the time to evaluate the technology and to understand the clients' individual requirements. Researching the problem independently often requires large amounts of time that many small manufacturers cannot afford, and vendors, although knowledgeable, are seldom objective in their recommendations. Moreover, just deciding which of these research methods to pursue can be time consuming in itself.
MEDS replaces many of these initial technology evaluation steps by providing background information and by enabling economic and technical "what if?" scenarios. The MEDS home page is in Figure 1.

The MEDS web site contains a large database of information regarding manufacturing technologies. There are several ways to get to an individual technology. First, you can browse the main graphical menu organized by industry sector operations. Alternatively, you could view an alphabetical list of all technologies by using either the "Technology" or "Case Study" pull-down menus located at the top of the homepage. And, finally, you could locate technologies containing keywords using the web site any-word search engine. Selecting the technology "ultrasonic cleaning" from the main graphical menu, or the technology pull-down menu would lead to the Technology Feasibility screen for ultrasonic cleaning (Figure 2).

The technology menu bar across the top of the screen provides access to five separate sections for each technology: Background Information, Case Studies, Economic Feasibility, Technology Feasibility, and Vendor Information. The Technology Feasibility page, an example of MEDS' interactive component, poses a series of questions to determine if the technology is appropriate for a specific facility. The first several questions assess the status of the current parts cleaning system. Two questions: "Are you currently cleaning your parts with a non-aqueous method involving harmful chemicals like TCE?" and "Are you cleaning small to medium parts (Parts with a general size under 5 cu. ft.?" act as obvious kill questions. In other words, if either answer is "no" this technology is not feasible in that particular circumstance. In this screen, the questions have been answered for a hypothetical situation. A score of 100 has been provided meaning that an ultrasonic cleaning system has a high probability of being technically feasible.

The Background Information section, which is an example of a static component of MEDS, includes a process description, picture, required raw materials, equipment description, lists of

advantages and disadvantages, and links to information sources. This section is designed so that everyone, regardless of experience, can gain some new insight into the technology.

Selecting Case Studies from the technology menu bar leads to a description of how the technology was used. Most of the MEDS technologies have been used by manufacturers, so case studies are available to show how the technology was employed, what worked, and what needed improvement. For the technology Ozone Treatment of Cooling Tower Water the case study describes how an ozone treatment system was chosen to replace a chemical treatment system for four cooling towers with a 2,500-ton capacity. In this example the surface water quality standards in Florida changed, prohibiting cooling tower blow-down discharge to local surface waters. After the purchase and installation of a technology utilizing ozone treatment of cooling tower water, acceptable surface water quality standards were met, and chemical and water usage were drastically reduced along with the permitting fees. The ozone system had a payback of approximately 2.5 years and a net present value of $799,705 over a 10-year life.

Next on the technology menu bar is the Economic Feasibility section, another interactive screen, which for the technology Liquid Nitrogen Cooling of VOC's is shown in Figure 3.

The Economic feasibility section starts with Part A - Equipment Costs Rules of Thumb which gives the estimated per unit cost and the total cost of the technology. Liquid nitrogen cooling systems cost roughly $2,000 per SCFM up to 150 SCFM, and $1,000 per SCFM from 150-500 SCFM. Thus a 50 SCFM unit would cost around $100,000, while a 250 SCFM unit would run about $250,000. The part B "Benefits" section describes the savings that a liquid nitrogen cooling system yields over the industry standard, which in this case is adsorption/incineration. For example, the liquid nitrogen cooling system eliminates 40-80% of the operating costs, and 95% of the maintenance costs associated with an equivalent capacity adsorption/incineration system. Part C covers "Qualitative Benefits". Next is a fill-in form used to calculate the savings and payback period in which users enter their existing VOC reduction operating costs, existing VOC reduction equipment maintenance costs, and their existing flow rate of VOC contaminated air. Once the Calculate Savings and Payback button is pushed, the annual savings in dollars, and the estimated payback range in years is displayed.

Lastly, on the technology menu bar is the Vendor Information section. This button links to the Thomas Register of American Manufacturers web site. Suggested key words to search the Register and the web for the technology are provided.

CONCLUSIONS

MEDS uses the web's static and interactive attributes to help manufacturers evaluate technologies and identify technically and economically feasible solutions for problems. MEDS assists with the evaluation and selection of over 175 technologies in the following industry sectors: Plant Utilities, Fabricated Metals, Plastics, and Electronics & Computers. Because MEDS is web-based, it is open to public use by any relevant individuals such as manufacturing plant personnel, consultants and academia.

REFERENCES

NIST-MEP: The Department of Commerce's National Institute of Standards and Technology (NIST) is sponsoring MEDS, and will use the tool to assist small and medium-sized manufacturers through it's 78 member nationwide Manufacturing Extension Partnership (MEP) network. The web site, however, is also available to the public at: http://meds.mmtc.org.

MMTC: MEDS was created and developed by the Michigan Manufacturing Technology Center (MMTC) formerly known as the Industrial Technology Institute (ITI) of Ann Arbor, Michigan. MMTC has formed a team with more than 80 years experience in manufacturing and manufacturing consulting to create the web-based tool.

BACK TO:
MEDS
SEARCH
FEEDBACK
FAQ
PROJECT BACKGROUND

Sponsored by:

MANUFACTURING EXTENSION PARTNERSHIP

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MEDS

manufacturing efficiency decision support

Case Studies Technology List

Select an area below or go directly to a technology by using one of the listings above

- plant utilities
  - energy systems
  - environmental systems
  - parts washing
- electronics & computers
  - printed wiring boards
  - semiconductors & related devices
- fabricated metal products
  - fabrication
  - surface preparation
  - finishing
- plastics
  - ancillary equipment
  - decorating
  - molding
  - recycling

Technology Feasibility - Ultrasonic Cleaning

Question	Response	Score
Are you currently cleaning your parts with a non-aqueous method involving harmful chemicals like TCE?	(•) Yes ( ) No	0 -1000
Are your workers currently exposed to a harmful environment while handling these parts?	(•) Yes ( ) No	10 0
Are your workers spending more time on parts cleaning, rather than other important operations?	(•) Yes ( ) No	50 0
Are you having trouble keeping the work environment clean?	( ) Yes (•) No	10 0
Are hazardous waste disposal costs expensive in your area?	(•) Yes ( ) No	30 0
Are you cleaning large parts? (Parts with a general size over 5 ft 3)	( ) Yes (•) No	-1000 0
Are you cleaning "sound absorbing" parts? (Fabrics, rubber, etc.)	( ) Yes (•) No	-100 0
Are you located in an area where pollution is a problem?	(•) Yes ( ) No	10 0
Score:	100	
Technical Feasibility Rating:	High Probability	

Technical Feasibility Ratings	
No Probability	<1
Low Probability	1-40
Moderate Probability	41-80
High Probability	>80

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Economic Feasibility - Liquid Nitrogen Cooling

A. Equipment Costs Rules of Thumb

	Estimated cost per unit	Estimated Total Cost
Typical Equipment Cost	*$2,000/SCFM: to 150 SCFM*	*$ 100,000 = 50 SCFM unit*
	$1000/SCFM: 150-500 SCFM	*$250,000 = 250 SCFM unit*

B. Benefits (Savings in Operating Costs)

Area of Savings	Annual Savings (Relative to adsorption/incineration)
Operating Costs	40-80%
Maintenance Costs	95%

C. Other Benefits

Reduces VOC and ODS emissions. Longer compliance window. Does not contaminate the recovered VOCs. Good reliability due to the low number of moving parts. No secondary pollution (contaminated water or combustion products) created.

Enter the following data to calculate the simple payback range. **No dollar signs ($) or commas allowed.**

Existing Operating Costs ($/yr)

Existing Maintenance Costs: ($/yr)

Existing Flow Rate of VOC Contaminated Stream: (SCFM)

Calculate Savings and Payback Reset

Savings:

Payback range years

If you have any comments, please feel free to let us know at meds@iti.org

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MEDS

Manufacturing Efficiency Decision Support:

A Web Based Tool

Scott Wells- Energy Engineer

Michigan Manufacturing Technology Center

MMTC

MICHIGAN

What is MEDS?

MEDS is an interactive web-based program that provides users with information on the performance, cost, energy, and environmental implications of alternative manufacturing technologies. (175)

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MEDS Technology Components

Background

Case Study

Technical Feasibility

Economic Feasibility

Vendor Information

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MEDS Roadmap-Industry Coverage

Cross Industry Plant Utilities

Industry Specific Sectors

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Cross Industry Plant Utilities

Parts Washing

e.g.Ultrasonic Cleaning,
Aqueous Degreasing, etc.

Energy Systems

e.g. Natural Gas Chiller,
Capacitor (Power Factor), etc.

Environmental Systems

e.g. Oil Skimmer, Solvent
Distillation, etc.

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Industry Specific Sectors

Fabricated Metal Products

e.g. CO2 Stripping, UV Curing, etc.

Plastics

e.g. Ultrasonic Welding, Catalytic IR Heating, etc.

Electronics & Computers

e.g. Megasonic Wafer Cleaning, Electrodialysis Metal Recovery, etc.

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Michigan Manufacturing Technology Center (MMTC)

Energy, Environment Health and Safety Services

Scott Wells

(800) 292-4484 x4514

scw@mmtc.org

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John W. Sutherland

Michigan Technological University

"Waste Reduction in Machining Processes"

BIOGRAPHY

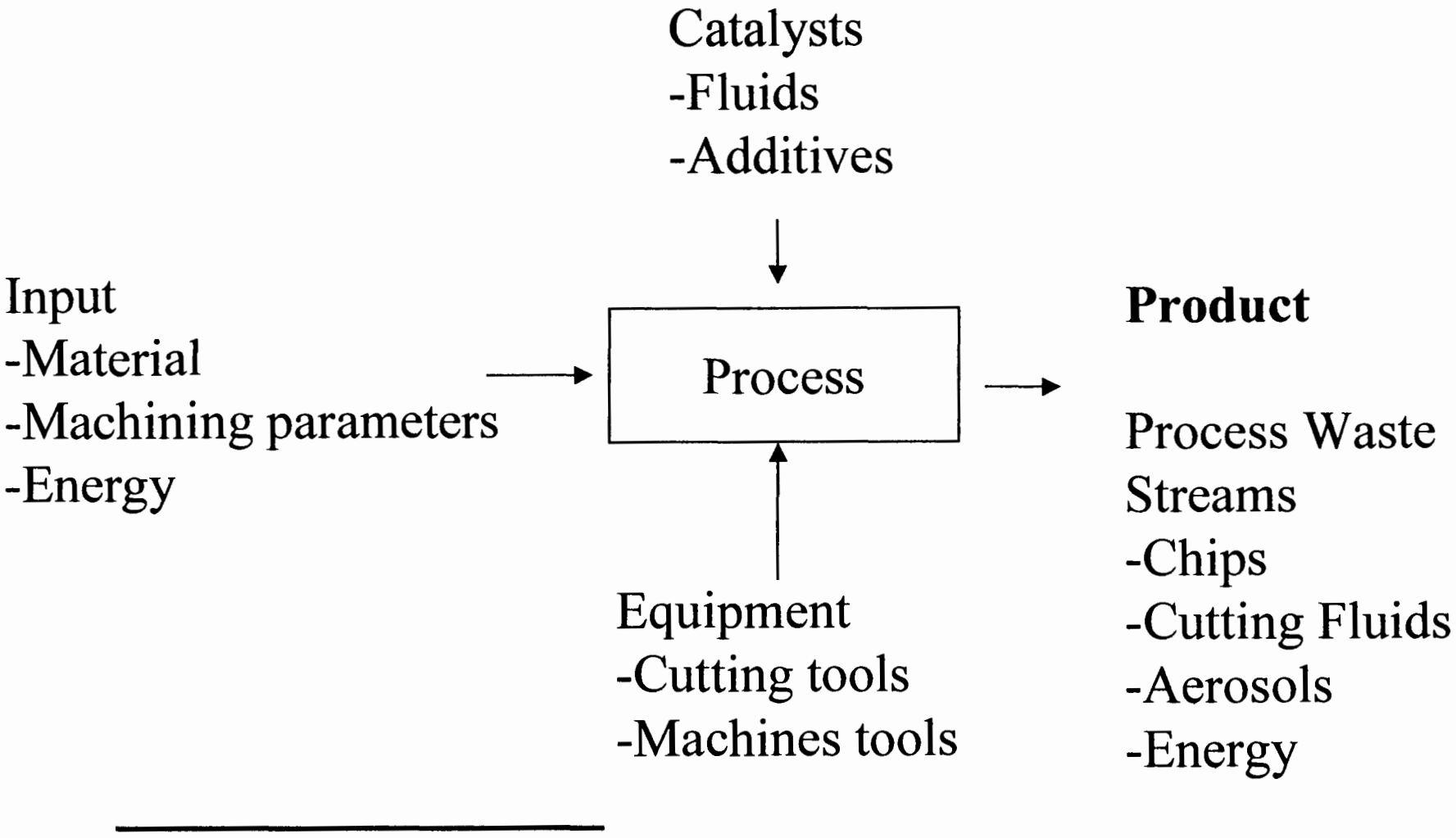
John W. Sutherland, Ph.D.

John W. Sutherland joined Michigan Technological University (MTU) in 1991 and is a Professor, Associate Chair, and Director of Graduate Studies in the Department of Mechanical Engineering - Engineering Mechanics. He received his B.S. and M.S. degrees in industrial engineering, and his Ph.D. in mechanical engineering all from the University of Illinois at Urbana-Champaign. Prior to coming to MTU, he was Vice-President of a consulting firm specializing in manufacturing and quality improvement. He held an adjunct faculty position at the University of Illinois from 1985-1991. In his university positions he has taught courses in Manufacturing Processes, Engineering for the Environment, Statistical Process Control, Statistical Design of Experiments, NC Machining, and Environmentally Conscious Design and Manufacturing. Dr. Sutherland has presented short courses on Quality Improvement to such companies as Ford, Caterpillar, Borg Warner, and Hyster. He has published over 100 technical papers in various journals and conference proceedings, and is a co-author of the textbook: Statistical Quality Design and Control: Contemporary Concepts and Methods.

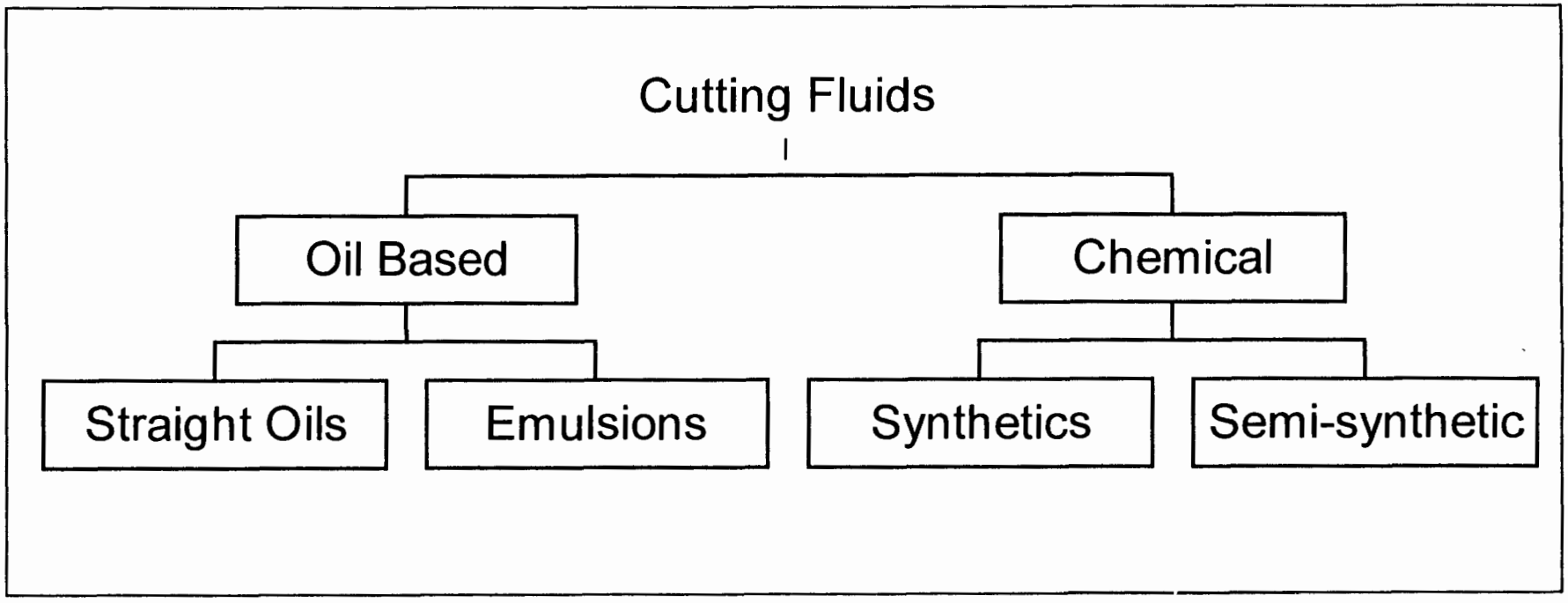
Professor Sutherland has served as the advisor of 27 M.S. students and 6 Ph.D. students, and is currently advising 17 graduate students (9 M.S. and 8 Ph.D.). He is a member of the American Society of Mechanical Engineers, the Society of Manufacturing Engineers, the Institute of Industrial Engineers, the American Society for Quality, Tau Beta Pi, Alpha Pi Mu, Phi Kappa Phi, Pi Tau Sigma, and Sigma Xi. He is a member of the Board of Directors and the Scientific Committee of the North American Manufacturing Research Institution, serves on the Executive Committee of ASME Manufacturing Engineering Division, and was an associate technical editor for the ASME Transactions - Journal of Engineering for Industry from 1993-97. Professor Sutherland was one of the recipients of the SME Outstanding Young Manufacturing Engineer Award in 1992, received the MTU Distinguished Teaching Award in 1992, and was selected as Teacher of the Year for the Department of ME-EM for the 1992-93 and 1993-94 academic years. In 1995 he was the recipient of a National Science Foundation Career Development Award. He was selected for a Presidential Early Career Award for Scientists and Engineers in 1996.

Waste Reduction in Machining Processes

Modeling Process Waste Streams



Background

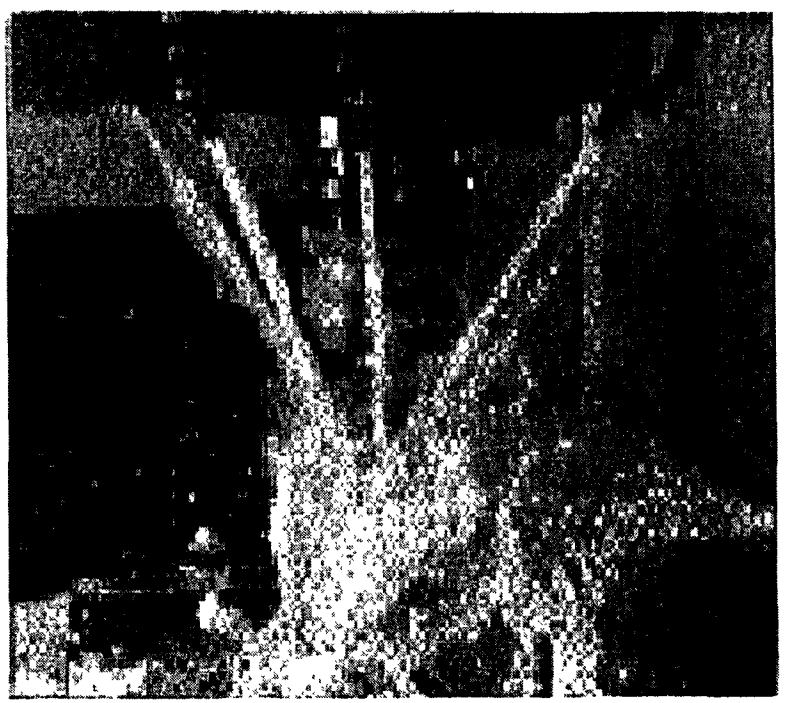


Additives: Chlorine, Sulfur, Phosphorus, Biocides, Odorants

Traditional View of Cutting Fluids

- Essential in metal cutting operations, especially high volume machining
- Primary functions: Cooling and Lubrication
- Secondary functions: Chip Flushing and Rust Inhibition
- Cutting fluids are the economical solution to reduce the effect of heat on product quality

Traditional View



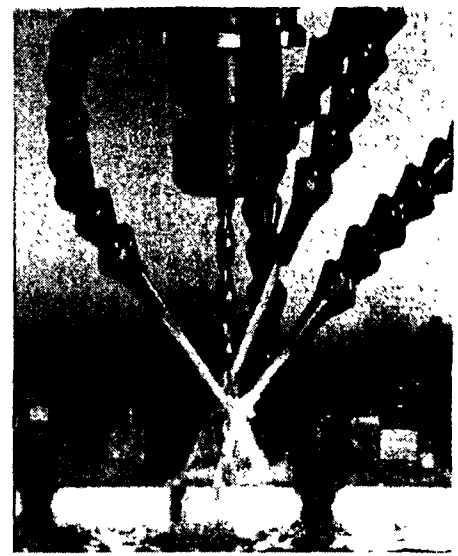
Motivation

- 100 million gallons of cutting fluid are consumed annually in the United States

- Environmental impact

- Mist Formation - health hazard

- Need to reduce or eliminate cutting fluid



Health Effects

- NIOSH:-1.2 million are exposed to cutting fluids [Hands et al., 1996]
- Aerosols from PM10 to PM2.5 and PM1.0 (EPA)
- Airborne particulate from 5 mg/cu. m to 0.5 and 0.1 mg/cu. m (UAW and OSHA)
- Bacteria / fungi in cutting fluid produce toxins [Thorne et al., 1996]
- Mist collectors are sometimes ineffective [Leith, 1996]

Environmental Effects

- Spent cutting fluid disposal -- waste water -- POTW changes
- Chemical reactivity
- Spill and Leak (eg. from chips)
- Recyclability
- Effect on BOD level in ground water and lakes

Why Not Dry Machining ?

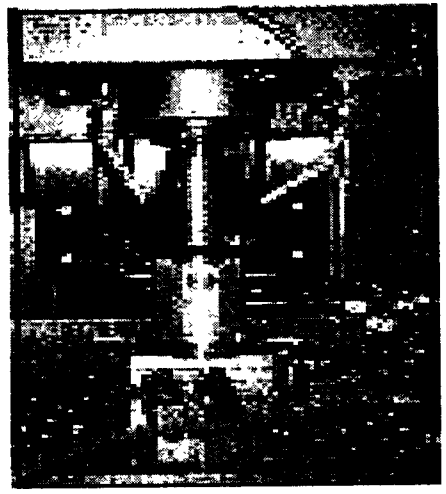
- Chip clogging : drilling process
- Friction too high - bad parts : tapping process
- Thermal deformation : boring
- Economic comparisons

Work at Michigan Tech.

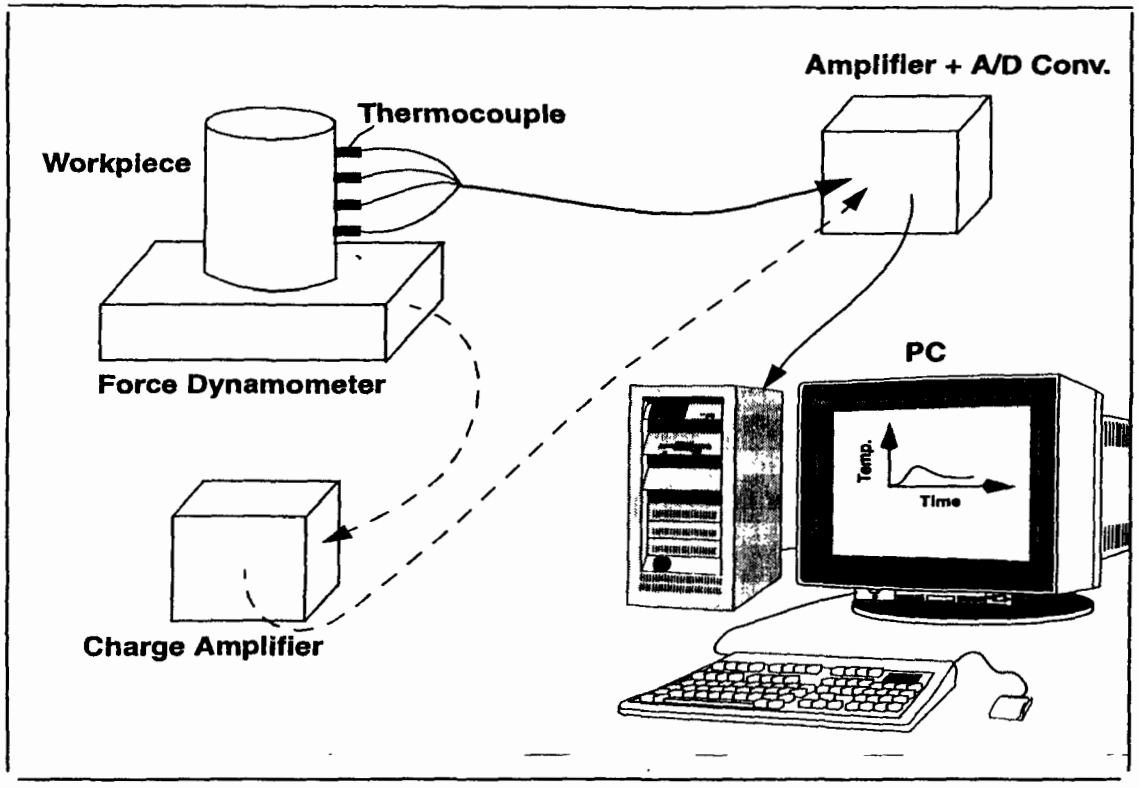
- Cylinder boring
- Mist formation
- Drilling
- Tapping
- Economic issues

Vision: Understand role of cutting fluids and eliminate them where possible

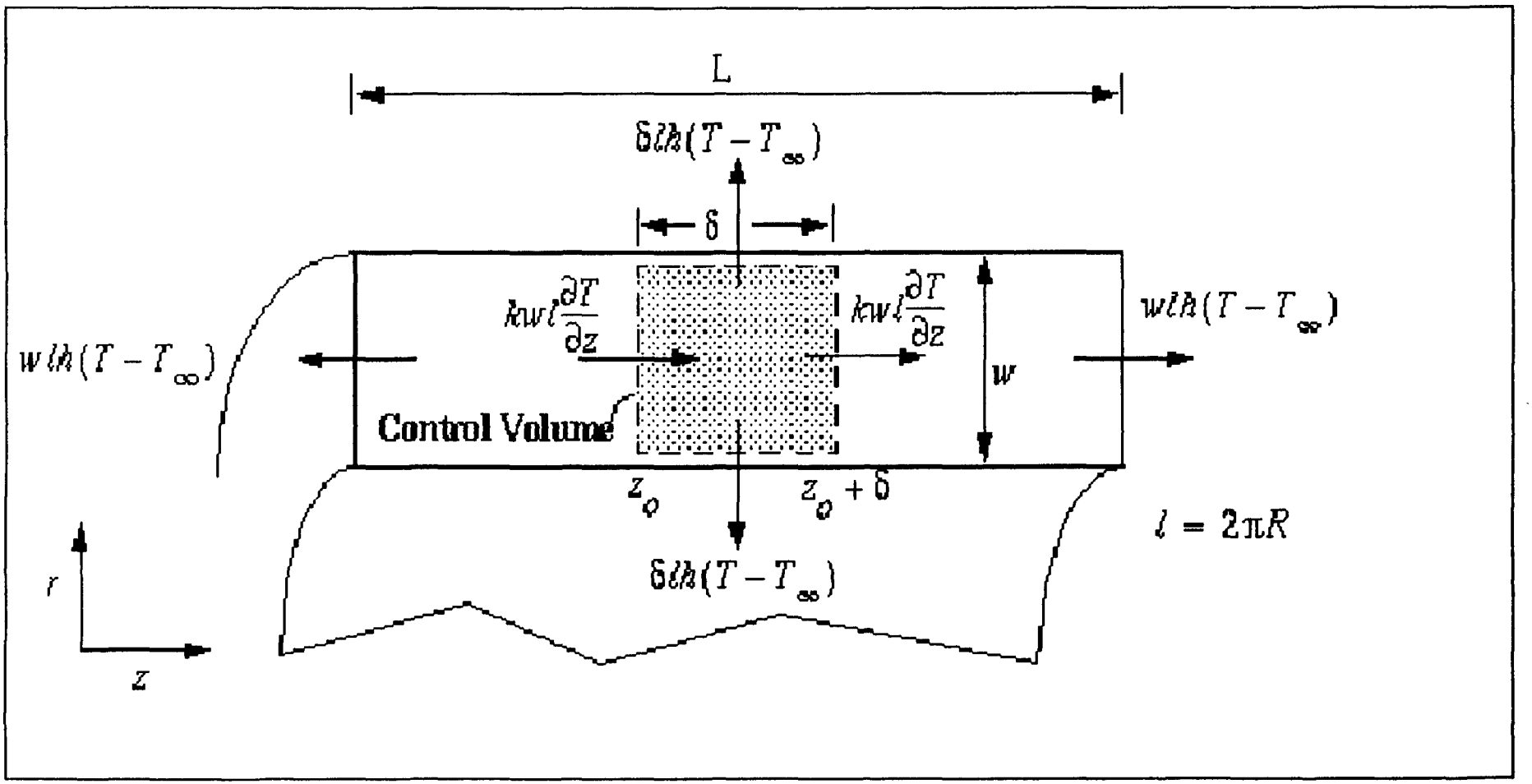
Cylinder Boring



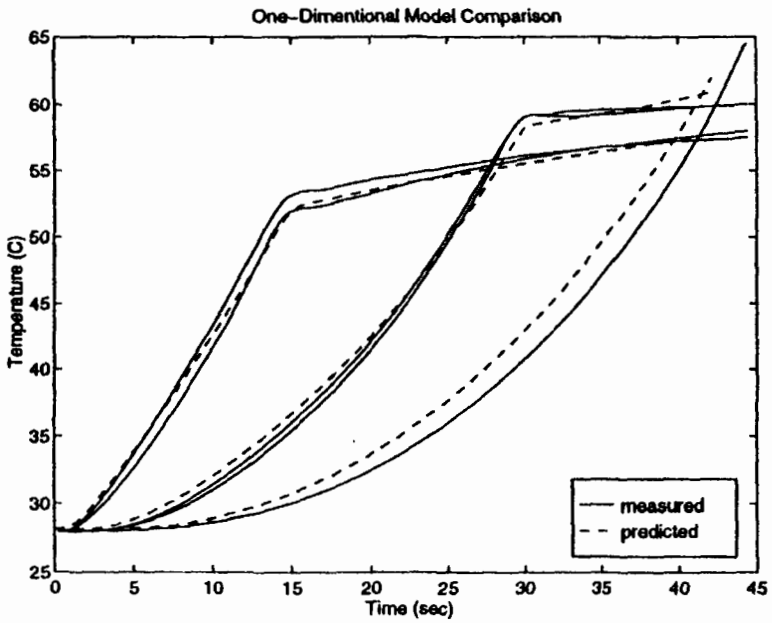
Role of Fluids on Heat Transfer Investigated Experimentally:



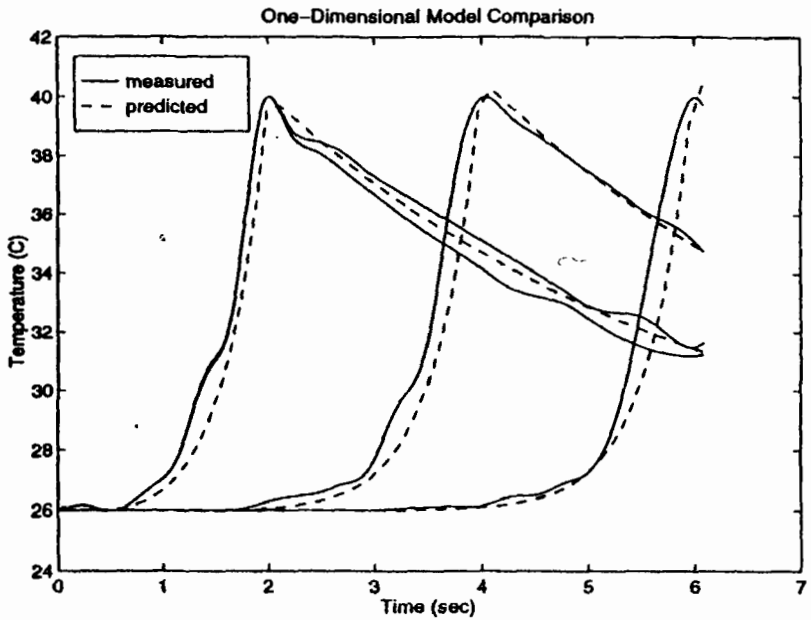
One-Dimensional Temperature Calculations



Temperature History



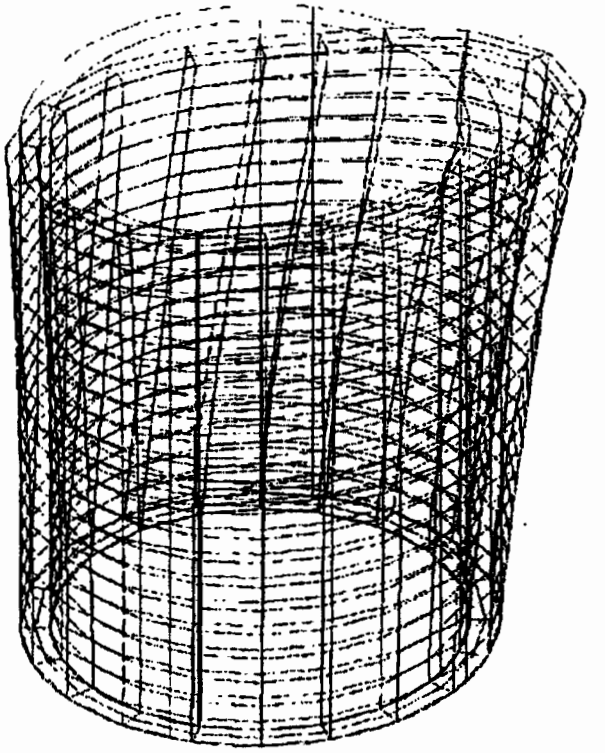
(a) Without Cutting Fluid

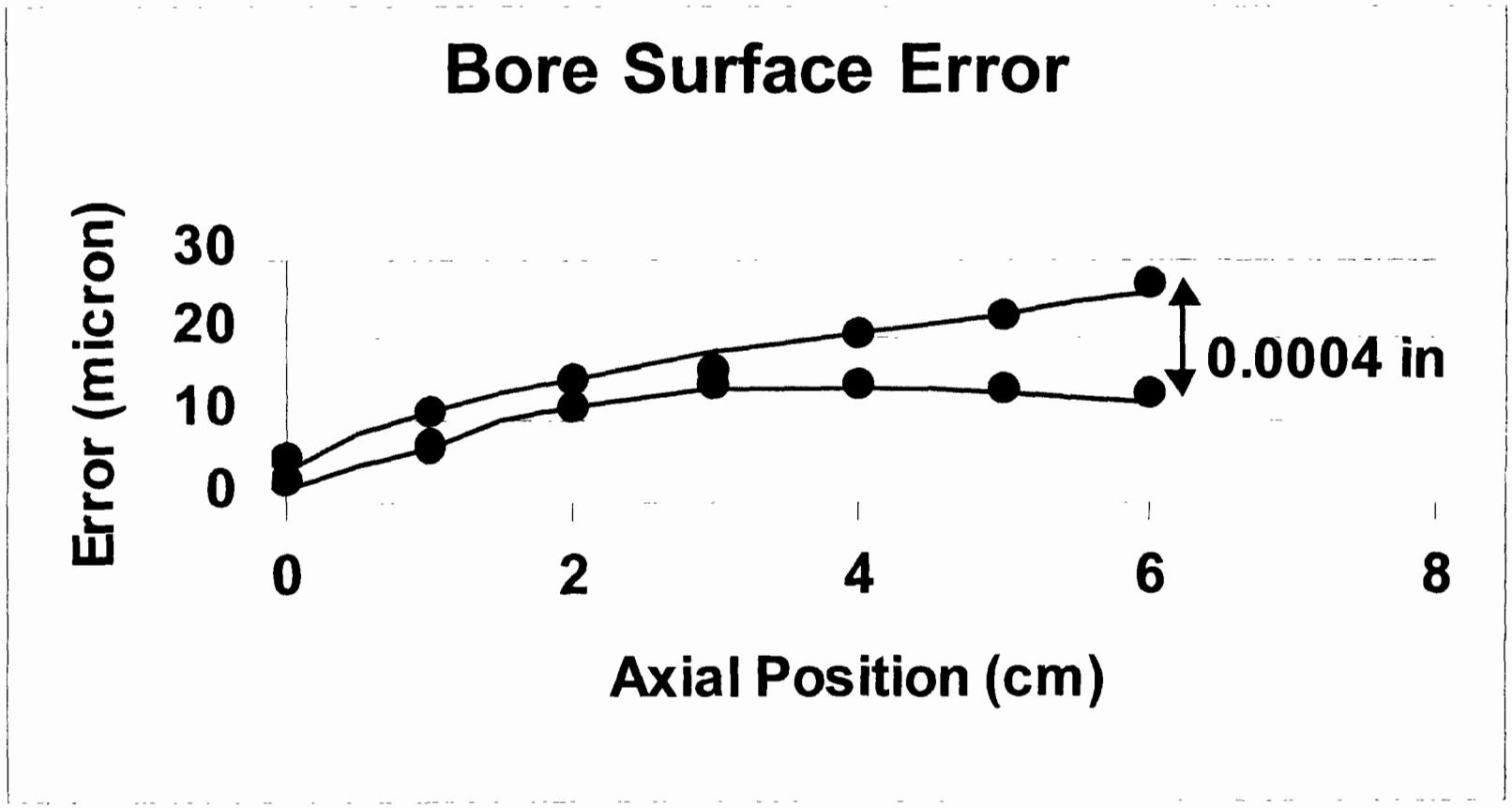


(b) With Cutting Fluid

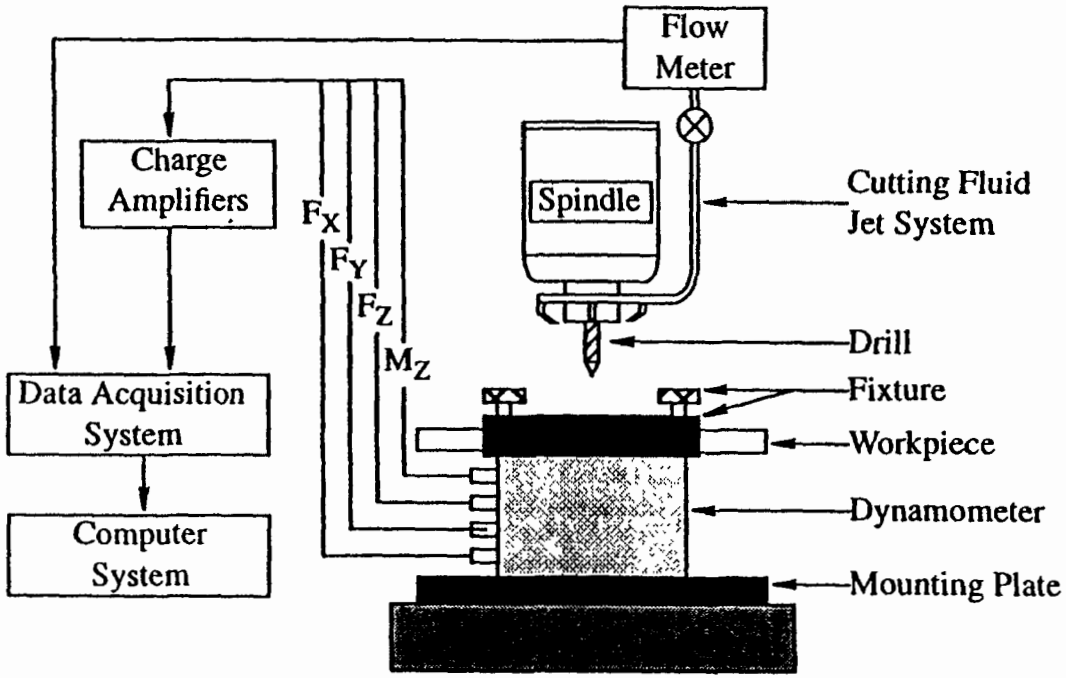
Dimension Error

- Boring of aluminum cylinders
- Radial, tangential and axial forces cause deformation
- Thermal deformation




Bore Surface Error
Error (micron)
30
20
10
0
0
2
4
6
8
Axial Position (cm)
0.0004 in

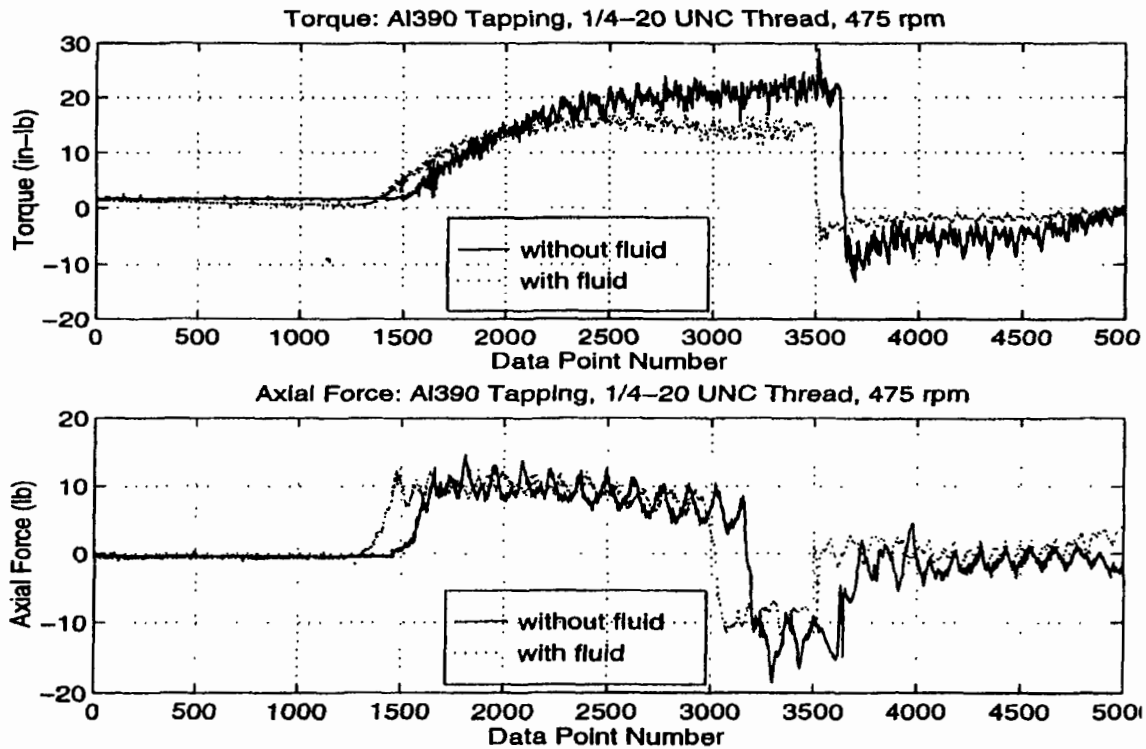
Experiments:Drilling



Experiments:Drilling

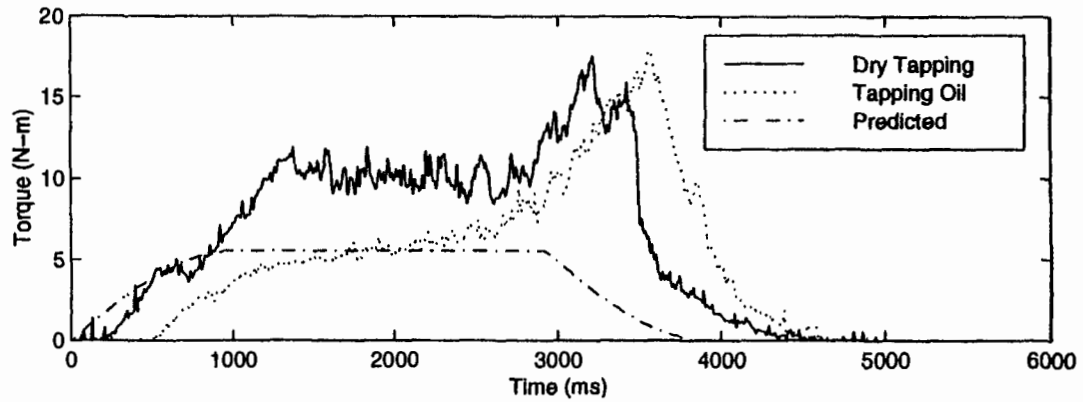
- Chip clogging in the absence of fluids
- Flow rates can be reduced by 2 orders of magnitude
- Tool coatings show promise as fluid replacement

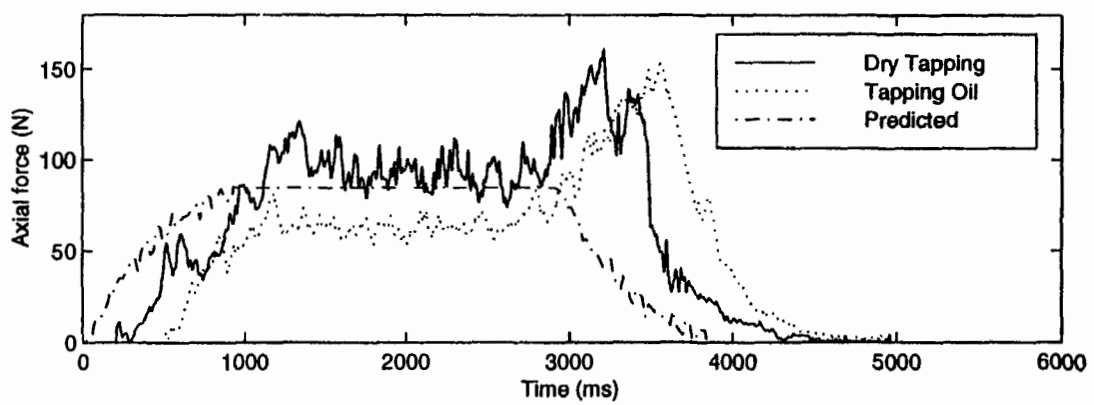
Experiments:Tapping



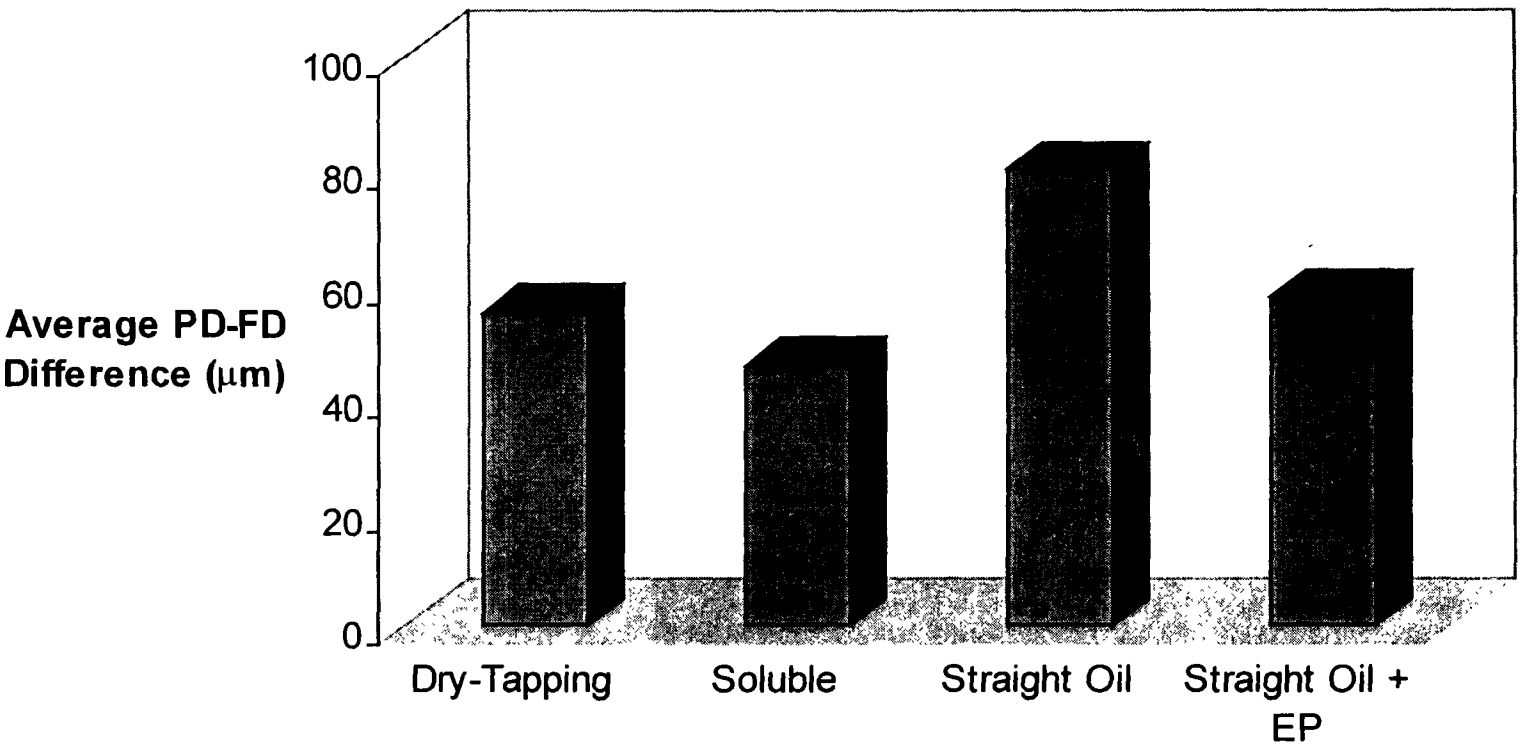
Dry and wet Tapping Experiments

Experiments:Tapping



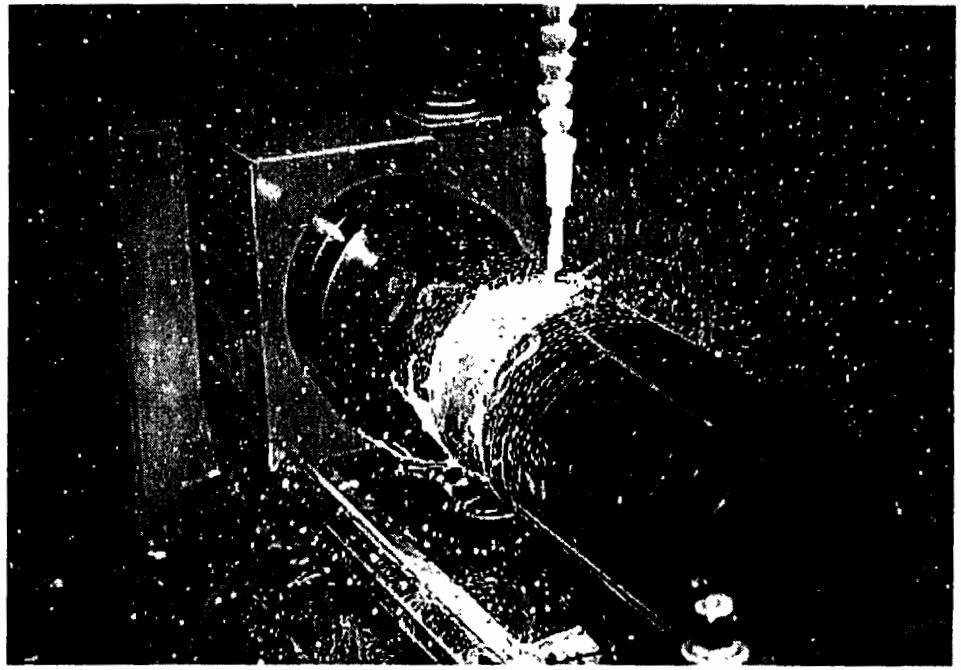


Experiments:Tapping

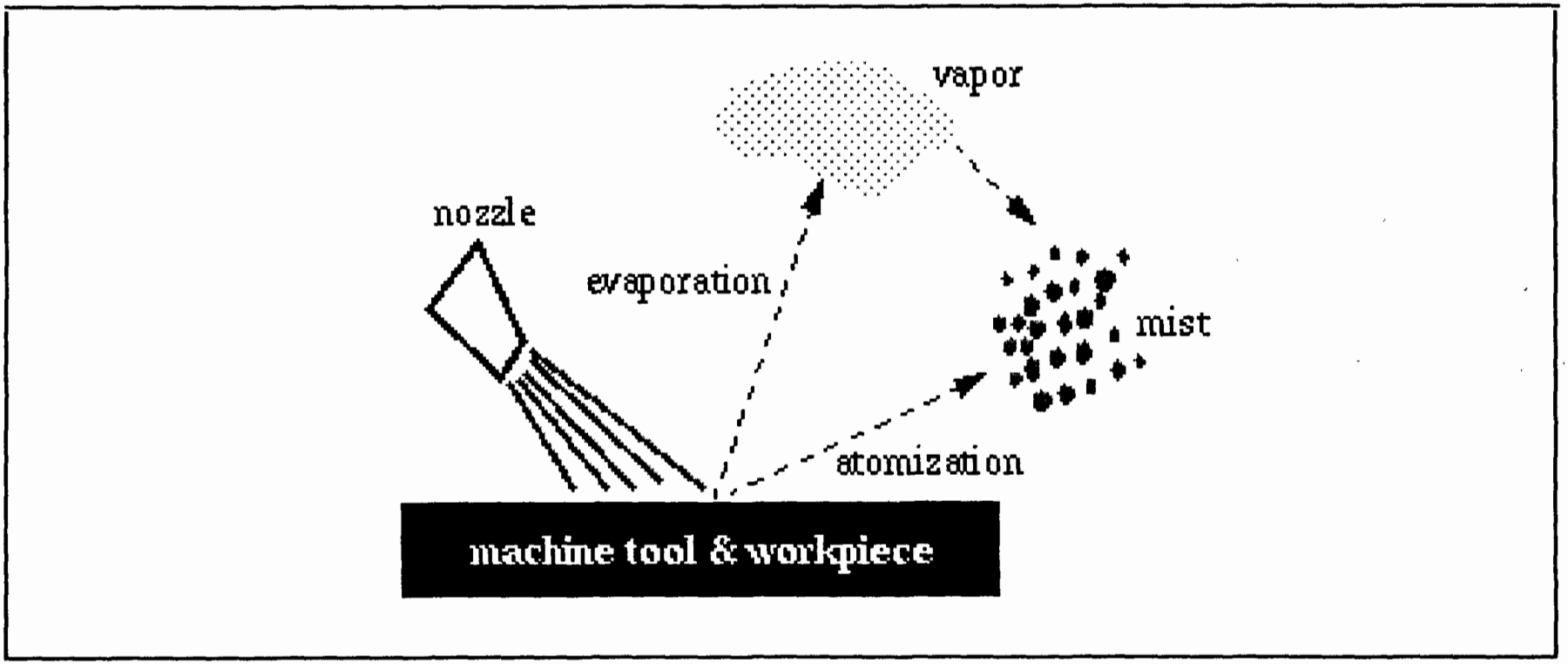


Mist in Machining

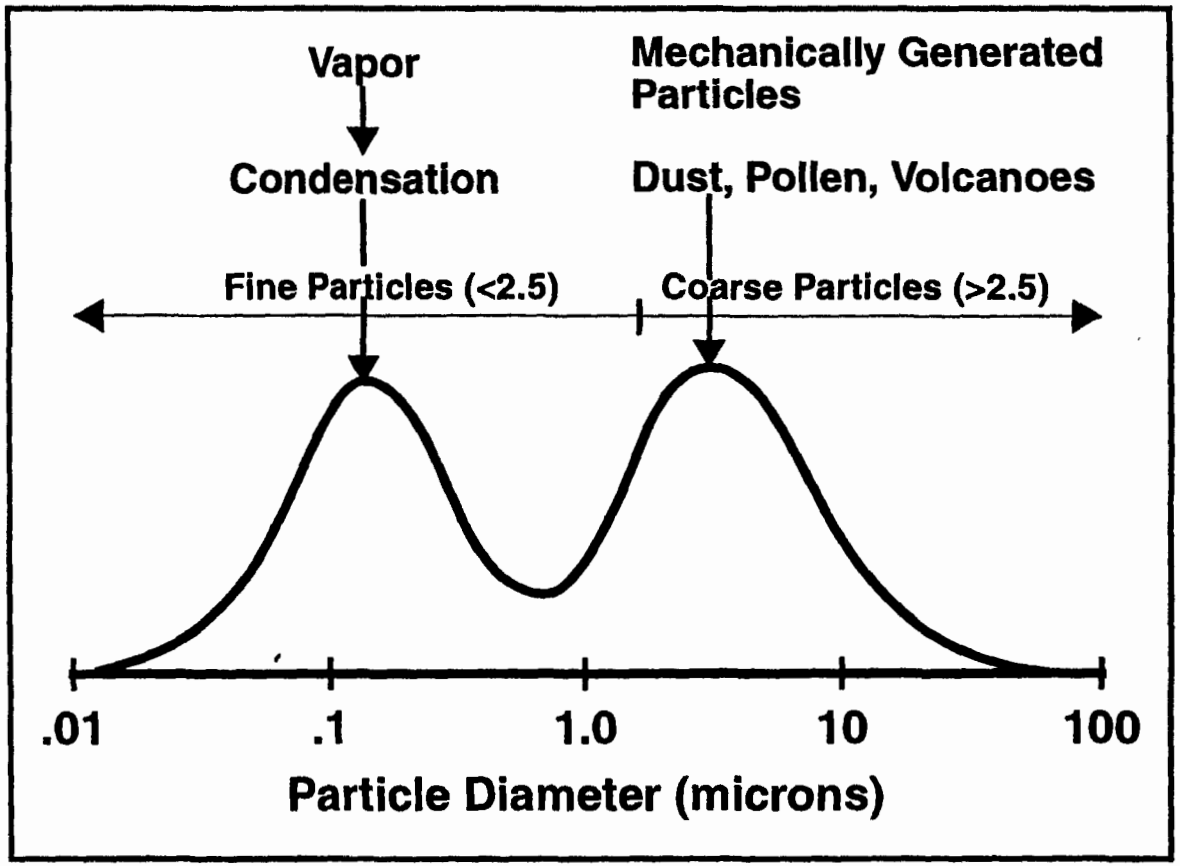
- Experiments with mist formation during turning



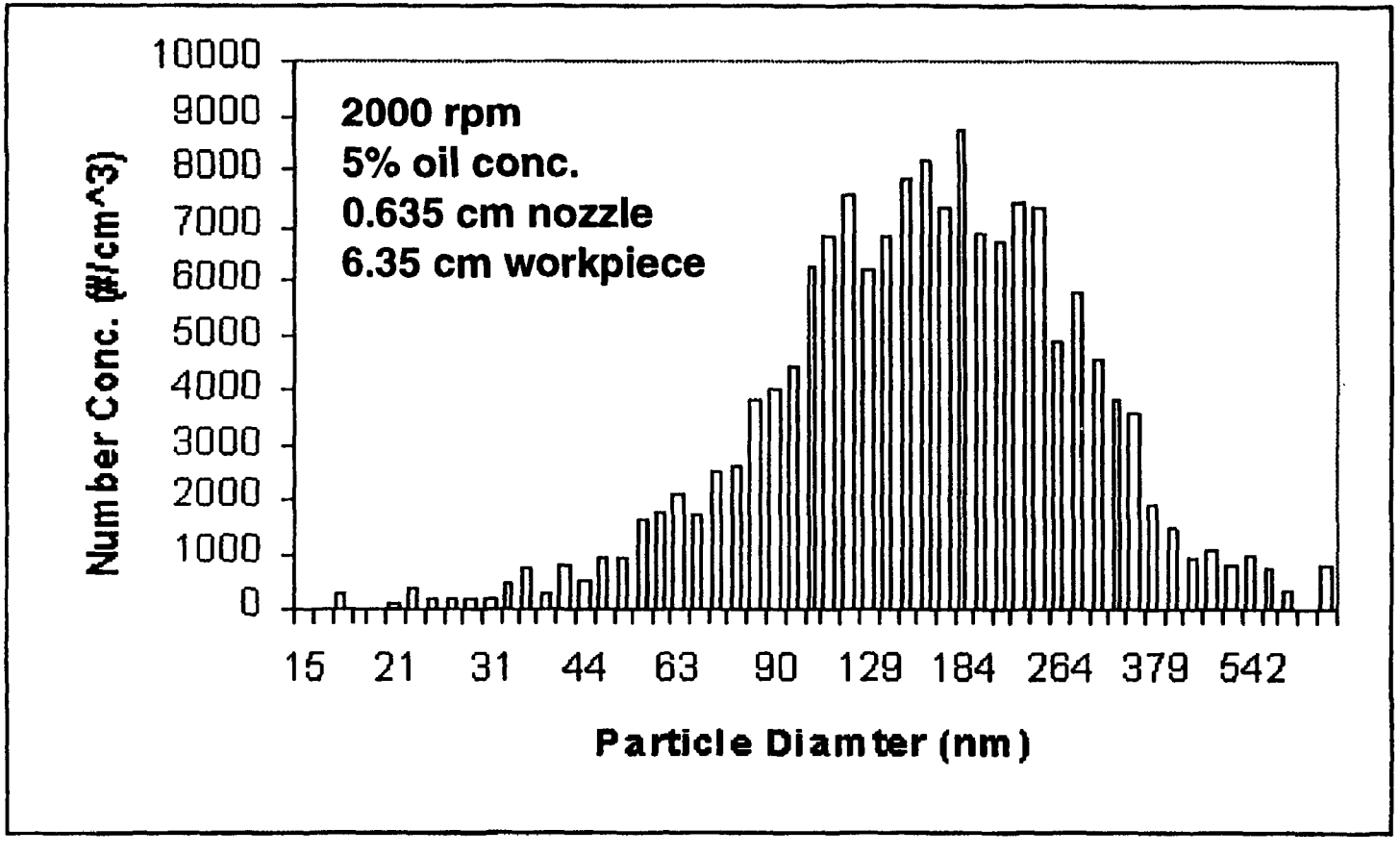
Mist Formation Mechanism



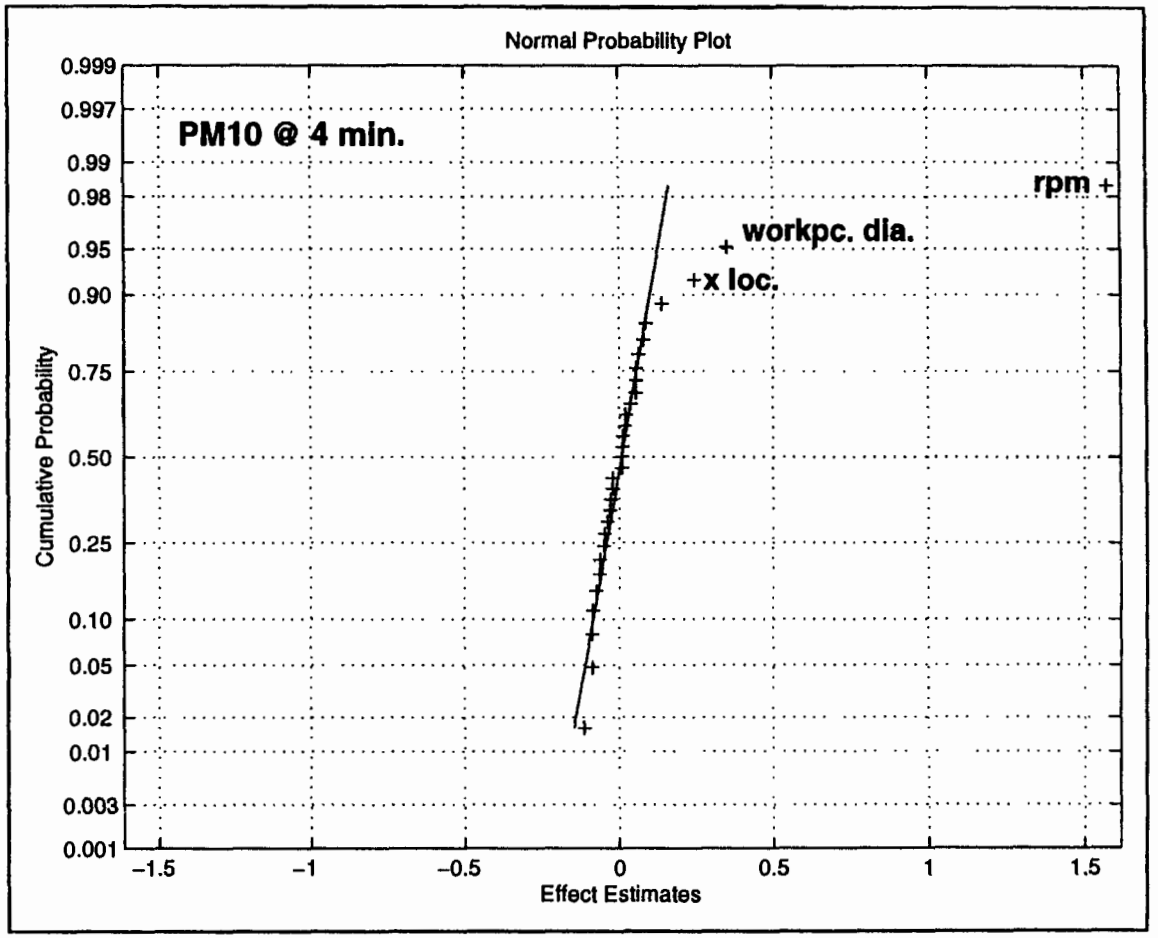
Hypothetical Bimodal Mist Distribution



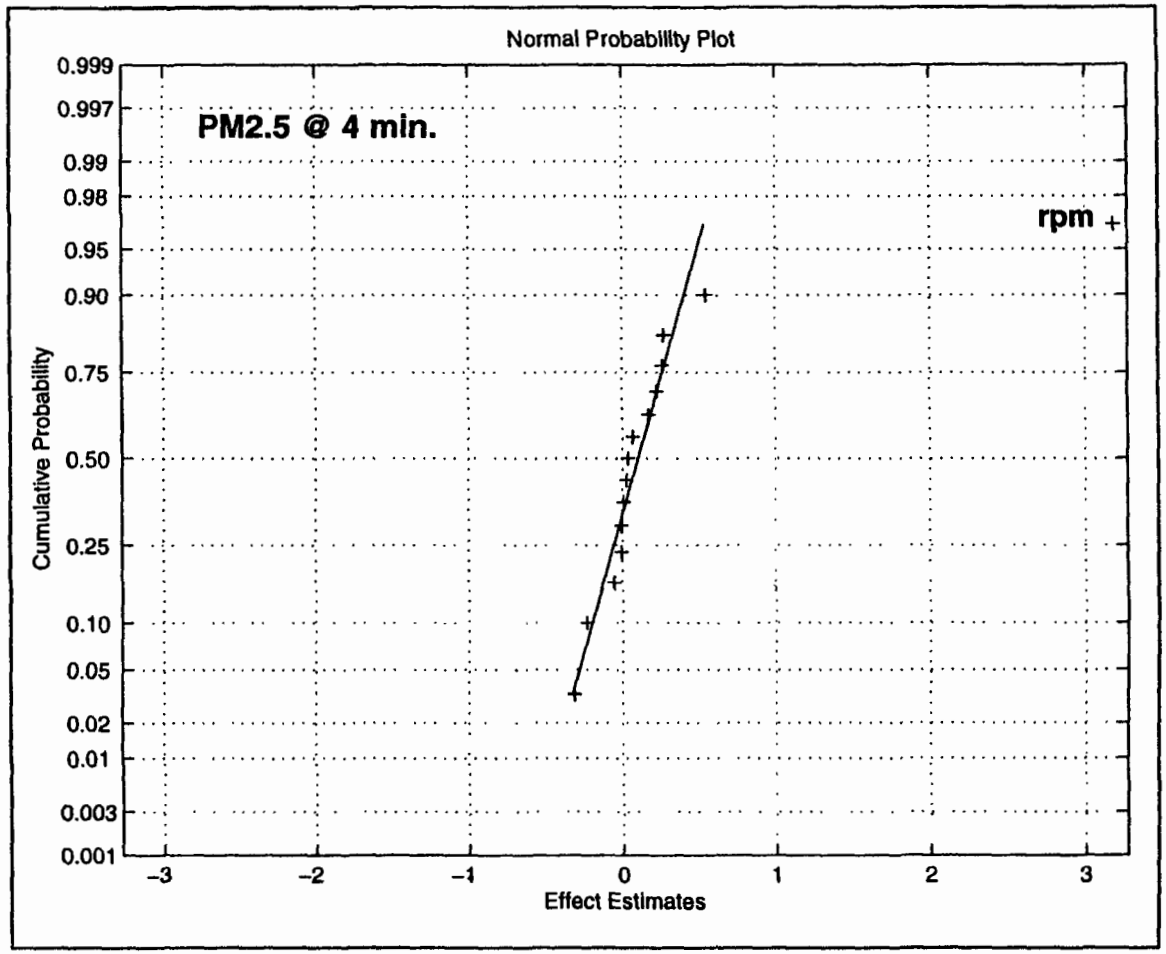
Drop Size Distribution for Submicron Particles



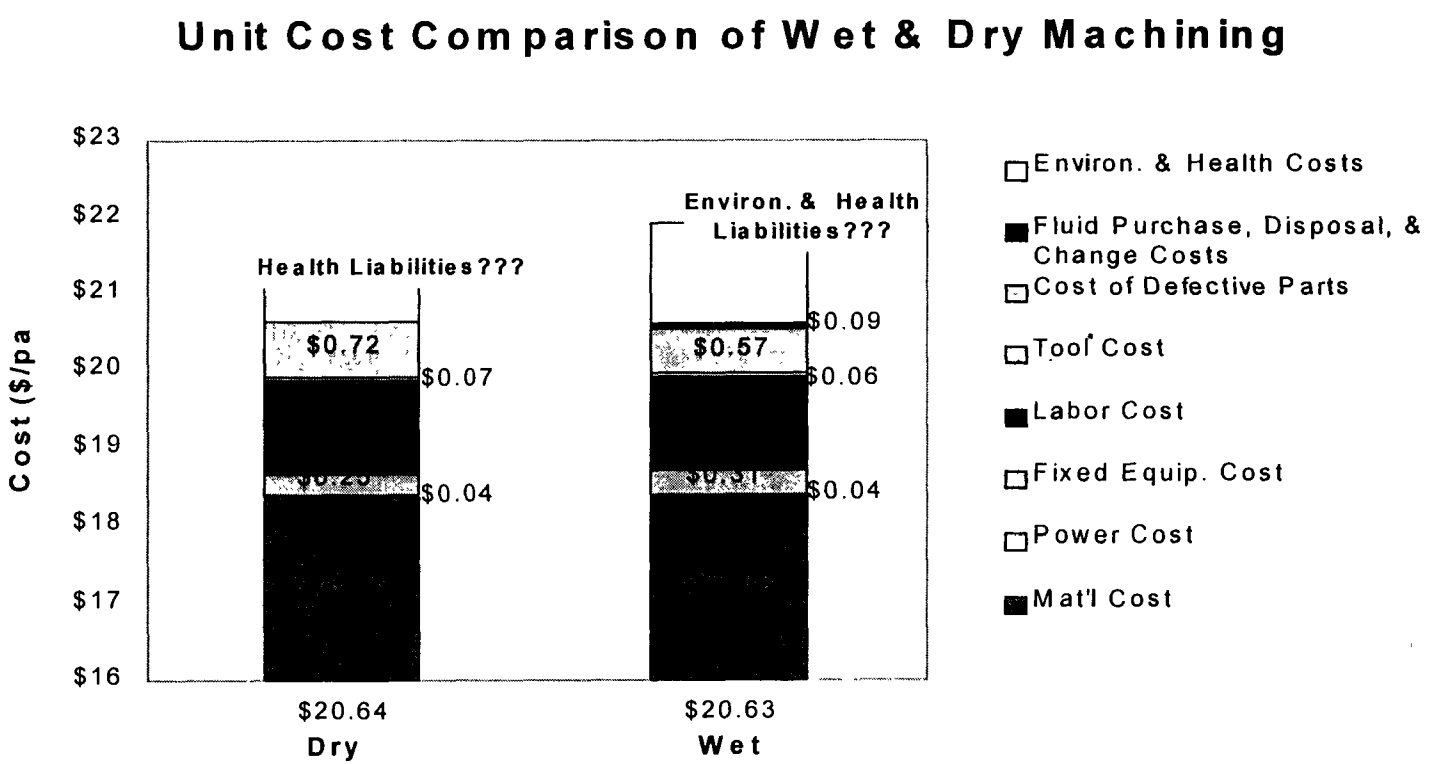
Significant Effects on PM10 Mass Concentration



Significant Effects on PM2.5 Mass Concentration



Economics


Unit Cost Comparison of Wet & Dry Machining
Cost ($/pa
$23
$22
$21
$20
$19
$18
$17
$16
Health Liabilities???
$0.72
$0.07
$0.04
Environ. & Health Liabilities???
$0.09
$0.57
$0.06
$0.04
$20.64
Dry
$20.63
Wet
Environ. & Health Costs
Fluid Purchase, Disposal, & Change Costs
Cost of Defective Parts
Tool Cost
Labor Cost
Fixed Equip. Cost
Power Cost
Mat'l Cost

Summary

- Dry machining represents a possible solution to cutting fluid problems

- Dry machining is not suitable for all situations

- In the absence of cutting fluids, such performance measures as tool life, dimensional accuracy and surface finish may be negatively impacted

Where do we go from here?

- We are learning more and more about cutting fluids
- Role of fluids is process dependent
- Dry machining - option for waste reduction

Keith Trychta

Argonne National Laboratory

"Waste Minimization and P2 at Argonne National Laboratory"

KEITH TRYCHTA

BIOGRAPHY

Keith Trychta is currently an employee of Argonne National Laboratory/University of Chicago as the Pollution Prevention Coordinator under Plant Facilities and Services-Waste Management Operations. Mr. Trychta has a B.A. from Benedictine University and a Masters of Project Management from Keller Graduate School of Management. Mr. Trychta has worked in the Solid Waste and Recycling field for over a decade. Prior to his tenure at Argonne National Laboratory (ANL), he worked for the DuPage County (Illinois) Solid Waste Department in the development and implementation of solid waste management programs and policies. While with Dupage County, Mr. Trychta was trained and certified by the Illinois Environmental Protection Agency as an Environmental Enforcement Officer.

Mr. Trychta is a Co-Chairman of the ANL-E Waste Minimization and Pollution Prevention Advisory Committee. His current position at ANL allows him to put his past experience to use, by developing and implementing waste minimization and pollution prevention initiatives and programs across all areas of the Laboratory.

ARGONNE NATIONAL LABORATORY-EAST

Waste Minimization and Pollution Prevention Program
at Argonne National Laboratory-East

Description of Work

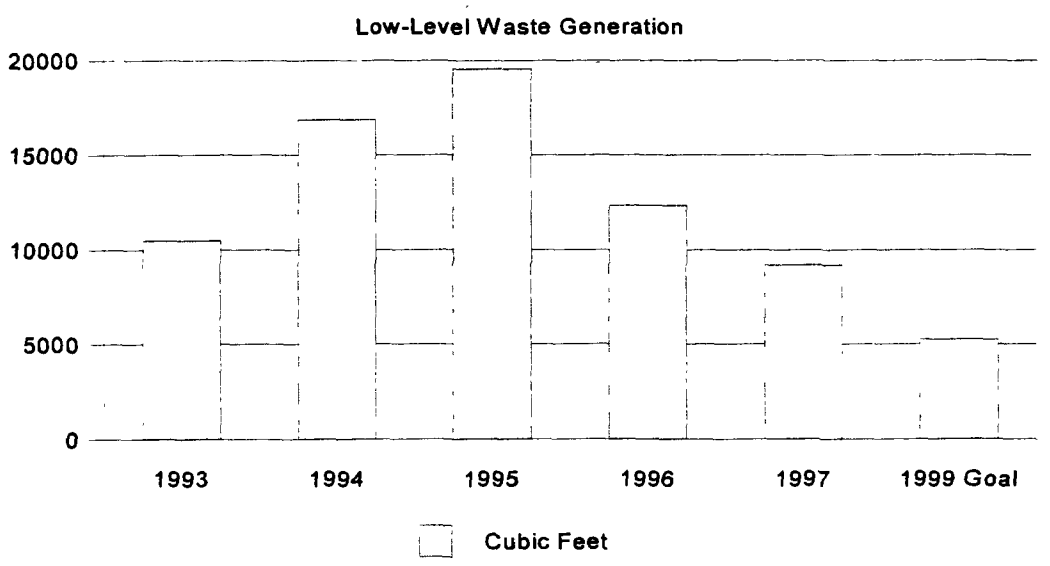
Argonne National Laboratory-East with more than 200 programs in basic and applied research is operated by the University of Chicago as part of the U.S. Department of Energy's national laboratory system. Located near Chicago, IL, Argonne employs more than 4,500 people. Argonne's mission is basic research and technology development to meet national goals in energy technology, environmental quality, scientific leadership, and educational infrastructure. Through the performance of these activities, Argonne generates radioactive waste, mixed waste, hazardous waste, State-regulated special waste, and sanitary waste on a routine and non-routine basis.

The closure of Argonne's sanitary landfill in 1992 triggered the start of a greater awareness of all the Laboratory's waste streams leading to the dynamic evolution of the Waste Minimization and Pollution Prevention (WM&P2) Program. The program's rapid growth during these years is attributed to the many pollution prevention projects initiated in the 1990s. Many of these activities were initiated through "grass roots" efforts of individuals and groups at Argonne. These efforts, coupled with the commitment of management, are what have contributed to the continuous growth and improvement of the ANL-E WM&P2 program, and the resulting cultural change across the Laboratory.

For example, in 1992 Argonne did not possess direct funding for the implementation of a formal WM&P2 program, an organized work group, a formal WM&P2 strategy, or a program plan. In 1997, Argonne has an established WM&P2 program, and a WM&P2 Advisory Committee with broad representation from across the Laboratory. The WM&P2 Program, and Advisory Committee, incorporates the use of a WM&P2 Strategic Plan, a 3-year Pollution Prevention Plan, and an annual WM&P2 Implementation Work Plan. This infrastructure and these documents are used to build upon ANL-E's past successes in the WM&P2 arena, and identify new initiatives that will eliminate, or reduce, potential waste or pollution in the future.

As Argonne's WM&P2 Program has evolved, so too has the recognition the program has received. Argonne has won several awards for pollution prevention initiatives within the last five years, such as the 1994 Governor's Pollution Prevention Award and a 1994 DOE Pollution Prevention Award for identifying and developing non-hazardous cleaning materials and procedures for metal surfaces within the Advanced Photon Source facility. In 1996, Argonne was named "STAR Partners" by the Illinois EPA. The STAR Partner Award gives special recognition to companies who participate in the Illinois EPA's voluntary Partners in Pollution Prevention and acts as mentors to further use the pollution prevention techniques in other companies. In 1997and 1998, Argonne was awarded the Illinois Governor's Pollution Prevention Certificate of Recognition in the category of continuous improvement. Argonne is especially proud of the it's regional reputation as leader in Pollution Prevention. This reputation is a result of Argonne's commitment to establishing, and maintaining, WM&P2 partnerships and outreach initiatives over the past several years.

As part of it's WM&P2 strategy, Argonne has placed focus and commitment on the 1999 DOE Pollution Prevention goals. During the past several years Argonne has may great strides to attaining all of these goals. It is Argonne's strategy to not only achieve these goals, but to surpass them, while evolving to the optimum goal of environmental enhancement and stewardship.

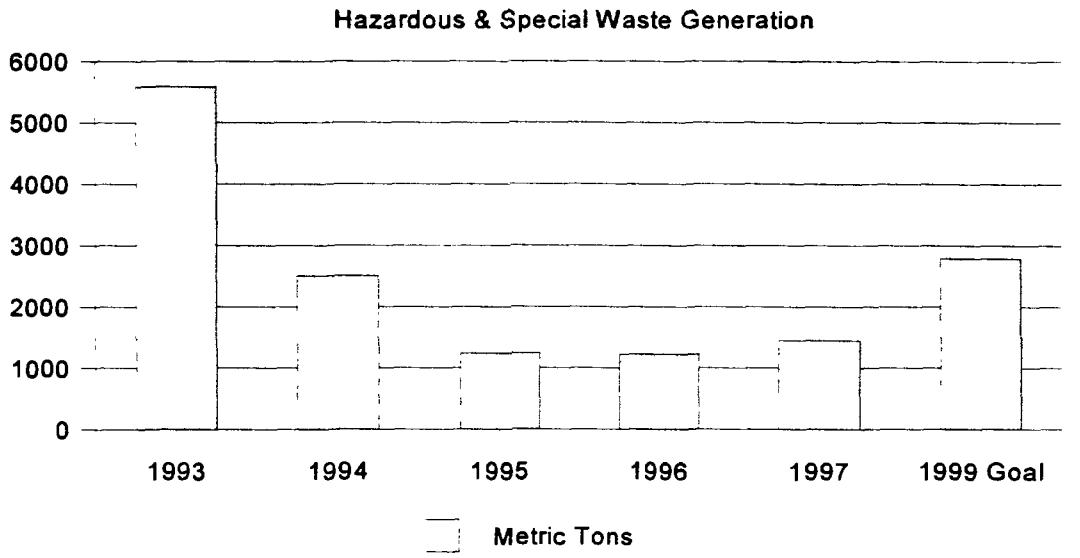


CY97 DOE Pollution Prevention Goal Status

Goal 1. Reduce by 50 % the generation of radioactive waste.

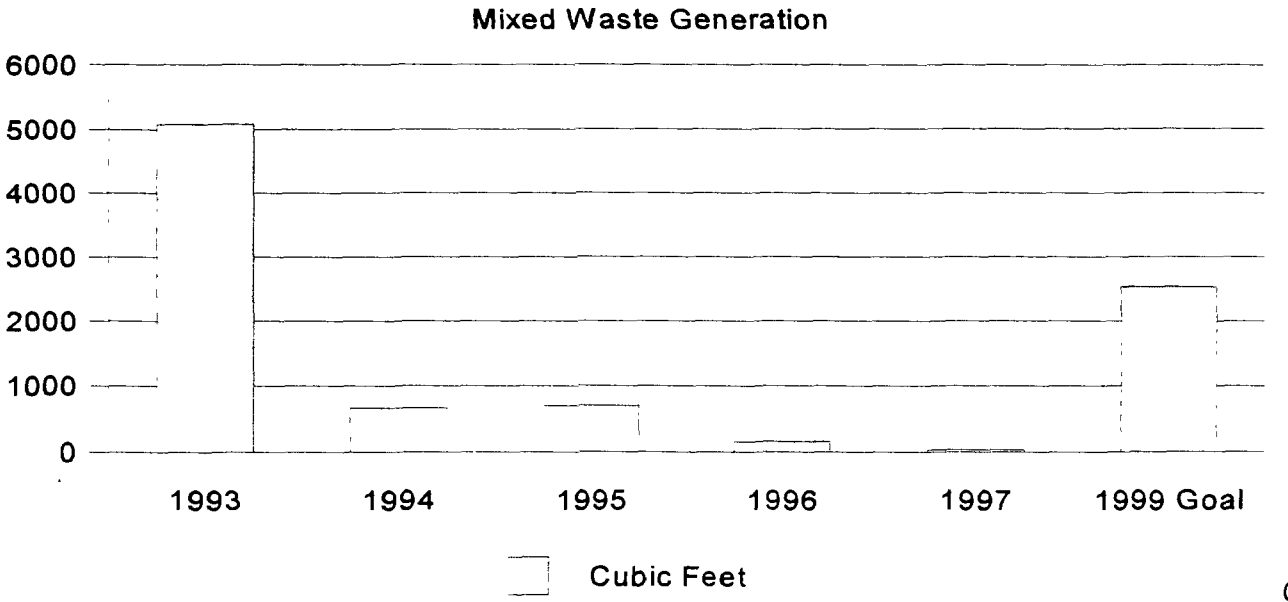
CY97 Low-Level Radioactive Waste generation has continued the downward trend, and is approaching levels established by the 1999 DOE Pollution Prevention Goals. Depletion of archived waste, in conjunction with the implementation of waste minimization and pollution prevention (WM&P2) activities, will result in a 50% reduction in radioactive waste by December 31, 1999.

Goal 2. Reduce by 50 % the generation of radioactive mixed waste.



CY97 Mixed Waste generation has continued the downward trend, and continues to maintain levels below the 1999 DOE Pollution Prevention Goals established from the 1993 baseline.

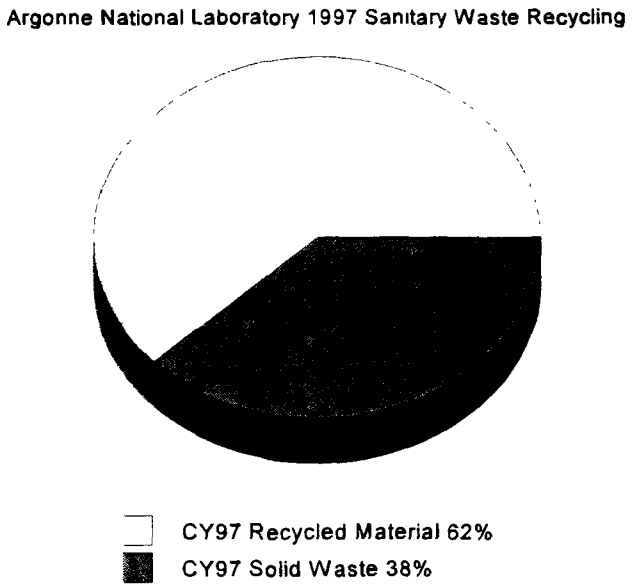
Goal 3. Reduce by 50 % the generation of hazardous waste.



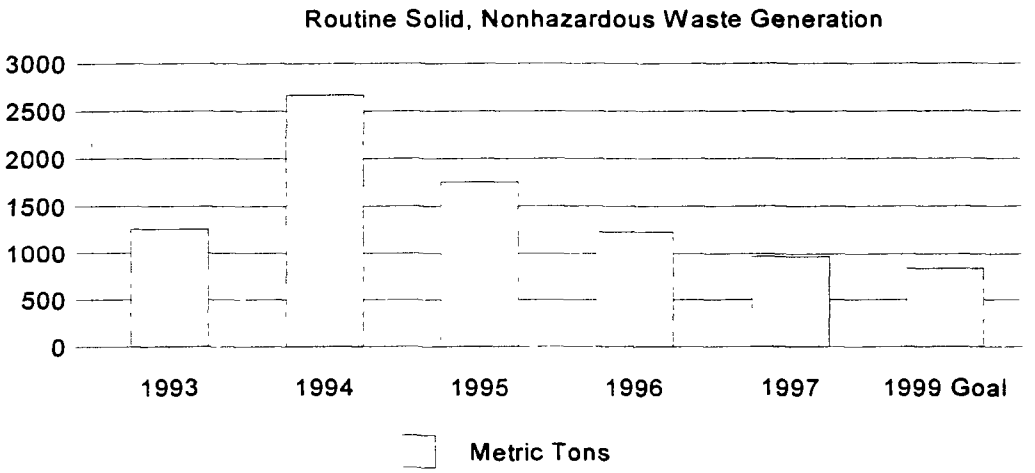
CY97 hazardous waste generation continues to maintain levels below the 1999 DOE Pollution Prevention Goals established from the 1993 baseline. The hazardous waste goal will be achieved by successfully identifying and implementing alternative uses for the State-regulated waste streams, i.e., sorbent, lime sludge, fly ash, coal fines, etc., and taking advantage of the Illinois Environmental Protection Agencies (IEPA's) new special waste regulations, which allow the Laboratory to certify some

State-regulated wastes as "non-special."

Goal 4. Reduce by 33 % the generation of sanitary waste.



During CY97, ANL-E continued the downward trend of reducing the amount of routine sanitary waste towards the 1999 DOE Pollution Prevention Goals established from the 1993 baseline . The Laboratory has developed and is implementing aggressive recycling programs that will be used to achieve this goal. Through the continuous improvement of recycling programs and improved data management, ANL-E will achieve this goal.



Goal 5. Reduce by 50% total releases and off-site transfers for treatment and disposal of toxic chemicals.

Since 1993, ANL-E has focused on eliminating all forms of toxic releases under this goal category.

From 1994 through 1996, ANL-E has maintained generation levels that are below the 1999 goal.

Goal 6. Recycle 33% of sanitary waste from all operations, including cleanup and stabilization activities.

During CY97, the Laboratory has generated over 35.8 million pounds of sanitary waste and materials from all operations (including clean up and stabilization activities). ANL-E was able to recycle (reuse) 22.1 million pounds of recycled materials from these same activities. This amounts to a 63% level of recycling of sanitary waste from all Laboratory operations.

Goal 7. Affirmative Procurement: Increase procurement of EPA-designated, recycled products to 100%, except where they are not commercially available competitively at a reasonable price or do not meet performance standards.

ANL-E is working to achieve this goal through a combination of an Affirmative Procurement Awareness Program, the development of an upgraded procurement tracking system (PARIS), and the development and execution of Laboratory-wide recycled product procurement procedures.

1997 ANL-E WM&P2 Activities and Accomplishments

The following section contains brief examples and descriptions of specific ANL-E WM&P2 activities and accomplishments for 1997. During FY1997, the ANL-E WM&P2 Program has estimated $800,000 in cost saving/avoidance, derived from WM&P2 activities. A complete list of all 1997 ANL-E WM&P2 activities and accomplishments is available upon request.

Low-Level Radioactive Waste - D&D Activities - 1997 Estimated Cost Savings/Avoidance = $91K

- Lead amounting to 207,230 pounds was free released from the Janus D&D Project (TD) and sent to the lead bank for recycling. The cost avoidance is estimated at $55,000.
- The CP-5 D&D Project (TD) recycled 700 pounds of non-radioactive cadmium. Cost avoidance is estimated at $3,000.
- Fifteen thousand (15,000) pounds of scrap metal were free released and shipped for recycling from the CP-5 D&D Project (TD). Cost avoidance and revenues are estimated at $3,500.
- During the planning of the Building 310 Retention Tank D&D Project (TD), a change in technical approach was taken that shortened the project duration by approximately five months. The new approach allowed for the excavation and recycling of tanks as whole units and resulted in a lower estimated project cost. While this is not a realized cost avoidance, it does demonstrate the cost savings that can be realized when WM&P2 efficiencies are applied.
- Fifty-five thousand (55,000) pounds of free-released lead and lead-bearing metals were recycled by TD within the CP-5 project. The recycled metals included large gamma shield assemblies, 21 plugs removed from the horizontal storage holes in E-wing, and many smaller steel and lead components. Cost avoidance is estimated at $27,500.

Radioactive Mixed Waste Activities - 1997 Estimated Cost Savings/Avoidance = $78K

- During the fourth quarter of CY97, EMO-WM decontaminated 6,807 pounds of radioactively-contaminated lead,

thereby diverting this material from the mixed waste category. EMO-WM employed the use of the CO_2 cleaning unit. The cost avoidance is estimated at $19,687.

- During the fourth quarter of CY97, EMO-WM released 19,025 pounds of steel encased lead, thereby diverting this material from the mixed waste category. The cost avoidance is estimated at $56,250.
- Through the use of microwave equipment used to prepare samples for mercury, metals, and radiochemical determinations, the Analytical Chemistry Laboratories reduced mixed waste generation by 15L. Cost avoidance is estimated at $2,000.

Hazardous and State Regulated Waste Activities - 1997 Estimated Cost Savings/Avoidance = $259K

- During CY97, hazardous waste labpacking efficiency increased by 43% through use of revised procedures and constant diligence. EMO-WM estimates generated a planned cost savings of over $10,000 during CY97.
- The ANL-E WM&P2 Program team (EMO) completed PPOA and implementation activities for the ANL Surplus Chemical Inventory and Exchange Pilot Program. This project was designed to investigate the transfer of surplus chemicals to users around Argonne and to remove chemicals from the hazardous waste stream. Cost avoidance derived from the pilot study are estimated to be approximately $5,000. This PPOA and Pilot study has resulted in the funding of a FY98 ROI Project to further develop the Chemical surplus program at ANL-E.
- Fifty-one (51) acetylene gas cylinders (48 from PFS-Site Services and 3 from WMO) shipped to Emergency Technical Services Corporation (ETSC), for recycling. Because the material will be recycled, it was shipped on a Bill of Lading and not a waste manifest. WM had previously made arrangements for a discounted cost of $100 per cylinder. Cost avoidance is estimated at $17,850.
- The disposal of 15 out-of-service criticality detectors was completed in the month of January. The detectors were disassembled, the check sources removed, and counting gases (boron trifluoride) absorbed into water. The majority of the detectors' components were able to be free released. Besides the check sources, only 15 small metal cylinders (now empty) were managed as low-level radioactive waste. An outside contractor gave a price quote of over $30,000 to complete this same work. This project resulted in cost avoidance of $28,655.
- During CY97 PFS-US generated 1,231 tons of coal fines from coal burning activities. PFS-US established a contract to sell the coal fines for recycling. The revenues generated from the sale of coal fines amounted to $31,700. The cost avoidance realized by avoiding the management and disposal of this special waste was $67,300. Total cost savings/avoidance $99,000.
- Seventy (70) large capacitors were drained of dielectric fluid. Analytical results of the drained oil determined the capacitors to be free of PCB's. The empty capacitors were recycled as metal scrap. Cost savings/avoidance estimated at $17,000.
- PFS-BM&C successfully performed the removal of CFC-11 (Class I ozone depletor) from two chillers located in Building 201 and replaced it with HCFC-123 (Class II ozone depletor). The completion of this activity resulted in a cost avoidance to the Laboratory of approximately $15,400, and greatly reduces the potential of ozone depleting substances to the environment.
- During soil sampling and groundwater sampling, "waste" soils and groundwater are produced. A policy was written, and eventually accepted in the ANL ESH manual which establishes protocol to discard Investigation Derived Waste (IDW) when sampling. EMO used this policy to justify discarding an estimated 150 drums of soil and groundwater IDW. The cost avoidance realized by avoiding the management and disposal of this material was $5,000.
- The ANL-E Vehicle Maintenance facility's anti-freeze reclamation and recycling initiative has resulted in the capturing and recycling of over 90% of the anti-freeze used in ANL-E vehicles. Costs savings/avoidance estimated at over $4,000.
- The ANL-E Vehicle Maintenance facility has established procedures to control the amount of vehicle refrigerant released into the atmosphere. Ninety-eight (98%) of all refrigerant was reclaimed from vehicle air conditioning systems this past year. This initiative has resulted in a cost avoidance, inventory reduction, and increased control of an ozone-depleting component.
- Argonne personnel have worked with Commonwealth Edison since January 1997 to establish a recycling outlet for the Laboratory's fly ash. The contract should be completed in January 1998. This agreement would reduce the Laboratory's fly ash disposal costs by 50%, and divert large volumes of material from the Laboratory's waste stream.

Sanitary Waste & Recycling Activities - 1997 Estimated Cost Savings/Avoidance = $266K

- During 1997, ANL-E diverted and recycled over 1.1 million pounds of mixed office paper or, over 35% of the routine sanitary waste stream. Cost savings/avoidance estimated at $50,000.
- During 1997, the ANL-E scrap metal recycling program, managed by OCF-PIM, recycled 254,920 pounds of scrap metal. Cost savings/ avoidance estimated at $60,000.
- During 1997, OCF-PIM implemented a pilot program that segregated 87,000 pounds of obsolete computer and

electronic equipment from the waste stream. Cost savings/avoidance estimated at $18,500.

- Argonne construction and demolition (C&D) projects recycled over 17 million pounds of material in 1997. The material recycled amounted to approximately 57% of the C&D waste stream. Diverting these materials from the waste stream, resulted in revenues and cost avoidance estimated at $120,000.

Research and Development Activities

- Argonne is helping government agencies find ways to remediate sites contaminated with hazardous materials. A pilot program has shown that feeding molasses to native bacteria in TNT-contaminated soil could be a simple and cost-effective alternative for cleanup project across the country.
- Argonne Researchers have found a way to make "green" paint and cleaning solvents marketable. New ethyl lactate-based solvents would take the place of trichloroethylene and methylene chloride solvents, which are known environmental contaminants. The technology would cuts the cost of producing lactic acid and ethyl lactate-based solvents in half.
- Argonne's Center for Transportation Research is involved with testing currently available alternative-fuel vehicles (AFV's); spurring the development of advanced vehicles powered by electricity, alternative fuels or a combination of the two; and developing cleaner-burning engines. Argonne maintains the largest demonstration center in the AMFA Program. Data collection focuses on vehicle driveability, reliability, fuel-efficiency, but other operational characteristics are also monitored, such as emissions and performance under varying weather conditions. Argonne has been able to partner with Northern Illinois Gas and other external partners to establish a Compressed Natural Gas fueling facilities at, and adjacent to, the Laboratory. Additional information relating to this project is located on the World Wide Web at http://www.es.anl.gov/htmls/afvinfo.html.
- Argonne researchers have developed an oxygen enrichment device that reduces particulate emissions almost 60 % while increasing power. This could be the link that can help diesel engines meet federal standards for particulate and smoke emissions set by the Clean Air Act. Argonne's work to improve diesel engine efficiency and emissions spans the range from the smallest diesel engines to locomotives. Argonne researchers work with such companies as Mercury Marine, Chrysler Corp., Ford Motor Co., and General Motors Co., as well as railroad associations and transit authorities.

Awareness, Outreach, Partnering and Technology Exchange - 1997 Estimated Cost Savings/Avoidance = $103K

- During 1997, the ANL-E WM&P2 Program funded four Micro-Chemistry Workshops. The Workshops were attended by over 120 High School Chemistry Teachers from the Chicagoland area. The purpose of the workshops was to teach the chemistry teachers how to employ micro-chemistry techniques into their curriculum, thereby minimizing the amounts of waste generated in High School chemistry experiments and to promote the principals of waste minimization to their students.
- Argonne participated in an ongoing Hazardous Waste Benchmarking Exercise with Abbott Laboratories located in North Chicago, IL. The WM&P2 benchmarking exercise focuses on each facility's hazardous waste stream and is designed to identify "Best-in-Class" WM&P2 policies, strategies, and methods in the area of hazardous waste management.
- Argonne worked with the DuPage County to implement the DuPage County Solid Waste Department Waste Survey and Education Program waste audit. The program established a partnership between DuPage County and Argonne, and provided the Laboratory with two free waste generation assessments. The data generated from the waste assessments was used to develop the *Illinois Construction and Demolition Recycling Guidebook* which was partially funded by the USEPA.
- Argonne organized, "America Recycles Day" activities in November. The theme of the National campaign is "Keep Recycling Working: Buy Recycled". There were exhibits by Illinois Recycling Services, BT Office Products, and the WM&P2 Advisory Committee. Argonne organized Earth Day activities in April. Participants included the DuPage County Forest Preserves, Resource Management Inc., Laidlaw Environmental Services and Commonwealth Edison..
- Representatives from Argonne attended the DOE Pollution Prevention Conference XIII in August. The representatives presented an exhibit and two poster sessions.
- During 1997, ANL-E participated in the 6th season of the Commonwealth Edison Energy Cooperative. Under this program ANL-E voluntarily reduced electrical demand during specific time periods. ANL-E was able to reduce power consumption by 2,900 kW. This waste (energy) minimizing initiative earned the Laboratory $102,700 from Commonwealth Edison.
- Argonne and DOE-HQ conducted a training seminar at ANL-E titled "Pollution Prevention on the Internet". The seminar helped attendees to better use the Internet to locate Pollution Prevention related information. Attendees included ANL-E, DOE, IEPA, the Illinois Waste Management Research Center, Abbott Laboratories, Commonwealth Edison, etc.

- Argonne and DOE volunteers participated in the Second Annual Argonne Cleanup walk on June 6th. The cleanup walk, sponsored by the WM&P2 Advisory Committee and the Argonne Club, with the DuPage County Forest Preserves.
- An Affordable Energy Home Center showcasing the benefits of energy-efficient housing recently opened its doors in Chicago's West Garfield Park. The center will offer public workshops on incorporating energy-efficient techniques into homes under construction. The center is sponsored by Argonne, Bethel New Life, the Chicago Department of Housing, ComEd, and DOE.
- Argonne ecologists are working on a project to preserve and restore on-site native habitat types, such as woodlands, wetlands and prairies and savannas, to protect native species and enhance the beauty of the ANL-E site. The re-establishment of native habitats at ANL-E is included in DOE and Argonne land management policies, which propose to manage land and facilities as valuable national resources.
- Argonne continued to perform developmental work on the ANL-E Waste Minimization and Pollution Prevention (WM&P2) Homepage. The WM&P2 Homepage is intended to be linked into the existing ANL-E Homepage in FY98.
- During 1997, PFS-Vehicle Maintenance completed a WM&P2 manual that describes the WM&P2 activities employed within the Argonne Vehicle Maintenance Facility. The manual has been electronically posted on the DOE EPIC site and is used as a tool to share WM&P2 information with internal and external partners.

WM&P2 ROI Projects (1997)

- The ANL-E WM&P2 Program funded an ROI Project titled: Cyclotron Case Study on Opportunities to Recycle Carbon Steel. The project was managed by TD, and focused on the recycling of carbon steel from the dismantlement of 60-in cyclotron. A PPOA was incorporated into the project. The project generated recommendations and identified risks and benefits to implementing WM&P2 initiatives.
- The ANL-E WM&P2 Program funded an ROI Project titled: WM through the use of alternative, less-hazardous solvents for radiochemical analyses. This project managed by (ACL/CMT) was able to identify alternative analytical procedures that reduce the amount of mixed waste generated. If implemented, procedures derived from this project can generate substantial cost avoidance at ANL-E and the DOE complex.
- The ANL-E WM&P2 Program funded an ROI Project titled: P2 in the Analytical Laboratory Using Solid-Phase Extraction Methods. The project was managed by ER, and focused in minimizing primary and secondary waste generated from chemical laboratory operations. The project was successful in developing new analytical methods that can be employed to reduce the large volume of laboratory hazardous waste currently generated across the DOE complex.
- In the fall of 1997, the ANL-E WM&P2 Program funded an ROI Project titled: Building 115 Shaker House Modification. This project will result in the more efficient management of coal, thereby reducing the amount of coal fines generated from the excessive movement of coal prior to burning.

David Ullrich

U.S. EPA Region 5

Mark Waldrop

BASF Corporation

" A Process to Vacuum Vapor Degrease Metal Parts with N-Methal Pyrrolidone"

Mark Waldrop

I am a Market Development Specialist for BASF Corporation's Chemicals Division (3000 Continental Drive North, Mt. Olive, NJ 07828). I joined BASF in 1990 as an engineer in the Professional Development program, holding positions in manufacturing, engineering, and technical service. From 1993 to present, I have worked in technical service for chemical intermediates, especially NMP. I hold three U.S. patents, including one on cleaning polymer residues with NMP. I have a B.S. in Chemical Engineering from Wayne State University in Detroit.

Title of Paper: A Process to Vacuum Vapor Degrease Metal Parts with N-Methyl Pyrrolidone

Abstract

N-Methyl Pyrrolidone (NMP), used in a heated immersion cleaning process, is a good alternative to traditional vapor degreasing solvents for most industrial degreasing applications. However, two key physical properties of NMP—its low vapor pressure and its flash point (196°F)—may make it inefficient or less effective in certain cleaning jobs: the removal of high melt waxes and greases; cleaning parts with deep blind holes or crevices; cleaning highly porous materials; and cleaning parts that require completely dry surfaces (i.e., not even trace amounts of solvent) immediately after being cleaned. This paper describes how NMP was used in a vacuum vapor, or "airless", degreasing process to overcome these physical property-based deficiencies. The vacuum vapor degreasing process offers the added benefits of almost no solvent emissions to the air and easy recycling of the solvent.

Introduction

The high solvent activity (Kauri Butanol Value 300) associated with the solvent N-Methyl Pyrrolidone (NMP), especially at elevated temperatures, is reflected in the ability of NMP, or NMP/solvent blends, to solvate many different types of soils and greases/oils.

A basic process to accomplish metal cleaning with NMP involves three steps.

a.) A cleaning cycle: This step involves immersing the parts into a heated bath of NMP

b.) A rinsing cycle: As with all immersion cleaning processes, the cleaning solvent/soil residue must be rinsed off of the part. This is accomplished with either a heated spray or an immersion cycle. The rinse solvent can be water, NMP or any other oxygenated solvent.

c.) And finally a drying cycle: Removal of the NMP from the surface of the parts is carried out most efficiently with a hot forced air current.

The basic immersion cleaning process described above is an adequate replacement method for most industrial degreasing applications where vapor degreasing cleaning processes have been used in the past.

There are, however, some cleaning jobs that will not be accomplished effectively or efficiently with an NMP immersion process. Some of the application areas where NMP immersion processes may be deficient, are:

1.) <u>The removal of high melt waxes or greases:</u>
Vapor degreasing processes based upon solvents boiled at temperatures close to, or above the flash point temperature for NMP (91°C/196°F).

2.) <u>Complex parts with many deep blind holes or crevices:</u>
Although tumbling of the parts during the drying process is a potential cure for this deficiency, there is no guarantee that all the solvent will be removed. Also, some parts do not lend themselves to be physically tumbled during the cleaning process.

3.) <u>Cleaning of porous materials:</u>
Again, it may be hard for the NMP to adequately penetrate into a porous substrate, to remove a soil, at the recommended operating temperatures for an NMP based immersion process. Total removal of rinse solvent, also, may not be guaranteed.

4.) <u>Applications where totally dry surfaces with no residual oils or cleaning solvent can be present (even in trace amounts):</u>
NMP is a pure solvent which will evaporate from the surface of a substrate leaving no residue behind. Water rinses, or alcohol rinses, such as are used in NMP based integrated circuit wafer cleaning processes, are added insurance that there is no residue. However, what if the part cannot have contact with water, or due to the size of the part (very large) a cleaning process using an alcohol rinse is not an economically viable option.

These four areas of cleaning, where efficient NMP immersion cleaning processes may be uneconomical or impractical are all due to two basic physical properties of the solvent, which cannot be changed.

a.) flash point and
b.) vapor pressure at atmospheric pressure

However, by introducing inerting agents into the atmosphere above the NMP, as well as by changing certain conditions in the process, to allow for increasing the vapor pressure of NMP, these two physical property based deficiencies of NMP cleaning processes can be overcome.

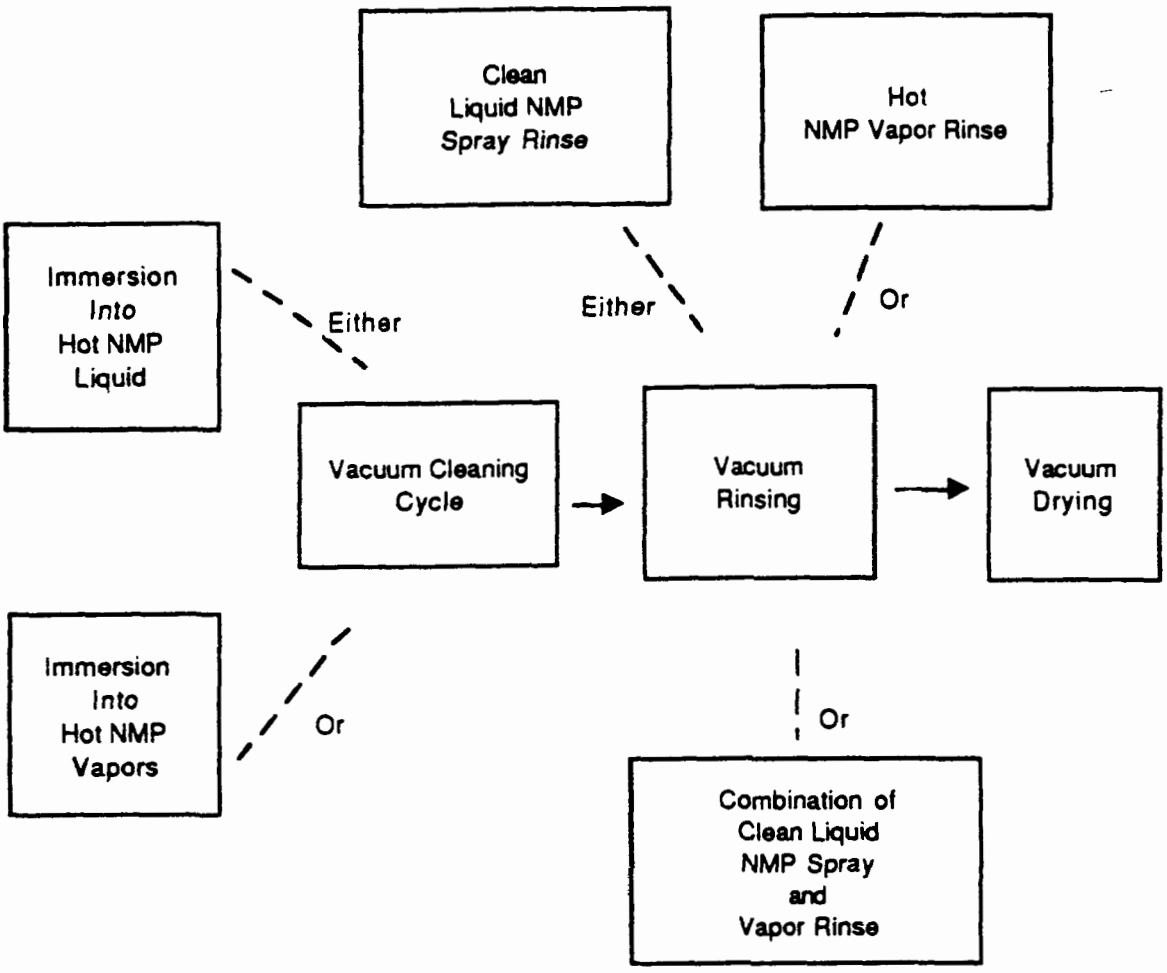
The work described in this paper was carried out in order that some guidelines might be established for such a process that overcomes both the flash point deficiency and the vapor pressure deficiency, and leads to an efficient NMP based cleaning process for these specialty cleaning problems.

DISCUSSION

A degreasing process, that will overcome both the flash point (Cleaning of High melt waxes) and vapor pressure (100% guarantee of total dryness) deficiencies, is an inherted atmosphere vacuum cleaning system. In an inhert atmosphere the NMP can be safely heated to the high temperatures required to melt waxes/greases. Also, pulling a vacuum on the system, after a cleaned part has been rinsed, will insure 100% removal of the NMP during the drying process.

Such a process (Figure 1) could be configured in many different ways so the maximum efficiency of NMP's solvating capacity, could be taken advantage of. (See Figure 1)

FIGURE 1: NMP VACUUM VAPOR CLEANING PROCESS



The cleaning step can be accomplished by either immersing the parts into hot liquid NMP or by allowing the parts to "hang" in heated air that is totally saturated with NMP.

The rinsing of the cleaned parts is accomplished by one of three different processes. a.) Hot clean NMP is sprayed over the parts, or b.) NMP vapors condense onto the parts rinsing the part clean of NMP/oil residue from the cleaning step or c.) a combination of both rinsing actions.

The common link, between the rinsing and cleaning steps, and the drying step, is that the total cycle is carried out under a vacuum with a positive bleed of an inhert gas being applied to the air space of the system.

An additional feature of such a system, that should be mentioned is the extremely low potential for emissions of organic solvents, into the environment, during the cleaning process. An NMP based immersion process system,

operated at the recommended cleaning temperature, will normally have low emissions of solvent to the air. However, when the system air is totally enclosed and then pulled through a cold trap or over a cooling coil, before exiting into the outside atmosphere, the organic solvent emissions are very low to almost non-existent.

EXPERIMENTAL

Three different sets of experiments were carried out during the data gathering phase of this vacuum cleaning work.

PHASE 1: Definition of vacuum drying parameters required for NMP removal

PHASE 2: Definition of base cleaning parameters

PHASE 3: Actual cleaning tests

Although there are several companies that manufacture equipment for vacuum vapor cleaning, there had been very little work done with NMP as the cleaning/rinsing solvent. So, before doing some actual cleaning of parts with this type of process, it was necessary to establish some process parameters (dwell time, vacuum, temperature).

PHASE 1: Definition of Vacuum Drying Parameters Required for NMP Removal

a.) To insure that the substrate surface was fully covered with NMP (and oil for the cleaning tests) a piece of sintered metal was used as the control substrate. The control part was

A Sintered Metal Disc
Weight: 16.1008 g
Diameter: 38.17mm
Thickness: 2.87 mm

b.) Drying tests were carried out using a vacuum oven as the drying instrument

PROCEDURE

i.) The control part was immersed into liquid NMP, at a set temperature, for 10 minutes time

ii.) The part was removed from the NMP and then placed into the vacuum oven (preset at the desired temperature)

iv.) The vacuum was applied to the oven and the rate of removal of NMP, from the sintered metal control part, was measured by weight change (0.0001 $\pm$ 5g) over time.

v.) Drying data was recorded and the results are presented in graphs 1-4

General Results of Drying Tests:

1.) 100% removal of the NMP from sintered metal is achievable when the temperature of the air in an evacuated chamber is kept above 70°C.

2.) For quickest removal of NMP from metal parts, vacuum conditions as close to full vacuum are required.

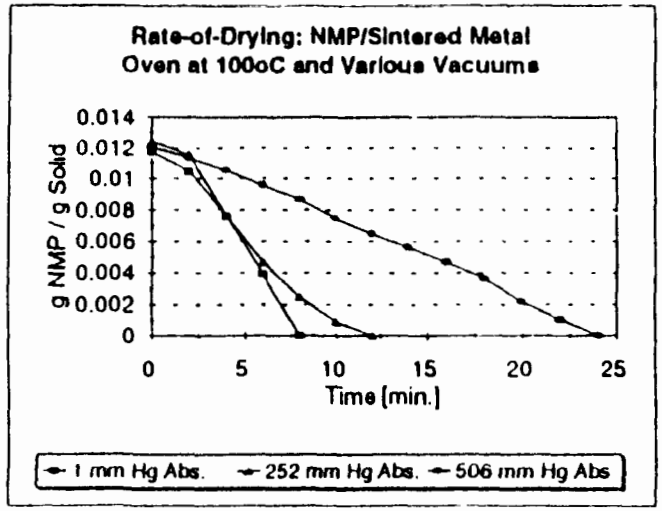
3.) Total removal of NMP from the sintered metal was achieved even at weak vacuum conditions.

PHASE II: Definition of base line cleaning/Rinsing process parameters

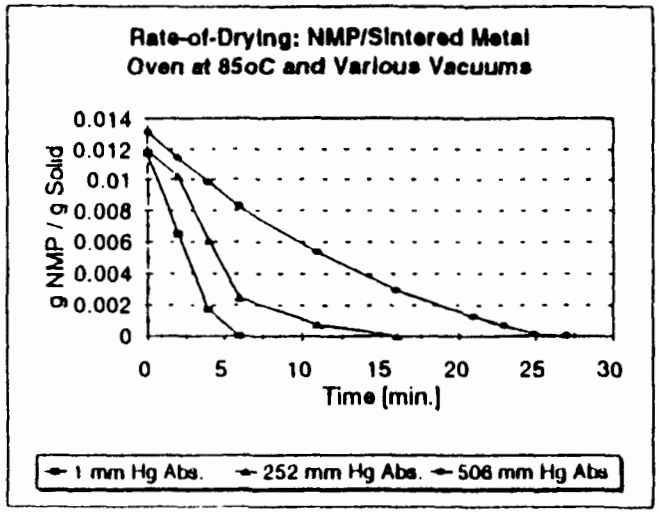
To simulate a cleaning chamber, such as one that would be found in a commercial vacuum cleaning unit, a double walled glass resin flask was used. This allowed for efficient control of the temperature of the liquid NMP as well as of the temperature of the NMP vapors in the evacuated air space above the liquid. A diagram of the test apparatus is shown in Figure 2

DRYING DATA

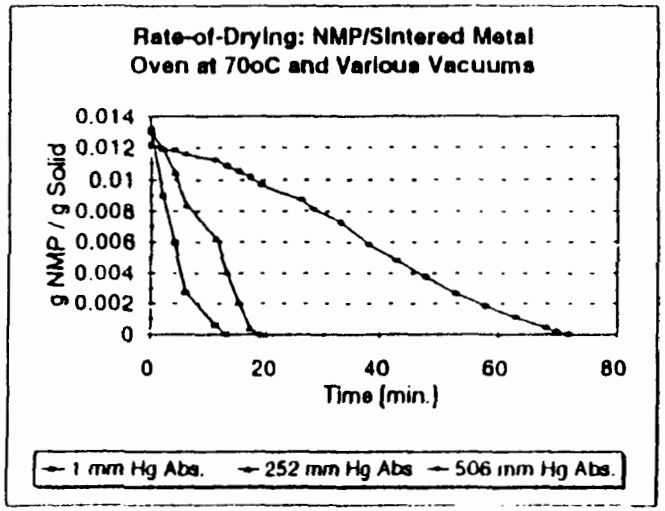
Graph 1



Graph 2



Graph 3



Graph 4

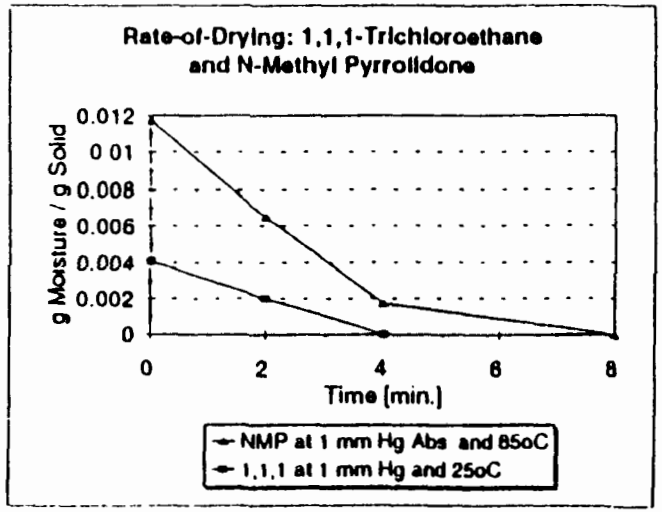
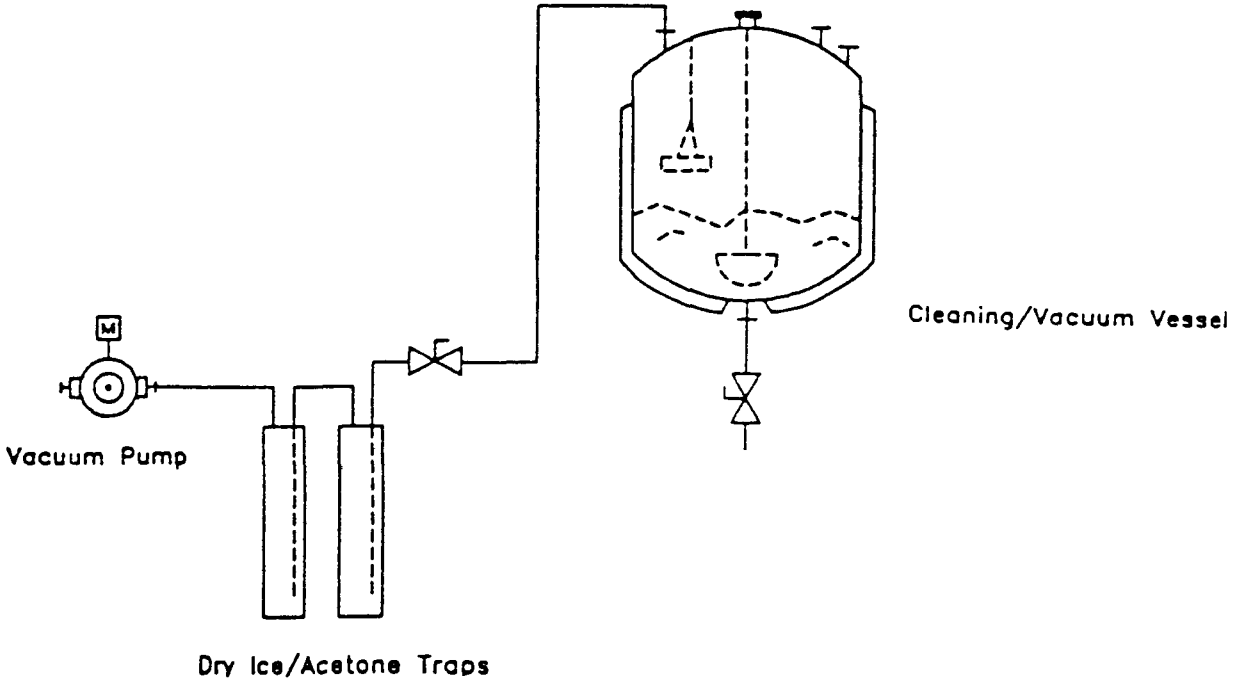


FIGURE 2

Vacuum Vapor Degreasing Equipment



General Discussion of Phase II tests:

1.) The control part cleaned, was the same sintered metal disc used for the drying studies

2.) In a commercial unit, the parts will be cleaned, rinsed and dried in the same chamber. The process of opening and closing the resin flask (and re-stabilizing the temperature) is a time consuming process, so once the part was cleaned and rinsed in order to speed up the lab work, the part was dried in the same vacuum oven used for the drying trials.

3.) The soil chosen, as a control and used to saturate the disc for all cleaning trials, was a 50/50 (by weight) blend of two heavy oils (Shell HVI-150 and Exxon Telura 323) that had a boiling point higher than NMP's. (After some discussion it was decided not to run trials with a light weight control oil. Most of these oils have boiling ranges that overlap the boiling point of NMP, and it was felt that a test run with such an oil would not be a true test of oil removal, as some of the light components could still be on the metal after the cleaning step. These residues would surely evaporate during the vacuum drying cycle.)

Procedure for Cleaning Trials:

i.) The control disc was immersed into the control oil blend. The dwell time in the oil was 10 minutes. the temperature of the oil bath was maintained at 70°C. (Dwell time and oil bath temperature remained the same for all trials.)

ii.) The disc was then wipe dried with a paper towel, to remove all gross amounts of surface oils.

iii.) The control part was then immersed into the NMP bath (pre-set at a given temperature). The resin flask, bath was covered, and a slight vacuum applied. Dwell time in the liquid NMP was varied from trial to trial. The pre-set temperature of the NMP bath was also varied. During all tests involving the heating of NMP above 63°C, the reactor vessel had a Nitrogen bleed into the air space above the NMP. (Even while vacuum was applied.)

iv.) After the pre-determined dwell time was reached, the majority of the liquid NMP was drawn out of the resin flask allowing the disc (which was held by a rack device) to sit in the evacuated air space.

v.) A full vacuum was applied to the system, until small amounts of the NMP were pulled out of the resin flask. The resin flask was then closed off, and the control part was let to rinse in the refluxing NMP vapors for 5 minutes.

vi.) The sintered metal was then removed from the resin flask, and placed into a pre-heated vacuum oven. Full vacuum was applied, and the part was dried.

vii.) The sintered metal disc was considered totally cleaned and dried when the weight of the disc was ± 0.0005g of the original dry/cleaned weight.

The data from the cleaning trials is reported here in Figure 3.

FIGURE 3: CLEANING HEAVY OIL FROM SURFACE OF SINTERED METAL DISC

	Trial Process Conditions	Results
1.	Resin Flask Temp 70°C; Dwell Time in Liquid NMP: 5 minutes Rinse 70°C Vapor; 5 minutes Dry Cycle; 7 minutes 30 inch vacuum 70° C	TOTALLY CLEAN AND DRY
2.	Resin Flask Temp 70°C; Dwell time in liquid NMP: 3 minutes Rinse 70°C Vapor; 5 minutes; Dry Cycle; 7 minutes 30 inch vacuum 70°C	TOTALLY CLEAN AND DRY
3.	Resin Flask Temp 85°C; Dwell time in liquid NMP: 5 minutes Rinse 85°C Vapor; 5 minutes; Dry Cycle; 7 minutes 30 inch vacuum 85°C	TOTALLY CLEAN AND DRY
4.	Resin Flask Temp 85°C; Dwell time in liquid NMP: 3 minutes Rinse 85°C Vapor; 5 minutes; Dry Cycle; 7 minutes 30 inch vacuum 85°C	TOTALLY CLEAN AND DRY
5.	Resin Flask Temp110°C; Dwell time in liquid NMP: 5 minutes Rinse 110°C Vapor; 5 minutes; Dry Cycle; 4 minutes 30 inch vacuum 100°C	TOTALLY CLEAN AND DRY
6.	Resin Flask Temp 110°C; Dwell time in liquid NMP: 3 minutes Rinse 110°C Vapor; 5 minutes; Dry Cycle; 4 minutes 30 inch vacuum 100°C	TOTALLY CLEAN AND DRY

GENERAL RESULTS OF CLEANING TESTS:

1.) The trials run at 100°C give some indication that total cycle times of 15 minutes are possible for small scale NMP vapor degreasing processes.
2.) Full vacuum (or as close to full vacuum) condition was chosen for the drying cycle, because at all temperatures tested, the best drying results were obtained when a full vacuum was applied.
3.) The results indicated that vacuum cleaning processes using liquid NMP and vaporized NMP, at temperatures as low as 70°C, can produce clean substrates in efficient time frames.

PHASE III: Cleaning of Parts

The proper cleaning, rinsing and drying parameters were already established for an NMP vacuum vapor degreasing process by the experiments carried out during Phase I and Phase II of the project.

During the final set of experiments, the total process knowledge was applied, and the test apparatus, shown in Figure 2, was operated in the same manner that a commercial unit would be run. (Cleaning, rinsing, and drying cycles take place in the same chamber; the parts remain stationary.)

GENERAL DISCUSSION OF PHASE III TESTS:

1.) Cleaning trials were carried out using (4) different test parts.
   a.) Pieces of stainless steel mesh screen
   (32 mesh screen; 0.495 mm per square side)
   b.) Glass capillary tubes

(a) 100 mm x 1.8 mm (OD)/1.5 ID (b) 10 microliter size capillary tubes

c.) Carbon steel bolts
(0.5 in. fully threaded; 4 inches long)

d.) Brass cabinet handles; Zinc die cast cabinet handles

2.) Parts a, b, and c were soiled with the same 50/50 oil blend (HVI-150/Telura 323) that was used for the cleaning trials.

3.) Part d (brass cabinet handles) trials were run on non-soiled parts. The brass handles were production parts coated with an epoxy powder coating. Part d trials were run, to demonstrate and observe, the potential, for an NMP immersion/vapor rinse process, to swell and remove the coating. The established method for removing this type of powder coating, with NMP, is to immerse the part into an ultrasonic bath. The NMP softens the powder coating and then the ultrasonic energy is needed to "blast" the softened coating off of the substrate surface. We wanted to examine the potential for vapor "coatings removal".

PROCEDURE FOR PARTS CLEANING TRIALS:

i.) The part being cleaned was immersed into a control oil bath. Dwell time in the oil was 10 minutes. The temperature of the oil bath was maintained at 70°C. (Both of these parameters remained constant for all parts cleaning trials.)

ii.) The part was then removed from the oil, shaken and wiped with a paper towel, in order to ensure gross amounts of oil were removed.

iii.) The part was them immersed into the NMP bath (Temperature pre-set at 70°C or 85°C) for the trials. The resin flask bath was covered, and a slight vacuum was applied to the system. The dwell time in the liquid NMP was varied from trial to trial.

iv.) After the prescribed dwell time was reached, a majority of the liquid NMP was drawn out of the resin flask, allowing the part to sit in the evacuated air space.

v.) A full vacuum was then applied to the system until small amounts of NMP were pulled out of the resin flask. The resin flask was then closed off, and the part was left to rinse in the refluxing NMP for 5 minutes. (all trials).

vi.) The remainder of the liquid NMP was drawn our of the resin flask, and a full vacuum was applied, for 7 - 10 minutes, to dry the parts.

vii.) Each part was weighed (to 0.0001 ± 5 grams) *after the cleaning process/ drying process was complete.*

The results of the parts cleaning trials are set forth in Figure 4.

FIGURE 4: PARTS CLEANING TEST RESULTS

	Parts Cleaned	Process Conditions	Results
1.	32 Mesh Screen	Resin Flask Temp: 70°C; Dwell time in liquid NMP: 3 min. Rinse 70°C vapors: 5 minutes Dry Cycle: 9 min. 30 inch vacuum	Part Totally Clean and Dry
2.	32 Mesh Screen	Resin Flask Temp: 70°C; Dwell time in liquid NMP: 5 min. Rinse 70°C vapors: 5 minutes Dry Cycle: 10 min. 30 inch vacuum	Part Totally Clean and Dry
3.	32 Mesh Screen	Resin Flask Temp: 85°C; Dwell time in liquid NMP: 3 min. Rinse 85°C vapors: 5 minutes Dry Cycle: 9 min. 30 inch vacuum	Part Totally Clean and Dry
4.	32 Mesh Screen	Resin Flask Temp: 85°C; Dwell time in liquid NMP: 5min. Rinse 85°C vapors: 5 minutes Dry Cycle: 9 min. 30 inch vacuum	Part Totally Clean and Dry

5.	Carbon Steel Bolts	Resin Flask Temp: 70°C; Dwell time in liquid NMP: 3 min. Rinse 70°C vapors: 5 minutes Dry Cycle: 10 min. 30 inch vacuum	Parts Totally Clean and Dry
6.	Carbon Steel Bolts	Resin Flask Temp: 70°C; Dwell time in liquid NMP: 5 min. Rinse 70°C vapors: 5 minutes Dry Cycle: 10 min. 30 inch vacuum	Parts Totally Clean and Dry
7.	Carbon Steel Bolts	Resin Flask Temp: 85°C; Dwell time in liquid NMP: 3 min. Rinse 85°C vapors: 5 minutes Dry Cycle: 10 min. 30 inch vacuum	Parts Totally Clean and Dry
8.	Carbon Steel Bolts	Resin Flask Temp: 85°C; Dwell time in liquid NMP: 5 min. Rinse 85°C vapors: 5 minutes Dry Cycle: 10 min. 30 inch vacuum	Parts Totally Clean and Dry
9.	Bundle of Mixed 10 microliter and 100mm capillary tubes	Resin Flask Temp: 70°C; Dwell time in liquid NMP: 3 min. Rinse 70°C vapors: 5 minutes Dry Cycle: 10 min. 30 inch vacuum	Parts Totally Clean and Dry
10.	Bundle of Mixed 10 microliter and 100mm capillary tubes	Resin Flask Temp: 70°C; Dwell time in liquid NMP: 5 min. Rinse 70°C vapors: 5 miutes Dry Cycle: 10 min. 30 inch vacuum	Parts Totally Clean and Dry
11.	Bundle of Mixed 10 microliter and 100mm capillary tubes	Resin Flask Temp: 85°C; Dwell time in liquid NMP: 3 min. Rinse 85°C vapors: 5 minutes Dry Cycle: 7 min. 30 inch vacuum	Parts Totally Clean and Dry
12.	Bundle of Mixed 10 microliter and 100mm capillary tubes	Resin Flask Temp: 85°C; Dwell time in liquid NMP: 5 min. Rinse 85°C vapors: 5 minutes Dry Cycle: 7 min. 30 inch vacuum	Parts Totally Clean and Dry
13.	Brass and Steel Zinc Die Cast Cabinet Handles	Resin Flask Temp: 85°C; Dwell time in liquid NMP: 20-30 min. Rinse 85°C vapors: 10 minutes No Dry	-At the 5 min mark of the cleaning cycle (immersed in liquid NMP), the powder coating bubbled, however, without the ultrasonic force, the coating was not lifted from 100% of the surface. - Rinsing in the vapors did not remove any additional amounts of coating
14.	Brass and Steel Zinc Die Cast Cabinet Handles	Resin Flask Temp: 110°C; Dwell time in liquid NMP: 20-30 min. Rinse 110°C vapors: 10 minutes No Dry	-Again by the 5 minute mark of the cleaning cycle, the powder coating was bubbled but without ultrasonics the coating could not be completely lifted from the surface -Rinsing in the vapors did not remove any additional amounts of coating

GENERAL DISCUSSION OF PARTS CLEANING RESULTS AND CONCLUSION:

1.) The parts cleaning tests were run in a closed container, and the container was not opened until after each test was complete. Because of this, in order to insure that the parts would be totally dry, the maximum drying times for cleaning trials on the sintered metal disc were used. Actual drying cycles for smooth surfaced parts will most likely be shorter.

2. Trials were not run at 110°C, as it was assumed that since the parts were cleaned at 70°C and 85°C, that the only data to be gained by running trials at 110°C, would be to determine the minimum total cycle time.

3.) A general cleaning cycle of 3 -5 minutes is sufficient.

4.) A general vapor rinsing cycle of 5 minutes is sufficient.

5.) Before the capillary tubes were immersed into the 70°C oil bath for "dirtying", oil was suctioned up into the tubes to insure that the total surface area of each tube had been exposed to the oil.

6.) The use of hot NMP in a vacuum chamber did give rise to a more rapid penetration and bubbling of the powder coating (less than 5 minutes) than the normal process of immersion into an ultrasonic bath, however, without the ultrasonics present, the coating film was not totally removed from the metal.

Further work may be done with processes that combine both vacuum and ultrasonics, to develop the most efficient powder coating removal processes.

FINAL CONCLUSIONS:

It has been demonstrated that, a liquid (NMP) immersion/NMP vapor rinse/vacuum dry, cleaning process can be employed to remove soils from hard surfaces. For a list of several companies that manufacture equipment capable of vacuum vapor degreasing, see appendix B of this report. These companies are familiar with NMP.

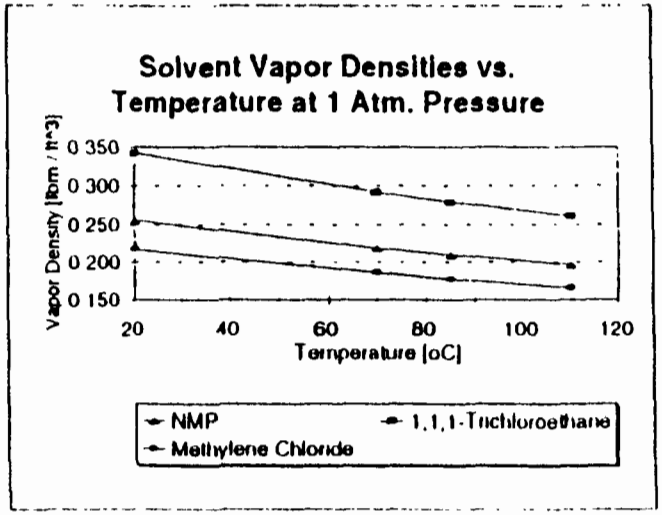
SAFETY CONSIDERATIONS:

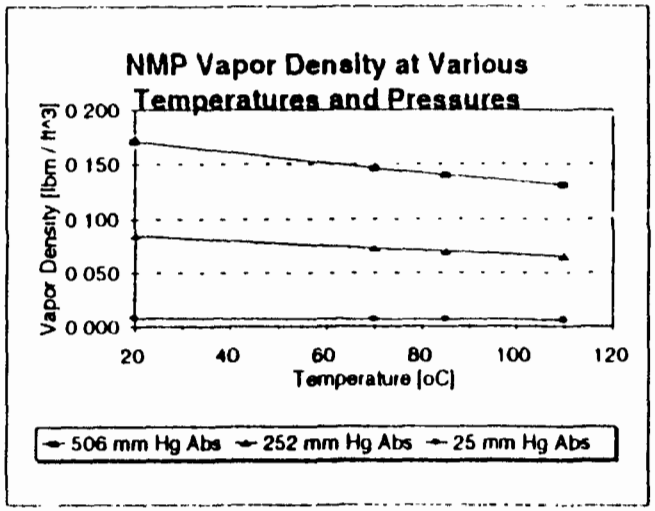
In order to generate a sufficient concentration of NMP vapor, in the cleaning chamber, to insure that an efficient/effective rinsing action occurs, the NMP may have to be heated up to temperatures that are higher than it's flash point.

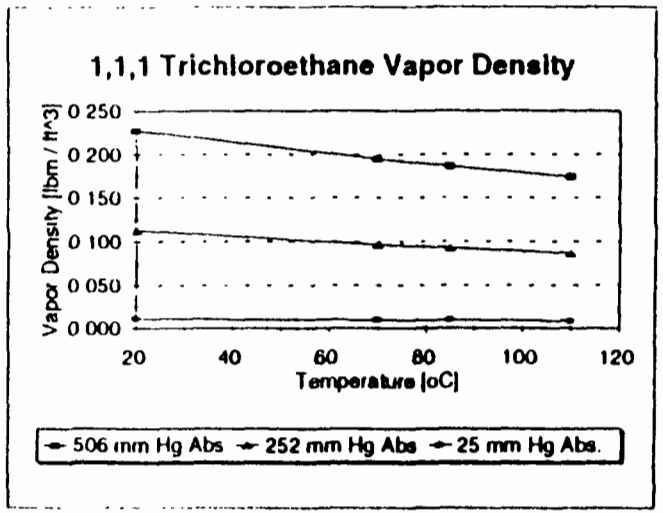
It is not recomended that NMP, or any other solvent, be heated up to a temperature close to, or above, the flash point of the solvent, in an oxygen rich atmosphere (i.e. air that we breathe). All of the experiments discussed in this paper, were carried out in Nitrogen rich atmospheres.

Also, please remember that NMP is a solvent, and like all other solvents, NMP will de-fat/de-oil the skin. When working with NMP be sure to wear proper NMP resistant butyl or neoprene rubber gloves (apron if the job demands). When working with NMP, or any other solvent, goggles should be worn to protect the eyes from accidental splashes.

APPENDIX A: NI Vapor Densities







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1.) MASS Transfer Operations, Third Edition by Robert E. Treybal; 1987. McGraw Hill Book Company. pp. 660-681.

2.) Unit Operations of Chemical Engineering, Fourth Edition by McCabel, Smith, and Harriott; 1985. McGraw Hill Book Company. pp. 940-942.

3.) 15th AESF/EPA Conference on Pollution Prevention and Control, Conference Proceedings, *January 1994*; Vacuum Vapor Degreasing System for Pollution Abatement; by M. Shenoy and D.J. Gray, SEREC Corporation, Providence, RI.

APPENDIX B
Vacuum Vapor Degreaser Manufacturers Familiar with NMP

Durr Automation
10301 Enterprise Drive
Davisburg, MI 48350

Contact: Tim Kelly
Phone: (810)625-5400

Durr GmbH
Filderstadt
Muhlen Strasse 12
D-70794
Filderstadt Germany

Tiyoda Manufacturing Co. Ltd.
Industrial Equipment Division
75-5 Imojiya Oaza Koshoku
387 Nagano Japan
Contact: Mr. Masahito Tanaka
Phone: 81-262-72-2381

SEREC Corporation
P.O. Box 28129
335 Valley Street
Providence, RI 02908
Contact: Peter T. Gebhard III
Phone: (401) 421-6080

Tiyoda Manufacturing USA Inc.
1613 Lockness Place
Torrance, CA 90501

Contact: Mr. Ohkubo
Phone: (310) 539-5471

William Wehrle

BASF Corporation

"Waste Minimization in the Agricultural Products Industry: Update on the Agricultural Container Research Council"

BIOGRAPHY

Bill Wehrle

Bill Wehrle is currently Manager of Formulation and Packaging for BASF Corporation in Research Triangle Park, North Carolina. He has held various manufacturing positions with BASF for the past twenty-two years, mostly in the Agricultural Products Group.

Bill has been a member of the American Crop Protection Association's (ACPA) Packaging Systems Round Table for the past nine years, and was one of the founding members of the Agricultural Container Research Council (ACRC). The Council is a nonprofit, joint-venture corporation formed in 1992 to establish a nationwide collection/recycling program for used plastic containers, as well as conduct research on end uses for the resulting recycled plastic.

After first serving as ACRC's Finance Committee Chairman for nearly two years, Bill was elected Chairman of the Board of Directors of ACRC in 1994. As a result of his involvement in the Agricultural Container Research Council, Wehrle was named recipient of the "Work Horse" award from the ACPA in 1997. The prestigious award, established in 1990, is given annually to the person or persons whose steady commitment to the industry, over time, has achieved a milestone.

Waste Minimization in the Agricultural Products Industry: Update on the Agricultural Container Research Council

Bill Wehrle

Industry Stewardship

The “Challenge”:

HDPE Bottles

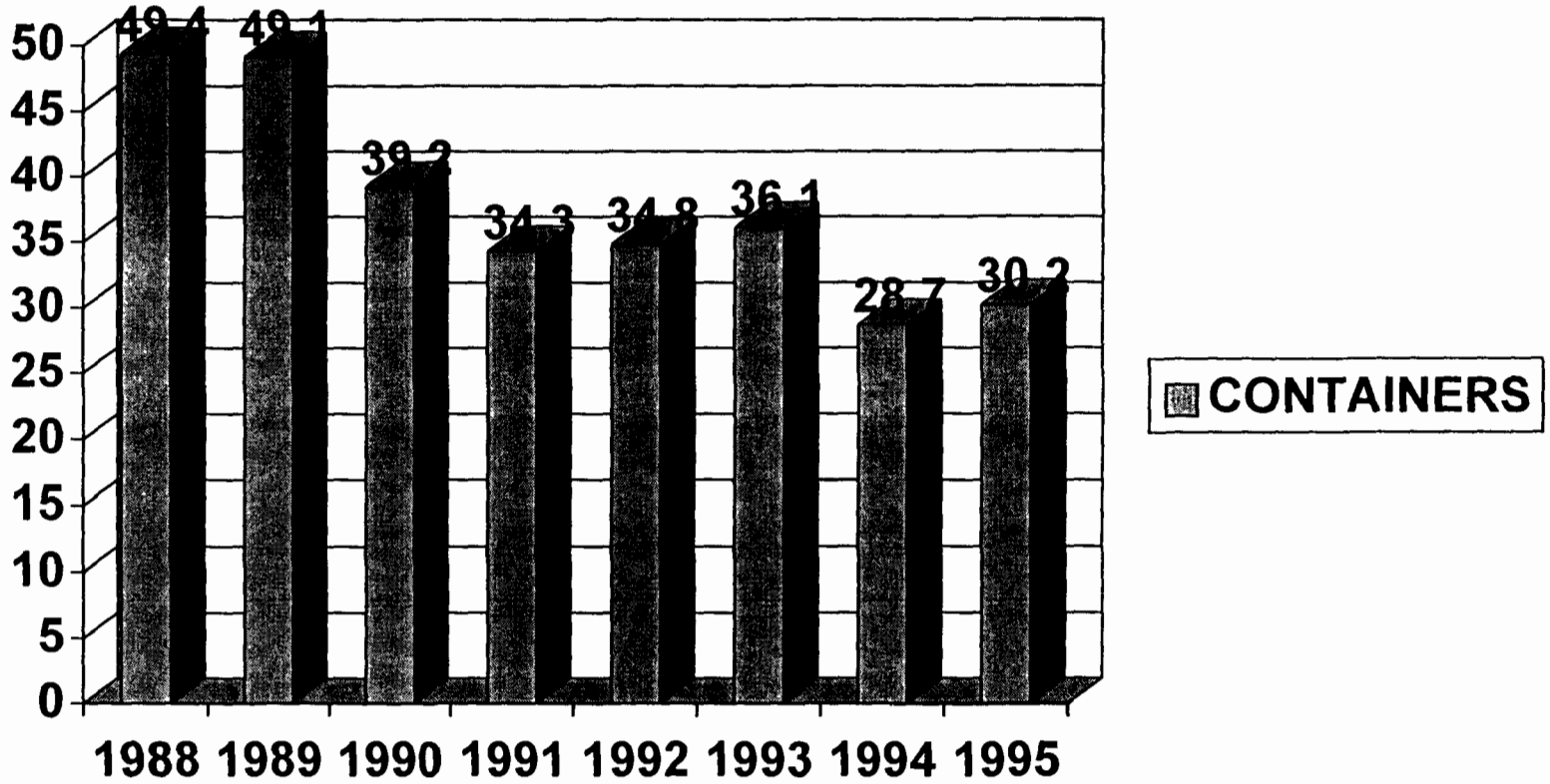
Traditional Disposition of HDPE Bottles

- Burning on the Farm
- Landfill
- Bury in the "Back 40"
- Improper reuse

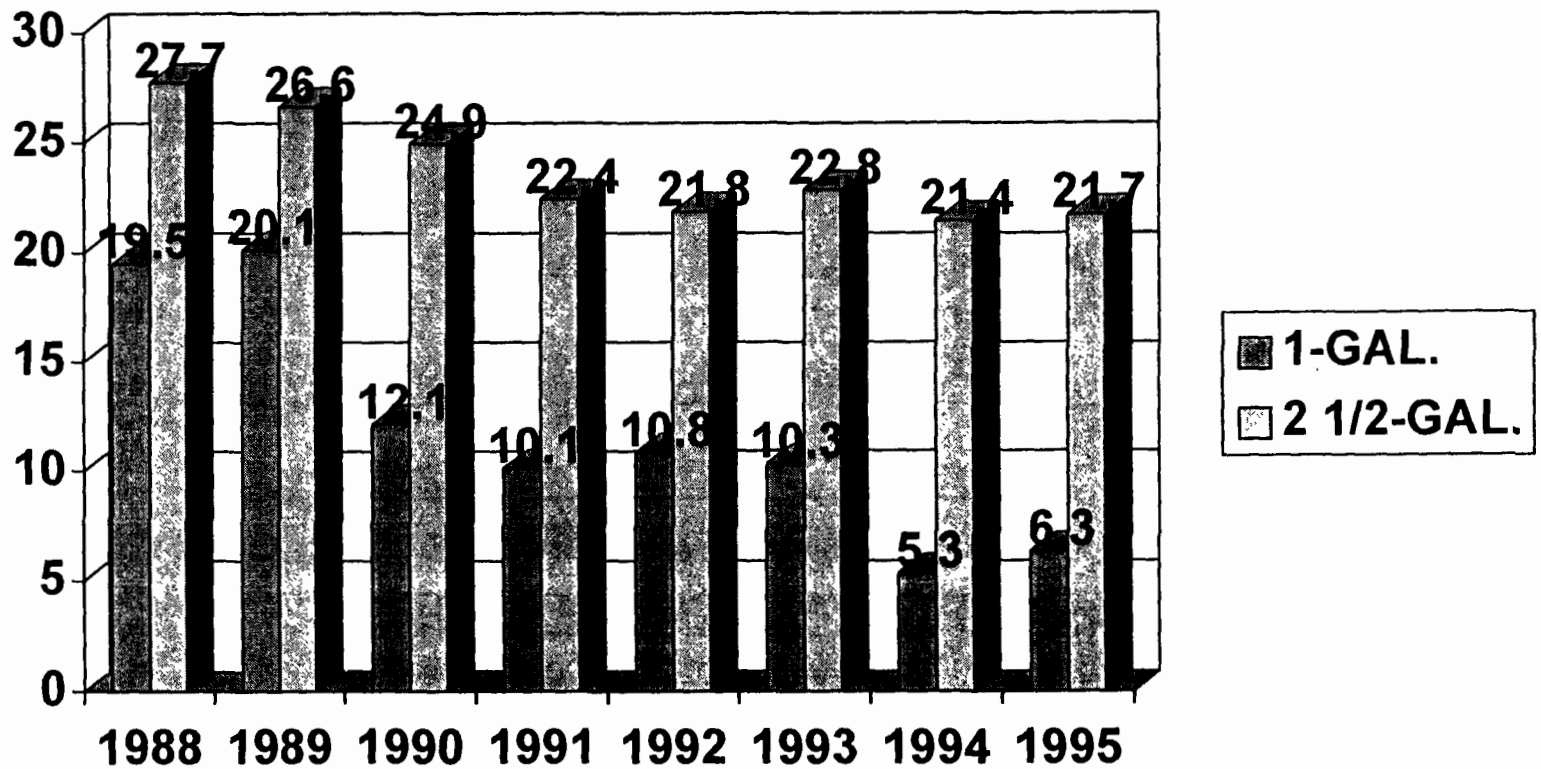
Industry Response

- 1988 - 1992, 1-way containers decreased from 49 to 34 million
- 1988 - 1992, bulk gallons increased from 23 to 63 million gallons

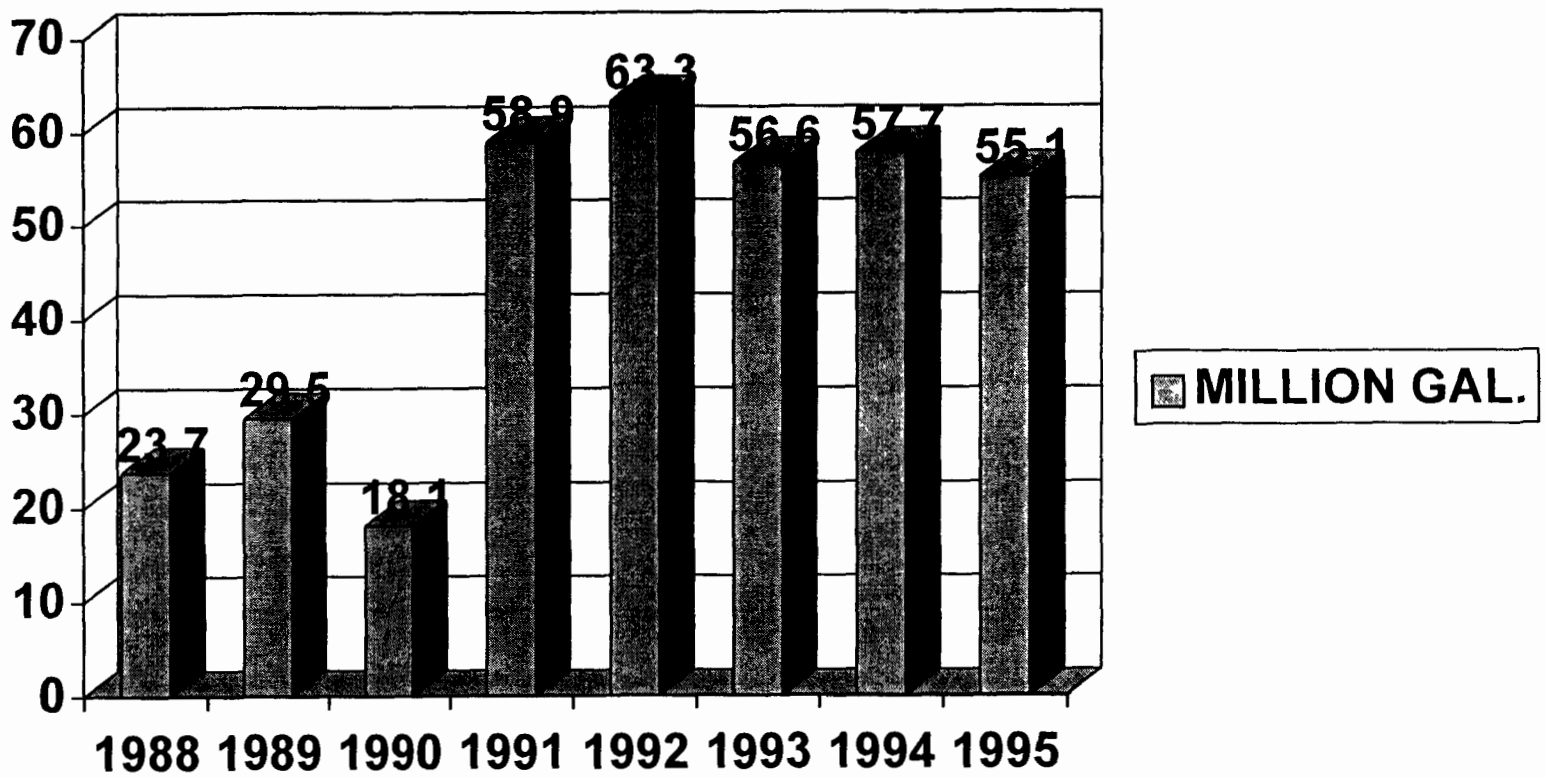
1-WAY LIQUID PACKAGING
TOTAL CONTAINERS ALL SIZES
(MILLIONS OF CONTAINERS)



1-WAY LIQUID PACKAGING
1-GALLON AND 2 1/2-GALLON PLASTIC
(MILLIONS OF JUGS)



TOTAL REFILLABLE LIQUID
ALL SIZES
(MILLIONS OF GALLONS)



Industry Response

- reformulation to dry products
- water soluble packaging for dry and liquid products

Industry Response

ACRC

Agricultural Container Research Council

ACRC

- Nonprofit, joint venture corporation.
- Formed in 1992 to respond to the increasing need to manage used pesticide containers.
- Membership includes agricultural chemical manufacturers, distributors, dealers, and other related industries.

ACRC
Primary Objectives

- To further develop state-level container collection programs.
- To conduct research to find acceptable end uses for empty plastic pesticide containers.

ACRC Members

- AgrEvo
- American Cyanamid
- BASF
- Bayer
- Cedar Chemical
- Cenex/Land-O-Lakes
- Dow AgroSciences
- DuPont
- Elf Atochem
- FMC
- Griffin
- Helena
- Monsanto
- Novartis
- PBI/Gordon
- Rhone-Poulenc
- Rohm and Haas
- Tenkoz
- Terra
- Uniroyal
- UAP
- Valent
- Wilfarm
- Zeneca

ACRC Affiliates

- Central Can
- Continental Plastics
- Fabri-Form
- Fluoro-Seal, Inc.
- Formulogics
- Inmark, Inc.
- Lee Container
- Polyethylene Ind.
- Rieke Corporation
- RXI Container
- Ring Can
- Southcorp Packaging

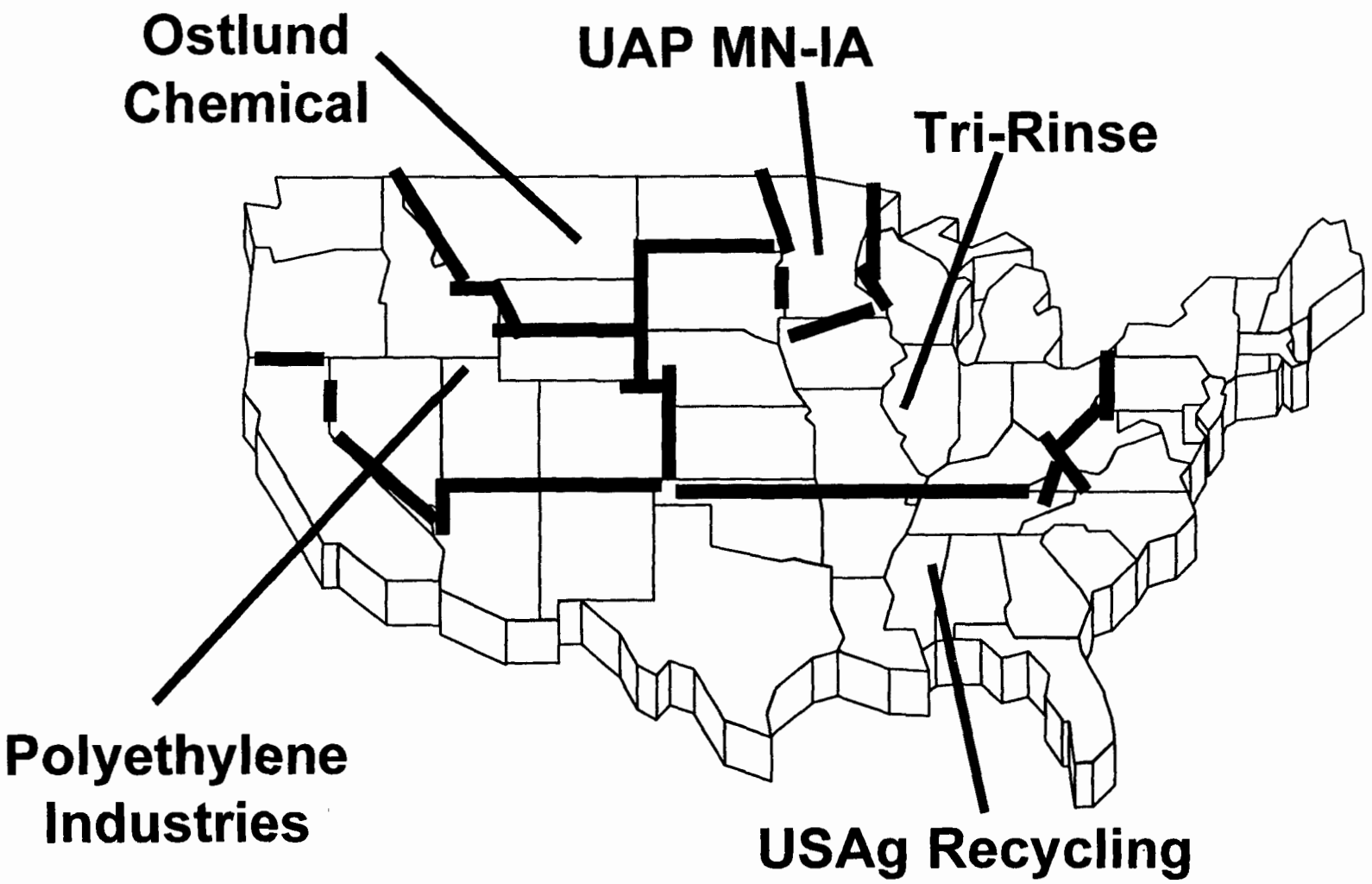
ACRC Executive Committee

- Bill Wehrle (BASF), Chairman
- Don Paulson (Novartis), Vice-Chairman
- Paul Otto, (Rohm & Haas), Finance Comm.
- Steve Hutton (Dow), Technical Comm.
- Bill Spencer (Elf Atochem), Ext. Affairs
- Dave Lindsay (Formulogics), Treasurer
- Lindy Griffith (Zeneca), Secretary

ACRC
Key Accomplishments

- Collection contractors established.
- Assisted in the establishment of state programs.
- Increased plastic collection.
- Program Administrator hired.
- Washington office established.
- Produced educational and promotional materials.
- Identified end uses for recycled plastic.
- Research projects.

1997 - 1998 ACRC Contractors



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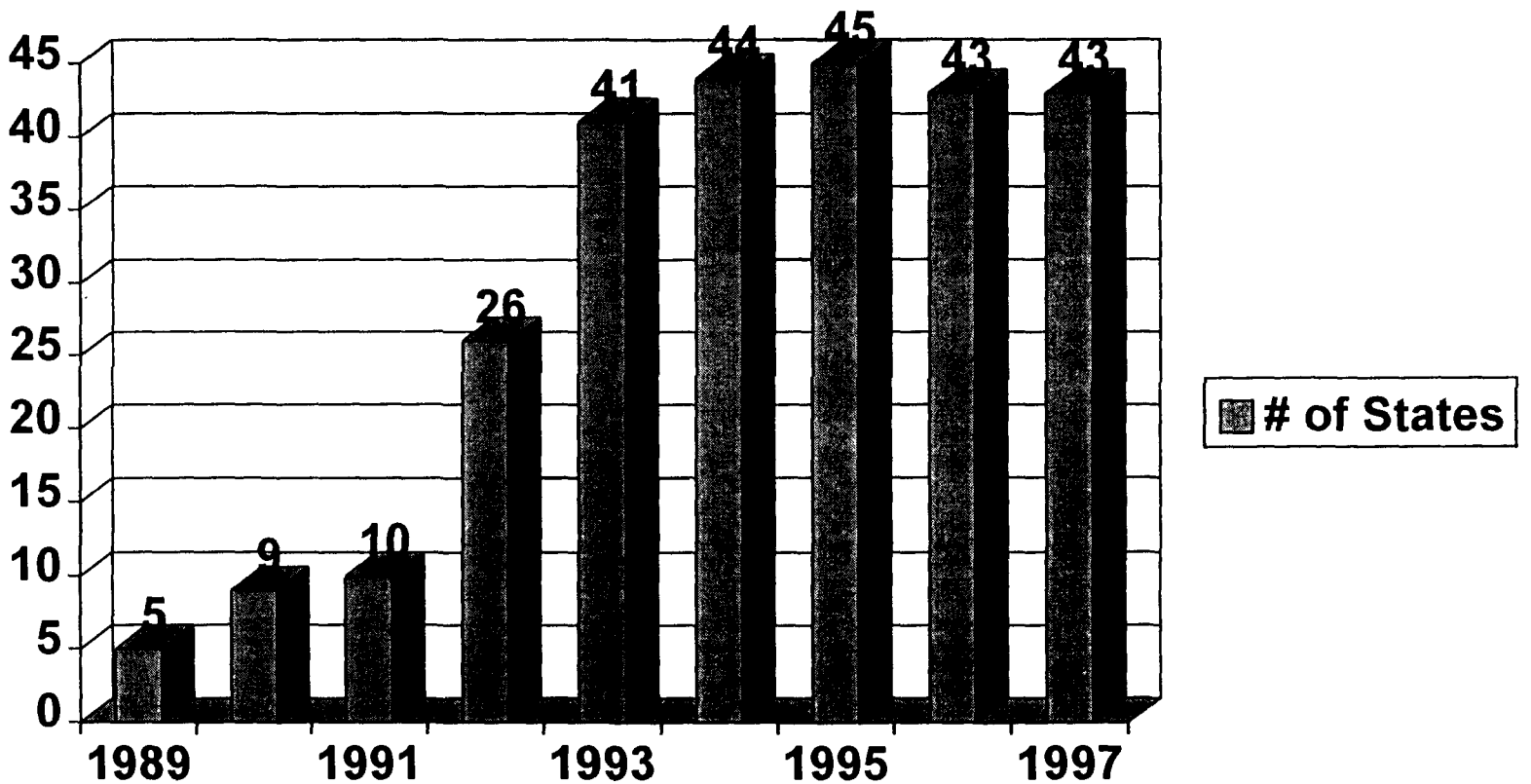
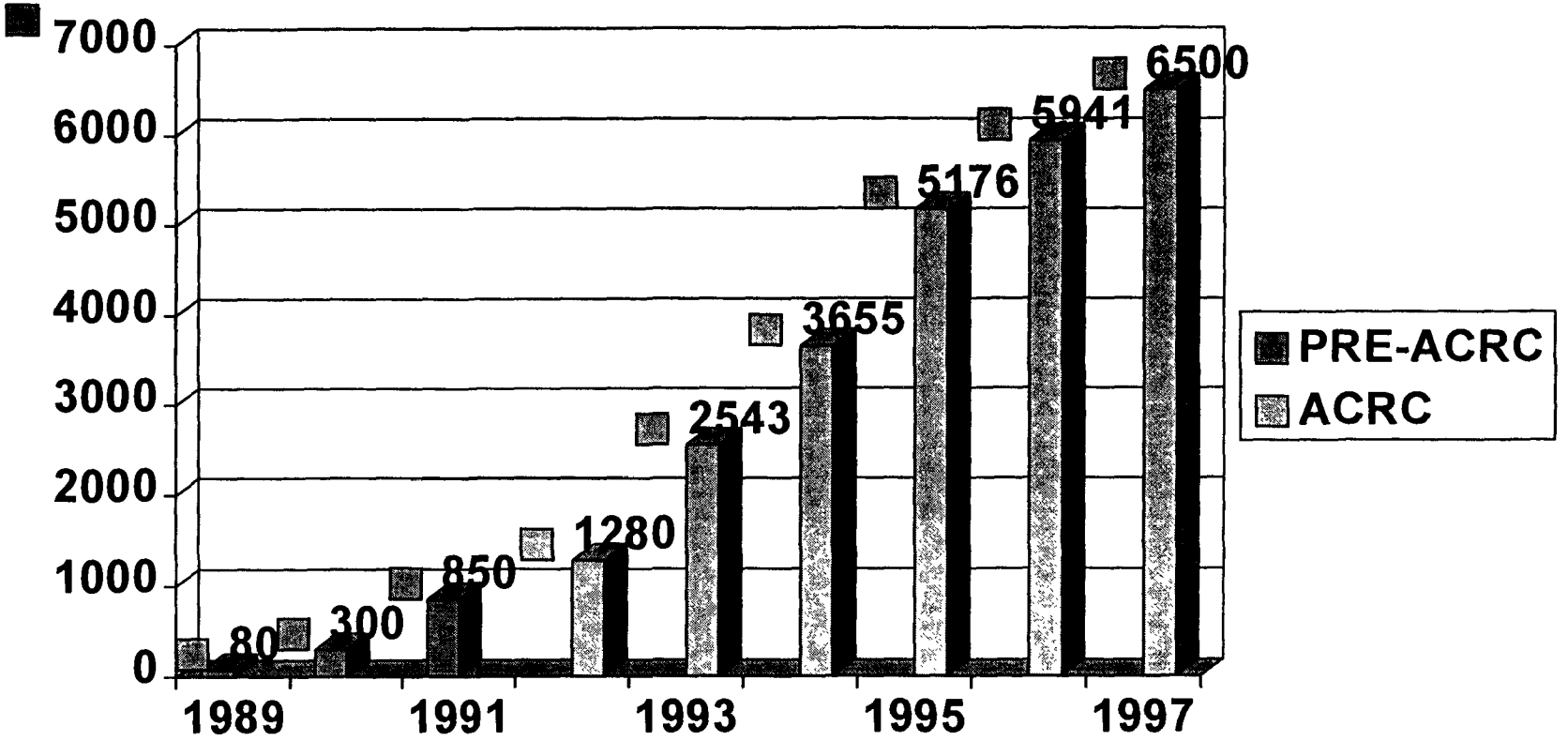
Participation by States



Lbs. Collected Plastic

(Thousands of lbs.)



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- Research projects.

ACRC Washington Office

For Further Information, Contact:

Rob Denny, Program Administrator
ACRC
1225 "I" Street, N.W.
Suite 500
Washington, D.C. 20005
phone (202) 682-4745

ACRC
Key Accomplishments

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- Research projects.

ACRC Educational Materials

- Bilingual video for proper rinsing techniques.
- ACRC informational brochure.
- 1-page Inspection Checklist for recycling plastic containers.
- "How to set up a collection program" slide presentation.
- Waste to energy white paper.

ACRC Outreach Activities

- Informational quarterly newsletter, entitled "ACRC News Bits...".
- Computerized database for all collection sites in the U.S.
- Internet web site for ACRC, including access to collection site database, newsletters, relevant regulatory and environmental information, etc.
- Recognition awards for significant achievements in container collection.

ACRC
Key Accomplishments

- Collection contractors established.
- Assisted in the establishment of state programs.
- Increased plastic collection.
- Program Administrator hired.
- Washington office established.
- Produced educational and promotional materials.
- Identified end uses for recycled plastic.
- Research projects.

Identified End Uses and Research Projects

- Jugs for crop protection products
- Energy recovery (Fuel)
- Pallets (plastic, wood/plastic comp.)
- Construction site mats
- Commercial truck / manure spreader deck boards
- Field drain tiles

Identified End Uses and Research Projects

- Speed bumps, parking stops
- Fence posts
- Hazardous waste drums
- Scaffold nailing strips
- Commercial truck sub-floor support members

Do Voluntary Programs Work?

ACRC

Industry Faced the
Challenge - - -

And Managed It !

ACRC
Current Challenges

- Contractors for 1999 and beyond
- Attain full industry support
- Identify additional end uses
- Increase collection volume
- Reduce collection costs
- Continue to publicize ACRC
- Possibly consider expanding ACRC charter to include other packaging

Scott Wells/Christopher Start
(see Christopher Start for paper)
Energy, Environment, Health and Safety Services
Michigan Manufacturing Technology Center

"MEDS: A Technology Division Support Tool for Industrial Job Shops"

Scott Wells

THE PRESENTER

Scott Wells is an Energy Engineer with the Energy, Environment, Health & Safety Department, 2901 Hubbard Rd. P.O. Box 1485, Ann Arbor, MI 48106-1485; Phone: (734) 769-4514; FAX: (734) 213-3408; E-mail scw@mmtc.org. He has received a BSEE in Electrical Engineering from the University of Missouri - Rolla and has completed numerous computer science courses towards a computer science degree. At the MMTC, Mr. Wells has a specific focus on the Manufacturing Energy Analysis program. Mr. Wells is currently working on the MEDS tool and is creating the project's website. Mr. Wells has also been a member of the project team for the Energy, Environmental, and Manufacturing Technology Access Project (a Technology Reinvestment Project), responsible for providing integrated energy, environment, and manufacturing approaches to small and medium sized manufacturers. He has provided training to field agents in the assessment process as well.

Scott Wells/Christopher Start
(see Christopher Start for paper)
Energy, Environment, Health and Safety Services
Michigan Manufacturing Technology Center

"MEDS: A Technology Division Support Tool for Industrial Job Shops"

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