Metal Products and Machinery-
Generic Scenario for Estimating Occupational Exposures and Environmental Releases

Draft

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ABSTRACT

The purpose of this report is to develop a standardized approach that EPA's Chemical Engineering Branch (CEB) can use to estimate potential occupational exposures and environmental releases from new chemicals used in the Metal Products and Machinery (MP&M) industry. This document also presents a detailed discussion of the MP&M industry and the unit operations that are involved.

Information used to develop the estimation procedures was obtained from the Metal Products and Machinery Effluent Limitations Guidelines Technical Development Document, including sampling data and data submitted by industry to EPA in response to the 1989 and 1996 Metal Products and Machinery Data Collection Portfolios.

For the purpose of this report, an estimation methodology was developed for two subcategories of the MP&M industry; metal finishing and metal shaping. This division was based on industry experience and data that show a substantial difference in the operations and potential releases from each subcategory.

Based on the analysis of information and data, reasonable worst-case release and exposure estimations can be made using the methodology and calculations that are discussed in detail in Sections 4 and 5. The calculations are summarized in Tables A-1 and A-2.

Table A-1

Release and Exposure Calculations for PMN Chemicals Used in Metal Finishing Operations

General Facility Estimates	
Number of Facilities:	$F = \dfrac{PV}{(C)(NB)(BS)(BC) + (C)(NB)(D)}$
Total Number of Workers:	$NW = \left(\dfrac{1\ \text{worker}}{\text{shift}\cdot\text{line}}\right)\dfrac{(NB)(F)(S)}{(NTP)} + \left(\dfrac{1\ \text{worker}}{\text{shift}\cdot\text{facility}}\right)(S)(F)$

Release Calculations

Medium	Calculation		
Water[a]	Total Releases to Water	= WR_{TTL} =	$WR_{WWT} + WR_{NT} + WR_{OT}$
	Water Releases from Facilities that Discharge Process Baths and Dragout to Wastewater Treatment (kg/site-day)	= WR_{WWT} =	$\dfrac{(0.5233)(PV)\ (0.916)}{(F)(DPY)}$
	Water Releases from Facilities that Treat Process Baths Through Other Methods (kg/site-day)	= WR_{OT} =	$\dfrac{(0.0974)(C)(NB)(D)\ (0.916)}{(DPY)}$
	Water Released from Facilities that Discharge Process Baths without Treatment (kg/site-day)	= WR_{NT} =	$\dfrac{(0.3792)(PV)}{(F)(DPY)}$

[a]For metal finishing operations, dragout is released into the rinse water following the operation.

Table A-1 (Continued)

Medium	Calculation		
Air	Air Release from Open Bath Surfaces	$= AR_{OS} =$	Negligible (PMN chemicals are expected to be nonvolatile with a VP <<0.01 torr. If bath temperature is >80°C, calculate the VP at the given temperature. The CEB Open Surface Model can be used to estimate this release if the VP exceeds 0.01 torr).
Incineration	Total Release to Incineration (kg/yr)	$= IR_{TTL} =$	$(FC)(0.1866) + (IR_{PB}) + (IR_{EV})$
	Incineration Releases from Evaporation Treatment System (kg/yr)	$= IR_{EV} =$	(0.016)(BS)(NB)(BC)(C)(F)
	Releases from Facilities that Incinerate Process Baths (kg/yr)	$= IR_{PB} =$	(0.0003)(C)(NB)(BS)(BC)(F)
Landfill[a]	Total Landfill Release (kg/yr)	$= LR_{TTL} =$	(FC)(0.8134)
	Total PMN Release in the Filter Cake (kg/yr)	= FC =	[(C)(NB)(D)(F)(0.0974) + (PV) (0.5233)] (0.084)
Occupational Exposure Calculations			
Inhalation Exposure (mg/day):		Negligible if VP of PMN chemical is <0.001 torr (exposure to mist and particulate matter containing new chemicals is not expected). If bath temperature is >80°C, calculate the VP at the given temperature. If VP is >0.001 torr, use the CEB Open Surface Model to determine I_{exp}. $I_{exp} = (C_M)(B)(NHP)$ The average number of hours of worker exposure to the PMN chemical = $NHP = \frac{(NH)(NTP)}{(NT)}$	
Electroplating (mist):		$C_M = C_{M,K}\ (C/C_K)$ $I_{exp} = (C_M)\ (B)\ (NHP)$	

Medium	Calculation
Dermal Exposure (mg/day):	DE = (C) (up to 3,100 mg/day)

[a]For metal finishing operations, dragout is released into the rinse water following the operation.

Table A-1 (Continued)

Where:

0.03	=	Percent of facilities that incinerate their process baths
1.60	=	Percent of facilities that treat their process baths through evaporation
9.74	=	Percent of facilities that send process baths to either incineration, evaporation, or other methods
18.66	=	Percent of facilities that dispose of filter cake via incineration
8.4	=	Percent of PMN that is released to the filter cake due to wastewater treatment
37.92	=	Percent of facilities that discharge process baths and dragout without treatment
52.33	=	Percent of facilities that send process baths to on-site wastewater treatment
91.6	=	Percent of PMN that passes through the wastewater treatment system and is released to water
81.34	=	Percent of facilities that dispose of filter cake via landfill
AR_{OS}	=	Air release (kg/site-day) due to open bath surface
B	=	Inhalation rate (m^3/hr) (default value = 1.25)
BC	=	Number of times a bath is changed/yr from Table 4-4 (default value = 45.7)
BS	=	Average bath size, not including dragout (kg) (default value = 2,271 kg)
C	=	% PMN in bath from Table 4-1 or 4-2
C_K	=	% of known chemical in bath from Appendix B (default value = 0.25)
C_M	=	Estimated airborne concentration of the PMN (mg/m^3)
$C_{M,K}$	=	Measured airborne concentration of the known chemical from Appendix B (mg/m^3) (default value = 0.5)
D	=	Dragout (kg_{BATH}/yr) (default value = 9,001 kg/yr-bath)
DE	=	Dermal exposure in mg/day
DPY	=	Days of facility operation/yr from Table 4-4 (default value = 216)
F	=	Number of facilities
FC	=	Total PMN release to the filter cake (kg_{PMN}/yr)
IR_{EV}	=	Incineration release (kg/yr) due to evaporation treatment
I_{exp}	=	Inhalation exposure to PMN (mg/day)
IR_{PB}	=	Incineration release (kg/yr) for facilities that incinerate their process baths
IR_{TTL}	=	Total incineration release (kg/yr)

LR_{TTL}	=	Total land release (kg/yr)
NB	=	Average number of baths/facility containing PMN from Table 4-4 (default value = 4.4)
NH	=	Average number of worker hours/day (default value = 8)
NHP	=	Average number of hours of worker exposure to the PMN chemical
NT	=	Average number of total baths/line (default value = 3)

Table A-1 (Continued)

NTP	=	Average number of baths containing PMN chemical per line from Table 4-4 (default value = 1.7)
NW	=	The total number of workers required for the given PV
PV	=	PMN production volume (kg/yr)
S	=	Number of shifts/day from Table 4-4 (default value = 2)
WR_{NT}	=	Water release (kg/site-day) from facilities that discharge their process baths and dragout to water without treatment
WR_{OT}	=	Water release (kg/site-day) for facilities that treat process baths through other methods
WR_{TTL}	=	Total water release (kg/site-day)
WR_{WWT}	=	Water release (kg/site-day) for facilities sending process baths and dragout to wastewater treatment

Table A-2

Release and Exposure Calculations for PMN Chemicals Used in Metal Shaping Operations

General Facility Estimates		
Number of Facilities: $$F = \frac{PV}{(C)(NM)(TS)(TC) + (C)(NM)(D)}$$		
Total Number of Workers: $$NW = \left(\frac{1\ \text{worker}}{\text{shift}\cdot\text{line}}\right)(NM)(F)(S) + \left(\frac{1\ \text{worker}}{\text{shift}\cdot\text{facility}}\right)(S)(F)$$		
Release Calculations		
Medium	**Calculation**	
Water[a]	Total Releases to Water (kg/site-day)	$= WR_{TTL} = WR_{WWT} + WR_{NT}$
	Releases from On-Site Wastewater Treatment Systems (kg/site-day)	$= WR_{WWT} = \frac{(0.6518)(PT)}{(DPY)(F)}[(PV) - (D_{PMN})]$
	Water Releases from Facilities that Discharge to Water Without Treatment (kg/site-day)	$= WR_{NT} = \frac{(0.1530)}{(DPY)(F)}[(PV) - (D_{PMN})]$
Air	Air Release from Open Trough Surfaces	$= AR_{OS} =$ Negligible (PMN chemicals are expected to be nonvolatile with a VP <<0.01 torr. The CEB Open Surface Model can be used to estimate this release if the VP exceeds 0.01 torr).

[a]For metal shaping facilities, dragout remains on the part following the process and is not included in any release estimates.

Table A-2 (Continued)

Medium	Calculation		
Incineration[a]	Total Release to Incineration (kg/yr)	$= IR_{TTL} =$	$IR_{WWT} + IR_{IN} + IR_{EV}$
	Releases from facilities that use Evaporation Treatment (kg/yr)	$= IR_{EV} =$	(0.034)(TS)(NM)(C)(TC)(F)
	Release from Facilities that Incinerate Process Troughs (kg/yr)	$= IR_{IN} =$	(0.0305) [(PV) - (D_{PMN})]
	Residuals from Wastewater Treatment of Process Troughs (kg/yr)	$= IR_{WWT} =$	(0.6518)(R) [(PV) - (D_{PMN})]
	PMN Losses due to Dragout (kg/yr)	$= D_{PMN} =$	(D)(C)(NM)(F)
Land[a]	Not expected (concentrates are typically contract hauled and used for off-site fuel blending).		
Occupational Exposure Calculations			
Inhalation Exposure (from mist, mg/day):			IE = (B) (OSHA PEL) (8) (C)
Dermal Exposure (mg/day):			DE = (C) (up to 3,100 mg/day)

[a]For metal shaping facilities, dragout remains on the part following the process and is not included in any release estimates.

Where:

3.4	=	The percent of facilities that evaporate their process baths
3.05	=	Percent of facilities that incinerate their process baths
8	=	Number of hours of worker exposure for TWA
15.30	=	Percent of facilities that discharge their process solution to water without treatment
65.18	=	Percent of facilities that send process baths to on-site wastewater treatment
AR_{OS}	=	Air release due to open trough surfaces
B	=	Standard breathing rate = 1.25 m^3/hr
C	=	% PMN in trough, from Table 5-1 (default value = 2.5%)
D	=	Dragout from processes (kg_{trough}/yr) (default value = 8,998 kg/yr)

Table A-2 (Continued)

DE	=	Dermal exposure in mg/day
D_{PMN}	=	PMN losses due to dragout (kg_{PMN}/yr)
DPY	=	Days of facility operation/yr from Table 5-2 (default value = 219)
F	=	Number of facilities
IE	=	Inhalation exposure (mg/day)
IR_{EV}	=	Incineration releases (kg/yr) due to evaporation treatment
IR_{IN}	=	Incineration releases (kg/yr) for facilities that incinerate process baths
IR_{TTL}	=	Total incineration releases (kg/yr)
IR_{WWT}	=	Incineration releases (kg/yr) for facilities sending process baths to wastewater treatment
NH	=	Number of hours of worker exposure (default value = 8)
NM	=	Average number of machines/facility, from Table 5-2 (default value = 24)
NW	=	The total number of workers required for the given PV
OSHA PEL	=	OSHA PEL (8-hr, TWA) for oil mists = 5 mg/m^3
PT	=	The percent of PMN that is not removed in wastewater treatment (Chemical Emulsion Breaking and Oil/Water Separation, PT = 50% (Default); Ultrafiltration, PT = 30%)
PV	=	PMN production volume (kg/yr)
R	=	Removal efficiency of wastewater treatment (Chemical Emulsion Breaking and Oil/Water Separation, R = 50% (Default); Ultrafiltration, R = 70%)
S	=	Number of shifts/day from Table 5-2 (default value = 2)
TC	=	Number of times a trough is changed/year from Table 5-2 (default value = 13.9)
TS	=	Average trough size (kg) (default value = 151.42 kg)
WR_{NT}	=	Water releases (kg/site-day) for facilities that discharge process solutions to water without treatment
WR_{TTL}	=	Total water releases (kg/site-day)
WR_{WWT}	=	Water releases (kg/site-day) for facilities sending process troughs to on-site wastewater treatment

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The data used to develop the estimation methodologies presented in this generic scenario was compiled primarily from the Metal Products and Machinery Effluent Limitations Guidelines Technical Development Document, including sampling data and data submitted by industry to EPA in response to the 1989 and 1996 Metal Products and Machinery Data Collection Portfolios. The initial questionnaire data analysis was performed for the U.S. Environmental Protection Agency, Office of Water, Engineering and Analysis Division, by ERG under Contract Nos. 68-C0-0005 and 68-C4-0024.

1.0 INTRODUCTION

This generic scenario has been developed to assist the Environmental Protection Agency's Chemical Engineering Branch (CEB) in estimating releases of, and occupational exposures to, new chemicals from metal products and machinery (MP&M) processes, specifically metal finishing and metal shaping operations. As part of the Premanufacture Notice (PMN) review process, CEB engineers will consider the potential for release and occupational exposures to the new chemical from the finishing or shaping of metal products. The assessment methodology presented here can be used to estimate reasonable worst-case scenario releases to air, land, water, and incineration as well as dermal and inhalation exposures due to MP&M processes.

The MP&M industry, as defined by EPA's Office of Water, includes facilities manufacturing, rebuilding, or maintaining metal products in one of 18 industrial sectors. EPA divided these sectors into two regulatory phases, as listed below:

Table 1-1

MP&M Industrial Sectors

MP&M Phase I Sectors	MP&M Phase II Sectors
Aerospace	Bus and Truck
Aircraft	Household Equipment
Electronic Equipment	Instruments
Hardware	Motor Vehicle
Mobile Industrial Equipment	Office Machine
Ordnance	Precious and Nonprecious Metals
Stationary Industrial Equipment	Railroad
	Ships and Boats
	Printed Wiring Boards
	Job Shops
	Miscellaneous Metal Products

Source: MP&M Phase I Development Document.

In May of 1995, EPA proposed effluent limitation guidelines and standards for MP&M Phase I facilities. EPA subsequently combined the two phases, and proposed the combined effluent limitation guidelines and standards in December 2000. The information presented in this generic scenario is based on data collected for the proposed Phase I effluent guidelines, but is expected to be applicable to Phase II facilities as well.

A variety of chemicals are used in the MP&M industry for a number of different process fluids. It is expected that new chemicals that may be the subject of future PMNs will be used in these fluids. A significant quantity of the process fluids may result in occupational exposure and may be released as waste to various media during metal processing operations. For the purpose of this generic scenario, MP&M waste production and disposal will be evaluated from two distinctly different types of MP&M processes: metal shaping and metal finishing. Therefore, this report presents a separate assessment methodology for each. Metal shaping fluids consist mainly of coolants and lubricants, while metal finishing fluids consist of a variety of components including cleaning chemicals, metal deposition chemicals, surfactants, wetting agents, brighteners, complexing agents, and sealant chemicals.

Section 2.0 presents an overview of the MP&M industry. Section 3.0 presents a discussion of how the proposed effluent guideline data were used and assumptions made to develop the estimation methodologies. Finally, Sections 4.0 and 5.0 present the methodology for characterizing operations at typical MP&M facilities, estimating releases, and estimating occupational exposures.

2.0 INDUSTRY PROFILE

The Metal Products and Machinery (MP&M) Point Source Category applies to industrial sites engaged in manufacturing, rebuilding, or maintaining finished metal parts, products, or machines within eighteen industrial sectors. Manufacturing, rebuilding, and maintenance are defined below (1).

- Manufacturing is the series of unit operations necessary to produce metal products. Manufacturing is generally performed in a production environment.
- Rebuilding is the series of unit operations necessary to disassemble used metal products into components, replace the components or subassemblies or restore them to original function, and reassemble the metal product. Rebuilding is generally performed in a production environment.
- Maintenance is the series of unit operations, on original or replacement components, required to keep metal products in operating condition. Maintenance is generally performed in a non-production environment.

Sites within these sectors manufacture, maintain, and rebuild products under more than 200 different Standard Industrial Classification (SIC) codes. At a given MP&M site, the specific unit operations performed and the sequence of operations depend on many factors, including the activity (i.e., manufacturing, rebuilding, or maintenance), industrial sector, and type of product processed. Depending on these factors, MP&M sites perform many different combinations and sequences of unit operations. The following subsections describe the industry and its unit operations in greater detail.

2.1 Industry Definition

As discussed in Section 1.0, the MP&M industry has been defined by EPA's Office of Water to include facilities that manufacture, rebuild, or maintain metal products or machinery in one of the following industrial sectors:

- Aerospace;

- Aircraft;
- Bus and Truck;
- Electronic Equipment;
- Hardware;
- Household Equipment;
- Instruments;
- Job Shops;
- Mobile Industrial Equipment;
- Motor Vehicle;
- Office Machine;
- Ordnance;
- Precious and Nonprecious Metals;
- Printed Wiring Boards;
- Railroad;
- Stationary Industrial Equipment;
- Ships and Boats; and
- Miscellaneous Metal Products.

Table 2-1 lists typical products manufactured within the MP&M industry. This is not an exhaustive list, but is presented to provide general guidance as to the types of products within the industry.

2.2 Unit Operations Performed at MP&M Sites

MP&M sites perform a wide variety of process unit operations on metal parts. The MP&M effluent guideline development effort focused on 47 unit operations (and their associated rinses) performed at MP&M sites, plus wet air pollution control operations, for a total of 48 unit operations. These unit operations are listed in Table 2-2, definitions and descriptions of these unit operations can be found in the MP&M Point Source Category Proposed Effluent Limitations Guideline Development Document. This is not an exhaustive list of operations performed at MP&M sites but represents the primary wastewater-generating operations. Table 2-3 presents the purpose of process water and the estimated total industry discharge flow for each unit operation. As shown in Table 2-3, most wastewater is discharged from associated rinses, with acid treatment rinsing and alkaline treatment rinsing generating the most wastewater of the MP&M unit operations. Each MP&M unit operation can be characterized as belonging to one or more of the following types of unit operations (1):

- Metal shaping operations;
- Surface preparation operations;
- Metal deposition operations;
- Organic deposition operations;
- Surface finishing operations; and
- Assembly operations.

Metal shaping operations (e.g., machining, grinding, impact and pressure deformation) are mechanical operations that alter the form of raw materials into intermediate and final product forms. Surface preparation operations (e.g., alkaline treatment, barrel finishing) are chemical and mechanical operations that remove unwanted materials or alter the chemical, or physical properties of the surface prior to subsequent MP&M operations. Metal deposition operations (e.g., electroplating, metal spraying) apply a metal coating to the part surface by chemical or physical means. Organic deposition operations (e.g., painting, corrosion preventive coating) apply an organic material to the part by chemical or physical means. Metal and organic deposition operations may be performed to protect the surface from wear or corrosion, modify the electrical properties of the surface, or alter the appearance of the surface. Surface finishing operations (e.g., chromate conversion coating, anodizing sealing) protect and seal the surface of the treated part from wear or corrosion by chemical means. Some surface finishing operations (e.g., metal coloring) may also be performed to alter the appearance of the part surface. Assembly operations (e.g., welding, soldering, testing, assembly, disassembly) are performed throughout the manufacturing, rebuilding, or maintenance process.

At a given MP&M site, the specific unit operations performed and the sequence of operations depend on many factors, including the activity (i.e., manufacturing, rebuilding, or maintenance), industrial sector, and type of product processed. Depending on these factors, MP&M sites perform many different combinations and sequences of unit operations. In general, however, MP&M products are processed in the following sequence (1):

- **Step 1 (Metal Shaping).** The raw material (e.g., bar stock, sheet stock, plates) undergoes some type of metal shaping process, such as impact or pressure deformation, machining, or grinding. In these operations, the raw material is shaped into intermediate forms for further processing or into final forms for assembly and shipment to the customer. Cleaning and degreasing processes are typically performed between some of the shaping operations to remove lubricants, coolants, and metal fines from the part. Heat treating operations may also be performed between shaping operations to alter the physical characteristics of the part.

- **Step 2 (Surface Preparation).** After shaping, the part typically undergoes some type of surface preparation operation, such as alkaline cleaning, acid pickling, or barrel finishing. The specific surface preparation operation that is used depends on the subsequent unit operations to be performed and the final use of the products. For example, prior to electroplating, parts typically undergo acid pickling to prepare the surface of the part for electroplating. Before assembly, parts typically undergo alkaline cleaning or barrel finishing. Parts undergo surface preparation operations at various stages of the production process. As mentioned above, cleaning and degreasing can occur between metal shaping operations. Additional cleaning and degreasing also occur prior to metal deposition, organic deposition, surface finishing, and assembly operations.

- **Step 3 (Metal and Organic Deposition).** Metal and organic deposition operations typically occur after shaping and surface preparation operations, and prior to surface finishing and final assembly operations. Electroplating operations typically follow alkaline and acid treatment operations, while painting operations typically follow phosphate conversion coating and alkaline treatment operations.

- **Step 4 (Surface Finishing).** Surface finishing operations are typically performed after shaping and surface preparation operations. Some surface finishing operations are performed after metal deposition operations. For example, chromate conversion coating is typically performed after acid cleaning, though this operation is sometimes performed as a sealant operation after electroplating. Some surface finishing operations are also performed prior to organic coating operations. For example, phosphate conversion coating is frequently performed prior to painting to enhance the paint adhesion.

- **Step 5 (Assembly).** Assembly operations are performed at many steps of the manufacturing and rebuilding process. Disassembling operations may be performed as the first step in the rebuilding process. Assembly operations are performed to prepare the final product. Assembly may also involve some final shaping operations (e.g., drilling and grinding) and surface preparation operations (e.g., alkaline cleaning). Final assembly operations are typically the last operations performed prior to shipment to the customer.

Process water is used during, and subsequently discharged from many of the unit operations listed in Table 2-3. Process water may or may not be used for some operations, depending on the purpose of the operation, raw materials, and final product use. For example, some machining operations (e.g., drilling), can often be performed without a coolant, while other machining operations (e.g., milling) typically require a coolant. Process water that is used for an operation is typically discharged, but this is not always the case. Section 2.3 describes sites that use but do not discharge process water. The individual unit operations are described in the next section.

Some MP&M sites perform all of these types of operations in manufacturing or rebuilding products, while others may focus on only a portion of these operations. For example, a site in the hardware sector may start with bar stock and manufacture a final hardware product, performing machining, cleaning, electroplating, conversion coating, painting, degreasing, and assembly operations. Another hardware site may focus on painting the parts, and only perform cleaning and painting operations. A third hardware site may focus on shaping the parts, and perform only machining, cleaning, and degreasing operations.

MP&M sites that repair, rebuild, or maintain products often perform preliminary operations that may not be performed at manufacturing facilities (e.g., disassembly, cleaning, or degreasing to remove dirt and oil accumulated during use of the product). Sites that manufacture products required to meet very strict performance specifications (e.g., aerospace or electronic components) often perform unit operations, such as gold electroplating or magnetic flux testing, that may not be performed when manufacturing other products.

2.2.1 Industry Division within the Generic Scenario

As stated in Section 2.2, MP&M unit operations can be characterized as belonging to one or more of the following:

- Metal shaping operations;
- Surface preparation operations;
- Metal deposition operations;
- Organic deposition operations;
- Surface finishing operations; and
- Assembly operations.

Metal shaping operations are performed to form components through either removal of metal (e.g., machinery, grinding) or deformation of the metal (e.g., impact deformation, pressure deformation). These operations are either performed dry, use a water-based coolant, oil-eased coolant, or lubricant and are expected to have similar worker exposures.

Spray application of process solutions can fall within a variety of industries and is not discussed in the generic scenario. Assembly operations are typically performed without the use of chemicals or process water and are not assessed in this generic scenario. Organic deposition operations (painting operations) are more appropriately covered under other generic scenarios. Therefore, assessments of releases and exposures from these operations will not be included here. Table 2-4 presents the unit operations typically used in each division. The types of unit operations covered by this generic scenario are divided into the two remaining categories:

- Metal shaping operations, and;

- Metal finishing operations.

The processes involved in surface preparation, metal deposition, and surface finishing are similar and can be combined into one category (metal finishing). Table 2-4 presents typical unit operations used in each category.

Spray application of process solutions and organic deposition operations (painting) is conducted as observed in other industries and is not discussed in this generic scenario. Also, assembly operations are not discussed because they do not typically require the use of chemicals and do not generate process wastewater. The remainder of this generic scenario presents information for the remaining two categories, metal finishing and metal shaping.

Table 2-1

Metal Products and Machinery (MP&M) Typical Products

AEROSPACE
Guided Missiles & Space Vehicles
Guided Missile & Space Vehicle Propulsion Units & Parts
Guided Missile & Space Vehicle Parts & Auxiliary Equip. NEC

AIRCRAFT
Aircraft
Aircraft Engines & Engine Parts
Aircraft Parts & Auxiliary Equipment
Air Transportation, Scheduled
Air Courier Services
Air Transportation, Non-Scheduled
Airports, Flying Fields, & Airport Terminal Services

BUS & TRUCK
Truck & Bus Bodies
Truck Trailers
Local & Suburban Transit (Bus & Subway)
Local Psngr. Trans. (Lim., Amb., Sight See)
Intercity & Rural Highway (Buslines)
Local Bus Charter Service
Bus Charter Service, Except Local
Terminal & Service Facilities for Motor Vehicle Transp.
Local Trucking Without Storage
Trucking, Except Local
Local Trucking With Storage
Courier Services, Except by Air
Terminal & Joint Terminal Maint. Facil. for Motor Freight Trans.

ELECTRONIC EQUIPMENT
Telephone & Telegraph Apparatus
Radio & TV Communications Equipment
Communications Equipment, NEC
Electron Tubes
Electronic Capacitors
Electronic Coils, Transformers, & Other Inductors
Electronic Connectors
Electronic Components, NEC
Electronic Machinery, Equipment, & Supplies, NEC

HARDWARE
Metal Heat Treating
Cutlery
Hand & Edge Tools, Except Mach. Tools & Handsaws
Saw Blades & Handsaws
Hardware NEC
Screw Machine Products
Bolts, Nuts, Screws, Rivets, & Washers
Metal Shipping Barrels, Drums, Kegs, Pails
Iron & Steel Forgings
Crowns & Closures
Metal Stampings NEC
Industrial Valves
Fluid Power Valves and Hose Fittings
Steel Springs, Except Wire
Wire Springs
Miscellaneous Fabricated Wire Products
Industrial Furnaces & Ovens
Fasteners, Buttons, Needles, & Pins
Valves & Pipe Fittings
Fabricated Pipe & Pipe Fittings
Fabricated Metal Products NEC
Machine Tools, Metal Cutting Types
Machine Tools, Metal Forming Types
Special Dies & Tools, Die Sets, Jigs, & Fixtures, & Indust. Molds
Cutting Tools, Machine Tool Access. & Machinists' Precision Measuring Devices
Power-Driven Handtools
Heating Equipment, Except Electric & Warm Air Furnace
Fabricated Structural Metal
Fabricated Plate Work (Boiler Shops)
Sheet Metal Work
Architectural & Ornamental Metal Work
Prefab. Metal Buildings & Components
Miscellaneous Structural Metal Work

HOUSEHOLD EQUIPMENT
Metal Household Furniture
Office Furniture, Except Wood
Public Building and Related Furniture
Office & Store Fixtures, Partitions, Shelving, & Lockers, Except Wood
Drapery Hardware and Window Blinds and Shades
Furniture and Fixtures, NEC
Enameled Iron and Metal Sanitary Ware
Plumbing Fixture Fittings and Trim
Metal Doors, Sash, Frames, Molding, and Trim
Household Cooking Equipment
Household Refrigerators & Home & Farm Freezers
Household Laundry Equipment
Electric Housewares & Fans
Household Vacuum Cleaners
Household Appliances, NEC

Table 2-1 (Continued)

Electric Lamp Bulbs & Tubes
Current-Carrying Wiring Devices
Noncurrent-Carrying Wiring Devices
Residential Electrical Lighting Fixtures
Comcl, Ind., & Inst. Elec. Lighting Fixtures
Lighting Equipment, NEC
Household Audio & Video Equipment
Silverware, Plated Ware, and Stainless Steel Ware
Refrigerators. & Air Cond. Serv. & Repair Shops

INSTRUMENTS
Search, Detect., Navigat., Guid., Aeronnaut., & Naut. Sys. & Instruments
Laboratory Apparatus & Furniture
Automatic Controls for Regulating Residential & Commercial Environments & Appliances
Industrial Instruments for Measurements & Display, and Control of Process Variables, and Related Products
Totalizing Fluid Meters and Counting Devices
Instruments to Measure and Test Electricity & Electrical Signals
Laboratory Analytical Instruments
Optical Instruments and Lenses
Measuring and Controlling Devices NEC
Surgical and Medical Instruments and Apparatus
Orthopedic, Prosthetic, and Surgical Appliances and Supplies
Dental Equipment and Supplies
X-Ray Apparatus and Tubes, and Related Irradiation Apparatus
Ophthalmic Goods
Electrical and Electronic Repair Shops, NEC

MOBILE INDUSTRIAL EQUIPMENT
Farm Machinery & Equipment
Lawn & Garden Tractors & Home Lawn & Garden Equipment
Mining Machinery & Equipment, Except Oil & Gas Field Machinery & Equipment
Overhead Traveling Cranes, Hoists, & Monorail Systems
Industrial Trucks, Tractors, Trailers, & Stackers
Tanks & Tank Components

MOTOR VEHICLE
Automotive Stampings
Carburetors, Piston Rings, Valves
Vehicular Lighting Equipment
Electrical Equipment for Internal Combustion Engines
Motor Vehicles & Passenger Car Bodies
Motor Vehicle Parts & Accessories
Motor Homes
Motorcycles, Bicycles, & Parts
Travel Trailers & Campers
Transportation Equipment, NEC
Taxicabs
Motor Vehicle Supplies & New Parts
Top, Body, & Upholstery Repair & Paint Shops
Automotive Exhaust System Repair Shops
Automotive Transmissions Repair Shops
General Automotive Repair Shops
Automotive Repair Shops, NEC
Automobile Services, Except Repair & Carwashes

OFFICE MACHINE
Electronic Computers
Computer Storage Devices
Computer Terminals
Computer Peripheral Equipment, NEC
Calculating & Accounting Equipment, Except Electronic Computers
Office Machines, NEC
Computer Maintenance & Repair
Computer Related Services, NEC

ORDNANCE
Small Arms Ammunition
Ammunition, Except for Small Arms
Small Arms
Ordnance & Accessories NEC

OTHER METAL PRODUCTS
Metal Foil & Leaf
Photographic Equipment & Supplies
Watches, Clocks, Clockwork Operated Devices, & Parts
Musical Instruments
Games, Toys, & Children's Vehicles, Except Dolls and Bicycles
Sporting and Athletic Goods, NEC
Pens, Mechanical Pencils, & Parts
Marking Devices
Signs & Advertising Specialties
Burial Caskets
Manufacturing Industries, NEC
Welding Shops
Miscellaneous Repair Shops & Related Services

PRECIOUS METALS AND JEWELRY
Jewelry, Precious Metal
Jewelers' Findings and Materials, and Lapidary Work
Costume Jewelry and Costume Novelties, Except Precious Metal
Watch, Clock, and Jewelry Repair

PRINTED CIRCUIT BOARDS
Printed Circuit Boards

Table 2-1 (Continued)

RAILROAD

Railroad Equipment

Railroad Line-Haul Operating

Railroad Switching & Terminal Establishments

SHIPS AND BOATS

Ship Building & Repairing

Boat Building & Repairing

Deep Sea Foreign Transportation of Freight

Deep Sea Domestic Transportation of Freight

Freight Transportation on the Great Lakes, St. Lawrence Seaway

Water Transportation of Freight, NEC

Deep Sea Passenger Transportation, Except by Ferry

Ferries

Water Passenger Transportation, NEC

Marine Cargo Handling

Towing & Tugboat Service

Marinas

Water Transportation Services, NEC

STATIONARY INDUSTRIAL EQUIPMENT

Steam, Gas, Hydraulic Turbines, & Turbine Generator Set Units

Internal Combustion Engines NEC

Construction Machinery & Equipment

Oil & Gas Field Machinery & Equipment

Elevators & Moving Stairways

Conveyors & Conveying Equipment

Industrial Patterns

Rolling Mill Machinery & Equipment

Food Products Machinery

Metal Working Machinery NEC

Textile Machinery

Woodworking Machinery

Paper Industries Machinery

Printing Trades Machinery & Equipment

Special Industry Machinery NEC

Pumps & Pumping Equipment

Ball & Roller Bearings

Air & Gas Compressors

Industrial & Commercial Fans & Blowers & Air Purification Equip.

Packaging Machinery

Speed Changers, Industrial High Speed Drives & Gears

Mechanical Power Transmission Equipment NEC

General Industrial Machinery & Equipment, NEC

Scales & Balances, Except Laboratory

Automatic Vending Machines

Commercial Laundry, Dry Cleaning, & Pressing Machines

Commercial Laundry & Warm Air Heating Equipment & Commercial & Industrial Refrigeration Equipment

Measuring & Dispensing Pumps

Service Industry Machines, NEC

Fluid Power Cylinders & Actuators

Fluid Power Pumps & Motors

Industrial & Commercial Machinery & Equipment, NEC

Power Distribution & Specialty Transformers

Switchgear & Switchboard Apparatus

Motors & Generators

Relays & Industrial Controls

Electric & Gas Welding & Soldering Equipment

Electric Industrial Apparatus NEC

Heavy Construction Equipment Rental & Leasing

Equipment Rental & Leasing, NEC

Source: MP&M Phase II Detailed Questionnaire.

Table 2-2

Typical Unit Operations Performed at MP&M Sites

Unit Operation Name			
1.	Abrasive Blasting	25.	Hot Dip Coating
2.	Abrasive Jet Machining	26.	Impact Deformation
3.	Acid Treatment	27.	Laminating
4.	Adhesive Bonding	28.	Laser Beam Machining
5.	Alkaline Treatment	29.	Machining
6.	Anodizing	30.	Metal Spraying
7.	Assembly	31.	Painting
8.	Barrel Finishing	32.	Plating
9.	Brazing	33.	Plasma Arc Machining
10.	Burnishing	34.	Polishing
11.	Calibration	35.	Pressure Deformation
12.	Chemical Conversion Coating	36.	Rinsing
13.	Chemical Machining	37.	Salt Bath Descaling
14.	Corrosion Preventive Coating	38.	Soldering
15.	Disassembly	39.	Solvent Degreasing
16.	Electrical Discharge Machining	40.	Sputtering
17.	Electrochemical Machining	41.	Stripping
18.	Electrolytic Cleaning	42.	Testing
19.	Electroplating	43.	Thermal Cutting
20.	Electron Beam Machining	44.	Thermal Infusion
21.	Electropolishing	45.	Ultrasonic Machining
22.	Floor Cleaning	46.	Vacuum Metalizing
23.	Grinding	47.	Welding
24.	Heat Treating	48.	Wet Air Pollution Control

Source: MP&M Phase I Effluent Guideline Development Document.

Table 2-3

MP&M Phase I Process Water Discharge Flow and Primary Function of Process Water by Unit Operation

Unit Operation		Primary Function of Process Water Use				Total Estimated Industry Discharge Flow[(a)] (million gal/yr)
		Typically Dry or Not Performed	Process Solution or Rinse	Coolant/ Lubricant/ Flux	Other (see operation description)	
1.	Abrasive Blasting	✓	✓			5.81
1R.	Abrasive Blasting Rinse		✓			11.4
2.	Abrasive Jet Machining	✓	✓			33.8
2R.	Abrasive Jet Machining Rinse	✓	✓			0
3.	Acid Treatment		✓			110
3R.	Acid Treatment Rinse		✓			3,320
4.	Adhesive Bonding	✓			✓	0.464
4R.	Adhesive Bonding Rinse	✓				0
5.	Alkaline Treatment		✓			780
5R.	Alkaline Treatment Rinse		✓			4,230
6.	Anodizing		✓			6.12
6R.	Anodizing Rinse		✓			707
7.	Assembly	✓			✓	19.0
7R.	Assembly Rinse	✓	✓			0.340
8.	Barrel Finishing		✓			704
8R.	Barrel Finishing Rinse		✓			81.0
9.	Brazing	✓				0
9R.	Brazing Rinse		✓			3.64
10.	Burnishing			✓		1.59
10R.	Burnishing Rinse	✓	✓			26.5
11.	Calibration	✓			✓	0.00180
11R.	Calibration Rinse	✓				0
12.	Chemical Conversion Coating		✓			622
12R.	Chemical Conversion Coating Rinse		✓			2,100
13.	Chemical Machining		✓			2.24
13R.	Chemical Machining Rinse		✓			346
14.	Corrosion Preventive Coating	✓	✓			14.6
14R.	Corrosion Preventive Coating Rinse	✓	✓			51.1
15.	Disassembly	✓				0
15R.	Disassembly Rinse	✓				0
16.	Electrical Discharge Machining	✓	✓			1.70
16R.	Electrical Discharge Machining Rinse	✓				0
17.	Electrochemical Machining		✓			37.1
17R.	Electrochemical Machining Rinse		✓			28.3

Table 2-3 (Continued)

Unit Operation		Primary Function of Process Water Use				Total Estimated Industry Discharge Flow[a] (million gal/yr)
		Typically Dry or Not Performed	Process Solution or Rinse	Coolant/ Lubricant/ Flux	Other (see operation description)	
18.	Electrolytic Cleaning		✓			57.1
18R	Electrolytic Cleaning Rinse		✓			1,620
19.	Electroplating		✓			14.9
19R.	Electroplating Rinse		✓			1,180
20.	Electron Beam Machining	✓				0
20R.	Electron Beam Machining Rinse	✓				0
21.	Electropolishing		✓			0.0394
21R.	Electropolishing Rinse		✓			14.1
22.	Floor Cleaning		✓			120
22R.	Floor Cleaning Rinse		✓			2.43
23.	Grinding			✓		60.7
23R.	Grinding Rinse		✓			6.93
24.	Heat Treating	✓	✓		✓	594
24R.	Heat Treating Rinse	✓	✓			128
25.	Hot Dip Coating	✓		✓	✓	0.000638
25R.	Hot Dip Coating Rinse	✓	✓			73.2
26.	Impact Deformation	✓		✓		30.2
26R.	Impact Deformation Rinse	✓	✓			0.562
27.	Laminating	✓				0
27R.	Laminating Rinse	✓				0
28.	Laser Beam Machining	✓				0
28R.	Laser Beam Machining Rinse	✓				0
29.	Machining			✓		99.1
29R.	Machining Rinse	✓	✓			1.23
30.	Metal Spraying	✓			✓	0.0967
30R.	Metal Spraying Rinse	✓				0
31.	Painting	✓	✓		✓	309
31R.	Painting Rinse	✓	✓			1,020
32.	Plating		✓			5.02
32R.	Plating Rinse		✓			196
33.	Plasma Arc Machining	✓			✓	36.2
33R.	Plasma Arc Machining Rinse	✓				0
34.	Polishing	✓			✓	23.1
34R.	Polishing Rinse	✓	✓			13.9
35.	Pressure Deformation	✓		✓		41.3
35R.	Pressure Deformation Rinse	✓	✓			31.3
36.	Rinsing		✓			694

Table 2-3 (Continued)

Unit Operation	Primary Function of Process Water Use				Total Estimated Industry Discharge Flow[a] (million gal/yr)
	Typically Dry or Not Performed	Process Solution or Rinse	Coolant/ Lubricant/ Flux	Other (see operation description)	
37. Salt Bath Descaling		✓			484
37R. Salt Bath Descaling Rinse		✓			5.07
38. Soldering	✓		✓	✓	18.5
38R. Soldering Rinse	✓	✓			72.4
39. Solvent Degreasing[b]	✓				20.0
39R. Solvent Degreasing Rinse	✓	✓			53.7
40. Sputtering	✓				0
40R. Sputtering Rinse	✓				0
41. Stripping		✓			13.8
41R. Stripping Rinse		✓			273
42. Testing		✓			491
42R. Testing Rinse		✓			94.5
43. Thermal Cutting			✓		2.31
43R. Thermal Cutting Rinse	✓				0
44. Thermal Infusion	✓			✓	1.15
44R. Thermal Infusion Rinse	✓				0
45. Ultrasonic Machining	✓				0
45R. Ultrasonic Machining Rinse	✓				0
46. Vacuum Metalizing	✓				0
46R. Vacuum Metalizing Rinse	✓				0
47. Welding	✓		✓		19.0
47R. Welding Rinse	✓	✓			27.4
48. Wet Air Pollution Control				✓	1,610

Source: MP&M Phase I Development Document.

[a]These totals do not include process wastewater that is contract hauled off site.
[b]Note: Solvent degreasing operations reported as using process water are discussed under emulsion cleaning (see unit operation #5).

Table 2-4

Typical Metal Products and Machinery Unit Operations

Metal Shaping	Metal Finishing (Surface Preparation and Metal Deposition)
• Abrasive Jet Machining • Electrical Discharge Machining • Electrochemical Machining • Electron Beam Machining • Grinding • Heat Treating • Impact Deformation • Machining • Plasma Arc Machining • Pressure Deformation • Thermal Cutting • Ultrasonic Machining	• Abrasive Blasting • Acid Treatment • Alkaline Treatment • Anodizing • Barrel Finishing • Chemical Conversion Coating • Chemical Machining • Corrosion Preventive Coating • Electrolytic Cleaning • Electroless and Immersion Plating • Electroplating • Electropolishing • Hot Dip Coating • Mechanical Plating • Metallic Coating Stripping • Organic Coating Stripping • Salt Bath Descaling • Solvent Degreasing
Organic Deposition	**Assembly**
• Metal Spraying • Painting • Sputtering • Vacuum Metalizing	• Adhesive Bonding • Assembly • Brazing • Burnishing • Calibration • Disassembly • Laminating • Polishing • Soldering • Testing • Thermal Infusion • Welding

Source: MP&M Data Collection Portfolios, MP&M site visits, technical literature from MP&M effluent guideline development.

2.2.1.1 Metal Finishing Operations

Metal finishing operations include acid treatment, alkaline treatment, electroplating, electroless plating, chemical conversion coating, and anodizing. These operations are performed in the MP&M industry to remove unwanted surface materials, to alter the chemical or physical characteristics of a surface in preparation for subsequent operations, or to provide either a protective or decorative coating to a part. These operations are typically performed by dipping the part(s) into an open treatment bath and then into a subsequent rinse. Worker exposures will result from chemical addition to the process baths and from vapor generation from the open bath surface. Wastes generated from these operations are typically metal-bearing cleaning solutions and rinsewaters, concentrated metal-bearing solutions, dilute metal-bearing rinse waters, and dilute solvent-bearing wastewaters. These wastewaters are typically discharged to the on-site wastewater treatment system where they are treated to remove metals.

2.2.1.2 Metal Shaping Operations

Metal shaping operations (listed in Table 2-4) include various types of machining, grinding, impact deformation, pressure deformation, and heat treatment operations. These operations are performed in the MP&M industry to alter the physical form of raw materials to make intermediate and final products. Metal shaping operations can be performed with or without the use of metal-working fluids. Wet operations are typically performed by pumping the fluid from a trough, passing the fluid over the parts, filtering the fluid, and then returning it to the trough. Metal-working fluids are usually oil-water emulsions or oil-based lubricants. After extended use, metal-working fluids become contaminated with metals, tramp oils, and cleaning materials (e.g., chlorinated solvents), and will spoil without proper management and storage. The life of metal-working fluids can be increased at the source through methods and technologies such as oil skimming, centrifugation, biocide addition, and pasteurization. Once metal-working fluids can no longer be recycled they are typically sent to an on-site wastewater treatment area. Wastes generated from these operations include scrap metal, spent metal-working fluids, and metal-bearing wastewaters. Worker exposures from these operations result from mist generated by sprayed machining coolant and from volatilization of chemicals from the open surface of the catch basin.

2.3 Wastewater Treatment

MP&M facilities may dispose of their wastewater in a variety of ways. Many MP&M sites contract haul some or all of their process wastewater and some MP&M sites use but do not discharge process water. Based on information gathered during the development of the MP&M guidelines, sites can achieve zero discharge of process wastewater in one of the following ways:

- Sites contract haul for off-site disposal all process wastewater generated on site;
- Sites discharge process wastewater either to on-site septic systems or deep-well injection systems;
- Sites perform end-of-pipe treatment and reuse all process wastewater generated on site;
- Sites perform either in-process or end-of-pipe evaporation to eliminate wastewater discharges; or
- Sites perform in-process recirculation and recycling to eliminate wastewater discharges.

Sites that discharge process wastewater include direct discharging sites, indirect discharging sites, and sites that are both direct and indirect dischargers. An <u>indirect discharger</u> is a site that discharges wastewater to a publicly-owned treatment works (POTW) or a federally-owned treatment works (FOTW). A <u>direct discharger</u> is a site that discharges wastewater to a surface water. Sites discharging exclusively to privately-owned treatment works are considered <u>zero dischargers</u> that contract haul to centralized waste treatment facilities.

During the development of the MP&M Phase I guidelines it was determined that facilities that perform *metal finishing operations* and send their wastewater to on-site treatment will typically use chemical precipitation and sedimentation as forms of treatment. There is a wide variety of other treatment options available, including microfiltration and ion exchange. Although these options are available they are not as widely utilized. Therefore, this generic scenario only assesses releases and exposures of metal finishing operations from chemical precipitation and related preliminary treatment processes.

Development of the MP&M Phase I guidelines also determined that facilities that perform *metal shaping operations* and send their wastewater to on-site treatment will typically use oil/water separation followed by chemical precipitation. During the Phase II guideline development process it has been observed that over the past nine years there has been a dramatic shift towards treatment by ultrafiltration prior to oil/water separation. Thus both ultrafiltration and oil/water separation are discussed in this generic scenario when referring to metal shaping operations.

2.3.1 Chemical Precipitation and Sedimentation

Chemical precipitation and sedimentation is a common process used to remove dissolved metals from wastewater. A typical chemical precipitation process is shown in Figure 2-1. The dissolved metals are converted to an insoluble form and separated from the wastewater. There are several basic methods of performing this process and many variations of each method. The four most common methods are hydroxide precipitation, sulfide precipitation, carbonate precipitation, and sodium borohydride precipitation. Hydroxide precipitation is the most common method of metals removal from MP&M wastewater, however, it is not designed to remove oil and grease or organic compounds. In treatment of MP&M operations, any oil and grease or organics removed is incidental.

The types of equipment used for chemical precipitation and sedimentation vary widely. Small batch operations can be performed in a single tank, usually having a conical bottom that permits removal of settled solids. Continuous processes are usually performed in a series of tanks, including a rapid mix tank for mixing the precipitating chemicals, a slow mix tank for addition of coagulants and flocculants and floc formation, and a settling tank or

Figure 2-1. Chemical Precipitation and Sedimentation

clarifier for separation of the solids from the wastewater. An alternative method of separating precipitated solids from wastewater is filtration, during which the entire wastewater flow is passed through either a filter press or a microfiltration unit.

The chemical precipitation systems will often be preceded by chemical reduction of hexavalent chromium or cyanide destruction through alkaline chlorination. These pretreatments are not designed to remove contaminants. Their purpose is to destroy target pollutants.

2.3.1.1 Chemical Reduction of Hexavalent Chromium

Sulfur dioxide, sodium bisulfite, sodium metabisulfite, and ferrous sulfate form strong reducing agents in water. These agents are often used at MP&M sites to reduce hexavalent chromium to the trivalent form, which allows the metal to be removed from solution by chemical precipitation. Chromium reduction is necessary because hexavalent chromium does not form a hydroxide, and therefore is not affected if hydroxide precipitation is utilized for chromium removal.

2.3.1.2 Cyanide Destruction through Alkaline Chlorination

Cyanide destruction through alkaline chlorination is widely used in industrial wastewater treatment. Chlorine is typically used as either chlorine gas or sodium hypochlorite. The alkaline chlorination process oxidizes cyanides to carbon dioxide and nitrogen. The equipment often consists of an equalization tank followed by two reaction tanks, although a batch reaction can be conducted in a single tank. Each tank has an electronic controller to monitor and maintain the required pH and oxidation reduction potential (ORP). In the first reaction tank, conditions are adjusted to oxidize cyanides to cyanates. To affect the reaction, chlorine or sodium hypochlorite is metered to the reaction tank as necessary to maintain the ORP at 350 to 400 millivolts, and aqueous sodium hydroxide is added to maintain a pH of 10 to 11. In the second reaction tank, the ORP and the pH level are maintained at 600 millivolts and 8 to 9, respectively, to oxidize cyanate to carbon dioxide and nitrogen. Each reaction tank has a chemical mixer designed to provide approximately one turnover per minute. The batch process is usually accomplished by using two tanks, one to collect water over a specified time period and one to treat an accumulated batch. When the holding tank is full, the liquid is transferred to the reaction tank for treatment.

2.3.2 Chemical Emulsion Breaking with Oil/Water Separation

Chemical emulsion breaking is used to break stable oil/water emulsions (oil dispersed in water, stabilized by electrical charges and emulsifying agents). Treatment of spent oil/water emulsions involves adding chemicals to break the emulsion followed by oil/water separation. The major equipment required for chemical emulsion breaking includes reaction chambers with agitators, chemical storage tanks, chemical feed systems, pumps, and piping. Factors to be considered for destroying emulsions are type of chemicals, dosage and sequence of addition, pH, mixing, heating requirements, and retention time.

Chemicals (e.g. polymers, alum, ferric chloride, and organic emulsion breakers) break emulsions by neutralizing repulsive charges between particles, precipitating or salting out emulsifying agents, or weakening the interfacial film between the oil and water so it is readily broken. Once the charges have been neutralized or the interfacial film broken, the small oil droplets and suspended solids either adsorb on the surface of the floc that is formed, or break out and float to the top. The oil floats to the surface of the water because of the difference in specific gravities between the oil and the water. Solids usually form a layer between the oil and water, since some solids become suspended in the oil. Oils and solids are typically skimmed from the surface of the water in a subsequent step after chemical emulsion breaking.

To separate oil from process solutions, oil skimming devices are typically mounted onto the side of a tank and operated on a continuous basis. Common separation devices include belts, rotating drums, disks, and weir oil skimmers and coalescers. Belt and drum skimmers operate in a similar manner, with either a continuous belt or drum rotating partially submerged in a tank. As the surface of the belt or drum emerges from the liquid, the oil that adheres to the surface is scraped off (drum) or squeezed off (belt) and diverted to a collection vessel. Gravity separators use overflow and underflow weirs to skim a floating oil layer from the surface of the wastewater. A weir allows the oil layer to flow over the weir into a trough for disposal or reuse while most of the water flows underneath the weir.

A skimmer's removal efficiency depends on the composition of the waste stream and the retention time of the water in the tank. Gravity-type separators tend to be more effective for wastewater streams with consistently large amounts of surface oil. Drum and belt type skimmers are more applicable to waste streams containing smaller amounts of floating oil.

Oil separation not only removes oil but also removes organics that are more soluble in oil than in water. Subsequent clarification removes organic solids directly and probably removes dissolved organics by adsorption on inorganic solids. In MP&M operations, sources of these organics are mainly process coolants and lubricants, additives to formulations of cleaners, paint formulations, or leaching from plastic lines and other materials.

Solid wastes generated by chemical emulsion breaking include surface oil and oily sludge, which are usually contract hauled for disposal by a licensed contractor. If the recovered oil contains a low enough percentage of water, it may be burned for its fuel value or processed and reused.

2.3.3 Ultrafiltration

Ultrafiltration is a pressure-driven membrane process used to separate solution components based on molecular size and shape. Using an applied pressure difference across a membrane, solvent and small solute species pass through the membrane and are collected as permeate while larger compounds are retained by the membrane and recovered as concentrate.

Filtration configurations can be either "dead-end" flow configurations, where the fluid flow is directed at a right angle to the membrane surface, or tangential-flow configurations, where the fluid flow is parallel to the membrane surface. Tangential-flow configurations are more common at MP&M facilities, based on information from site visits and surveys. Several types of tangential-flow configurations are available, including plate and frame, hollow fiber, tubular, and spiral-wound. The systems are typically operated in batch or semibatch mode, in which a batch of wastewater is recirculated from a holding tank through the filter. The concentrate is returned to the holding tank while a continuous stream of permeate is discharged. The concentrate remaining in the holding tank is typically batch discharged.

2.3.4 Evaporation

Evaporation is a common chemical recovery technology. There are two basic types of evaporators: atmospheric and vacuum. Atmospheric evaporators are more prevalent. Vacuum evaporators are typically used when evaporation rates greater than 50 - 70 gph are required. There are two typical methods of evaporation: 1) evaporate the water and then condense the water for reuse in baths and rinses, and 2) evaporate the water and reuse the concentrate (the process solution that remains after the water is evaporated) in process baths. Of the 91 MP&M screener surveys reporting evaporation technology, all use the first method. If the first method is used, any solid wastes remaining in the tank are contract hauled off-site for incineration or reclaimation.

3.0 BASIS OF ESTIMATION APPROACH

This section discusses the data collection activities performed by the U.S. EPA during the development of the proposed MP&M Phase I guidelines and the further development of the combined (Phase I and Phase II) guidelines (see Section 2.1 for a discussion of Phase I and Phase II). These data were used as the primary source for the development of this generic scenario. A discussion of the data used and uncertainties is also included.

3.1 Survey Activities

In August and September 1990, EPA's Office of Water mailed 8,342 mini data collection portfolios (MDCPs), or screener questionnaires, to sites believed to be engaged in MP&M manufacturing, rebuilding, or maintenance activities. Mailout of the MDCP was the preliminary step in an extensive data-gathering effort for the MP&M category. The purpose of the MDCP was to identify sites to receive the more detailed data collection portfolio (DCP) and to make a preliminary assessment of Phase I of the MP&M industry. The Agency requested the following site-specific information in the MDCP:

- Name and address of facility;
- Contact person;
- Parent company;
- Sectors in which the site manufactures, rebuild, or maintain machines or metal components;
- SIC codes corresponding to products at the site;
- Number of employees;
- Annual revenues;
- Unit operations performed at the site;

- Whether there is process water use and/or wastewater discharge for each unit operation performed at the site; and

- Base metal(s) on which each unit operation is performed.

Of the total potential respondents, 84% (6,981) returned the MDCP to EPA. Approximately 52% of the MDCP respondents reported that the site was engaged in MP&M operations.

Based on responses to the MDCP, EPA sent a more detailed questionnaire to 1,020 water-using MP&M sites. This questionnaire, or data collection portfolio, was designed to collect detailed technical and financial information. This information was used to characterize MP&M Phase I sites, develop pollutant loadings and reductions, and develop compliance cost estimates. EPA selected the DCP recipients from the following three groups of sites:

- Water-discharging Phase I MDCP respondents (860 recipient sites);

- Water-using Phase I MDCP respondents that did not discharge process water (74 recipient sites); and

- Water-discharging sites from key Phase I companies that did not receive the MDCP (86 recipient sites).

The Agency designed the DCP to collect information necessary for the development of effluent guidelines and standards for the MP&M industry. The DCP was divided into the following six parts, described below:

- Part I - General Information;
- Part II - Process Information;
- Part III - Water Supply;
- Part IV - Wastewater Treatment and Discharge;
- Part V - Process and Hazardous Wastes; and
- Part VI - Financial and Economic Information.

Part I (questions 1 through 13) requested information necessary to identify the site, to characterize the site by certain variables (including number of employees, facility age, and location), and to confirm that the site was engaged in MP&M operations. This information included: site name, address, contact person, number of employees, facility age, average energy usage, discharge permit status, and MP&M activity (manufacturing, rebuilding, or maintenance).

Part II (questions 14 through 21) requested detailed information on MP&M products, production levels, unit operations, activity, water use for unit operations, wastewater discharge from unit operations, miscellaneous wastewater sources, waste minimization practices (e.g., pollution prevention), and air pollution control for unit operations. The site was requested to provide detailed technical information (e.g., water balance, chemical additives, metal type processed, disposition of wastewater) for each MP&M unit operation and air pollution control device using process water. This section also requested information on unique and/or auxiliary MP&M operations. This information was used to evaluate raw waste characteristics, water use and discharge practices, and sources of pollutants for each MP&M unit operation.

Part III (question 22) requested information on the water supply for the site. The site was required to specify the source water origin, average intake flow, average intake operating hours, and the percentage of water used for MP&M operations. This information was used to evaluate overall water use for the site.

Part IV (questions 23 through 33) requested detailed information on MP&M influent and effluent wastewater treatment streams and wastewater treatment operations. The information requested included: the origin of each stream contributing to the site's overall wastewater discharge; a block diagram of the wastewater treatment system; detailed technical information (e.g., wastewater stream flow rates, treatment chemical additives, system capacity, disposition of treatment sludge) for each wastewater treatment operation; self-sampling monitoring data; and capital and operating cost data. EPA collected this information to evaluate treatment in place at MP&M sites, to develop and design a cost model for Phase I of the MP&M industry, and to assess the long-term variability of MP&M effluent streams.

Part V (question 34) requested detailed information on the types, amounts, and composition of wastewater and solid/hazardous wastes generated during production or waste treatment, and the costs of solid waste disposal. This information was collected to evaluate the types and amounts of wastes currently discharged, the amount of waste that is contract hauled off site, and the cost of contract hauling wastes.

Part VI requested detailed financial and economic information from the site and the company owning the site. Information from this part presented in the Industry Profile and Economic Impact documents for Metal Products and Machinery Industry Phase I, which are both included in the administrative record for the proposed rulemaking.

Of the 1,020 DCPs mailed, 792 were returned. Of these, 75 facilities were determined to be engaged in both Phase I and Phase II activities, 87 were engaged in Phase II activities only, and 630 were engaged in Phase I activities only. The data from these surveys was then scaled-up based on statistical weighting factors to provide estimates of the national population of MP&M water discharging sites with regard to size, location, sector, unit operations, metal types, discharge flow, and production normalized flows.

For the purposes of this generic scenario, results from responses to Part II through Part IV of the DCP were evaluated.

3.2 Site Visits

The Agency visited 201 MP&M sites between 1986 and August 1999 to collect information about MP&M unit operations, water use practices, pollution prevention, treatment technologies, and waste disposal methods; and to evaluate sites for potential inclusion in the MP&M sampling program (described in Section 3.3) to support development of the effluent guidelines. In general, the Agency selected sites for these visits to encompass the range of sectors, unit operations, and wastewater treatment technologies within the MP&M industry including both Phase I and Phase II sites. The Agency based site selection on information contained in the MP&M MDCPs and DCPs, and contacts with regional EPA personnel, state environmental agency personnel, and local pretreatment coordinators. The Agency used the following four general criteria to select sites that encompassed the range of sectors and unit operations within the MP&M industry.

1. The site performed MP&M unit operations in one of the industrial sectors. To assess the variation of unit operations and water use practices across the sectors, the Agency visited sites in each of the MP&M sectors;

2. The site performed MP&M unit operations that needed to be characterized for development of the regulation;

3. The site had water use practices that were believed to be representative of the best sites within an industrial sector; and

4. The site operated in-process source reduction, recycling, or end-of-pipe treatment technologies considered in development of the MP&M technology options.

The Agency also attempted to visit sites of various sizes. EPA visited sites with wastewater flows ranging from less than 200 gallons per day to more than 1,000,000 gallons per day. During the site visits, EPA collected the following types of information:

- Unit operations performed at the site and the types of metals processed through these operations;

- Purpose of unit operations performed and purpose for any process water and chemical additions used by the unit operations;

- Types and disposition of wastewater generated at the site;

- Types of in-process source reduction and recycling technologies performed at the site;

- Cross-media impacts of in-process source reduction and recycling technologies;

- Types of end-of-pipe treatment technologies performed at the site; and

- Logistical information required for sampling.

This information has been compiled into a database, which was used during the development of the MP&M generic scenario.

3.3 Wastewater and Solid Waste Sampling

The Agency conducted sampling episodes at 72 sites between 1986 and 1999 to obtain data on the characteristics of MP&M wastewaters and solid wastes, and to assess the following: the loading of pollutants to surface waters and POTWs from MP&M sites; the effectiveness of technologies designed to reduce and remove pollutants from MP&M wastewater; and the variation of MP&M wastewater characteristics across unit operations, metal types processed in each unit operation, and sectors. The Agency used the following general criteria to select sites for sampling:

- The site performed MP&M unit operations EPA was evaluating for development of the MP&M regulation;
- The site processed metals through MP&M unit operations for which the metal type/unit operation combination needed to be characterized for the sampling database;
- The site performed in-process source reduction, recycling, or end-of-pipe treatment technologies that EPA was evaluating for technology option development; and
- The site performed unit operations in a sector that EPA was evaluating for development of the MP&M regulation.

The Agency also attempted to sample at sites of various sizes. EPA sampled at sites with wastewater flows ranging from less than 200 gallons per day to more than 1,000,000 gallons per day. Analytical data from sampling activities was used in the development of the MP&M generic scenario.

3.4 Rationale for Grouping Data

As mentioned in Section 2.2.2 of this document, EPA grouped the 48 MP&M unit operations into six groups for development of the effluent guidelines: metal shaping operations, surface preparation operations, metal deposition operations, organic deposition operations, surface finishing operations, and assembly operations. The Agency chose these groupings based on similarity of purposes of the unit operations within each group. The development of this generic scenario also considered comparability between process descriptions, environmental releases, and worker exposures. Based on the rationale discussed below, this generic scenario separated MP&M into two primary subgroups: metal shaping and metal finishing. Assessment methodologies are presented for each.

Upon evaluation of the industry it was found that surface preparation operations, metal deposition operations, and surface deposition operations, although performed for different reasons, are performed in a similar manor and result in similar releases and occupational exposures. Due to their similarities, surface preparation, metal deposition, and surface deposition operations have been grouped as metal finishing operations for the purposes of this generic scenario.

When using water, metal finishing operations require parts to be dipped into an open process bath. Many of the operations also require a subsequent rinse. These process baths will be situated in “lines” within a facility with several different baths and rinses on each line. A typical electroplating line, for example, would consist of an alkaline cleaning bath and subsequent rinse, an electrocleaning bath and rinse, an acid treatment bath and rinse, an electroplating bath and rinses, and a final hot water rinse. In older process lines, workers are required to stand in front of the baths while parts are being processed, thus being exposed in the same way to each process step. Newer process lines are frequently automated. Environmental releases from these processes occur from both the occasional disposal of the process baths and from dragout. Dragout is the extra process solution remaining on parts leaving the process baths. This extra solution is captured in the subsequent process rinses.

Metal finishing operations are designed to add or remove metal or contaminants from a part. Therefore, the main disposal concern from these baths is metal contamination. Chemical precipitation and sedimentation is the most commonly used method of treatment prior to disposal. Some systems may have cyanide destruction, chromium reduction, or oil/water separation prior to chemical precipitation. Some facilities have replaced the system clarifier with microfiltration, but this method is typically more expensive and is not widely used at the present time.

Metal shaping operations, like metal finishing operations, can be performed either wet or dry. Grinding operations, for example, can include, but do not require the use of lubricants. If a metal-working fluid is necessary, it is stored in a trough located within the process machinery or in a neutralized sump serving multiple grinding units. The fluid is pumped as needed from the trough or sump and sprayed over the part for lubrication and cooling during operation. The fluid becomes contaminated with tramp oils (usually hydraulic oils) and metal fines as it is used. The bulk of the fines are filtered from the coolant, the tramp oil is skimmed, and the fluid is recycled to the trough or sump. As the fluid becomes unusable, it may be removed from the trough and sent through a recycling system (e.g., centrifugation or pasteurization) to extend its life. These units thoroughly remove the metal fines and tramp oils and help to destroy any bacteria that has grown in the fluid. The metal-working fluids are then returned to the trough for further reuse. Workers standing over the machines will be exposed to mist from the spraying of the fluid during operation. Unlike metal finishing, the part is not usually rinsed following shaping, but is allowed to drip dry. The fluid will be collected and combined with the process contaminated fluids, then treated. Dragout will primarily remain on the part or the metal fines. Regardless of the type of operation, the metal-working fluid will eventually breakdown and need to be disposed, thus resulting in an environmental release.

When metal-working fluids can no longer be recycled they are usually treated by either oil/water separation or ultrafiltration, typically followed by chemical precipitation and sedimentation. Data gathering for the development of the MP&M Phase I effluent guidelines occurred between 1989 and 1993. During this time is was seen that oil/water separation followed by chemical precipitation was the most frequently performed method of disposal. However, during data collection for the combined guidelines (1995 to 2000) it has been observed that more facilities are employing ultrafiltration either as a stand alone treatment operation or followed by chemical precipitation and sedimentation because it is more effective at removing oils (including emulsions) and organic constituents that are present in metal-working fluids (analysis of data gathered during guideline development has shown ultrafiltration to be over 90% effective in removing organics).

3.5 Data Excluded from Consideration for the Generic Scenario

Several of the 48 MP&M unit operations listed in Section 2.2.1 were not included in the development of this generic scenario. The rationale for excluding these operations is discussed in Sections 3.5.1 through 3.5.4.

3.5.1 Dry Operations Including Assembly Operations

Many operations involved in the MP&M industry are “dry” operations, meaning that they do not require the use of water. Data for these operations were not gathered during the development of the MP&M guideline. These operations include some forms of grinding and machining, polishing, and all assembly operations. Dry operations are not expected to involve the use of PMN chemicals and are not discussed in this generic scenario.

3.5.2 Organic Deposition Operations

Organic deposition operations include any type of painting operation. Painting operations are not exclusive to the MP&M industry and are similar to those presented in existing generic scenarios; therefore, these operations are not discussed in this generic scenario.

3.5.3 Spray Cleaning Operations

Alkaline and acid cleaning operations (contained under the grouping of metal finishing operations) are sometimes performed in spray applications. Spray cleaning is not an operation that is exclusive to the MP&M industry and is comparable to spray operations discussed in other generic scenarios. Therefore, spray applications for alkaline and acid cleanings are not considered in this generic scenario.

3.6 Assumptions

In order to generalize a very broad industry, several assumptions were made during the development of this generic scenario. It was assumed that all metal finishing waste reported as being contract hauled is treated through chemical precipitation. Likewise, it was assumed that contract hauled metal shaping wastes are treated via ultrafiltration or oil/water separation. These assumptions are based on knowledge gained through industrial site visits and sampling episodes.

Based on previous PMNs, it was assumed that future PMNs will be organic in nature. The removal efficiency of wastewater treatment was therefore determined through the removal efficiencies of organics, using total organic carbon (TOC) as an indicator for organics (MP&M Public Record W-99-23, Sect. 6.3, DCN 16030).

4.0 ESTIMATION METHODOLOGIES FOR METAL FINISHING

This generic scenario contains several levels of detail that can be used for making release and exposure assessments, based on the amount of information provided by the submitter. The first step of the assessment methodology is to estimate the percent PMN chemical in the bath or trough. Section 4.1 presents the methodology for this estimate. Subsequent sections then discuss the methodology for release and exposure estimates. As previously stated, distinct assessment methodologies are presented for metal finishing and for metal shaping chemicals.

4.1 Percent PMN in Baths

If the submission provides enough data to determine the exact type of metal finishing operation (e.g., gold electroplating, alkaline etching) and the chemical's primary function (e.g., metal source, pH adjustment, cleaner) in the operation, then Table 4-1 should be referenced. Based on the specific metal finishing operation, the table contains the expected percent of the chemical component (e.g., metal source, pH adjustment, cleaner) within each finishing bath. The percent of PMN in the finishing bath can be determined by multiplying the percentage of PMN in the chemical component by the percent of the chemical component in the finishing bath from Table 4-1. Data in this table is based on bath concentrations listed in the 1991 issue of the Metal Finishing Guidebook.

If the submitter provides only a general type of metal finishing operation (electroplating, alkaline cleaning) and the primary function of the new chemical (e.g., metal source, pH adjustment, cleaner) then Table 4-2 should be referenced. Based on the general metal finishing type, the table contains the expected percent of the chemical component within each metal finishing bath. The percent of PMN in the finishing bath can be determined by multiplying the percentage of PMN in the chemical component by the percent of the chemical component in the finishing bath from Table 4-2.

If the submission does not provide a primary function for the new chemical, then Table 4-3 should be referenced. This table contains a list of common chemicals used in metal

Table 4-1

Finishing Bath Composition Listed by Metal Finishing Operation and Function of Chemical Containing PMN

OPERATION	PERCENT OF CHEMICAL COMPONENT IN FINISHING BATH				
	Cleaner	Miscellaneous	Metal Source	pH adjustment	Cyanide Source
Alkaline Cleaner	8.85	7.18	-	-	-
Alkaline Etching	3.13	-	-	-	-
Electrocleaning	7.60	4.05	-	-	-
Acid Bright Dipping	13.56	3.13	-	-	-
Acid Cleaning	38.70	1.20	-	-	-
Brass Electroplating	-	0.36	2.67	1.92	7.59
Cadmium Electroplating	-	5.02	2.34	2.33	9.10
Chromium Electroplating	-	0.25	22.72	18.43	-
Copper Electroplating	-	3.77	10.39	2.74	5.96
Gold Electroplating	-	5.10	0.96	5.83	4.02
Indium Electroplating	-	2.36	10.38	3.36	8.68
Iron Electroplating	-	5.19	15.92	-	-
Nickel Electroplating	-	2.77	22.97	-	-
Palladium Electroplating	-	6.94	3.38	-	-
Platinum Electroplating	-	5.80	6.20	22.84	-
Rhodium Electroplating	-	6.93	0.20	-	-
Ruthenium Electroplating	-	1.38	0.36	-	-
Silver Electroplating	-	1.46	2.01	-	-
Tin/lead Electroplating	-	0.71	26.92	10.46	-
Lead Electroplating	-	0.79	18.90	1.66	-
Tin Electroplating	-	-	7.86	12.54	-
Tin/nickel Electroplating	-	1.76	6.56	-	-
Zinc Electroplating	-	5.80	1.73	6.85	4.71
Nickel Electroless Plating	-	3.99	2.86	-	-
Copper Electroless Plating	-	2.13	1.45	-	-
Gold Electroless Plating	-	0.23	0.30	-	0.04
Palladium Electroless Plating	-	1.60	1.00	-	-
Cobalt Electroless Plating	-	3.30	2.80	-	-
Anodizing	-	-	-	12.95	-
Conversion Coating	-	1.20	0.11	2.32	0.25
Plating Stripping	-	9.84	-	19.23	4.89
Metal Finishing Average[a]	**14.37**	**3.37**	**5.10**	**8.82**	**5.03**

Source: Metal Finishing Guidebook, 1991
[a]Default
- Indicates that the Metal Finishing Guidebook did not include chemicals used for this function in the bath formulation.

Table 4-2

Finishing Bath Composition Listed by General Metal Finishing Operation and Function of Chemical Containing PMN

OPERATION	PERCENT OF CHEMICAL COMPONENT IN FINISHING BATH				
	Cleaner	**Miscellaneous**	**Metal Source**	**pH Adjustment**	**Cyanide Source**
Alkaline Cleaning	6.53	5.62	-	-	-
Acid Cleaning	26.13	2.17	-	-	-
Electroplating	-	3.32	9.03	8.09	6.68
Electroless Plating	-	2.25	1.68	-	0.04
Anodizing	-	-	-	12.95	-
Conversion Coating	-	1.20	0.11	2.32	0.25
Plating Stripping	-	9.84	-	19.23	4.89
Metal Finishing Average[a]	**14.37**	**3.37**	**5.10**	**8.82**	**5.03**

Source: Metal Finishing Guidebook, 1991
- Indicates that the Metal Finishing Guidebook did not include chemicals used for this function in the bath formulation.
[a] Metal Finishing Average represents the average of the numbers listed in Table 4-1. This value is recommended as the default value.

Table 4-3

Common Chemicals Found in Metal Finishing Baths Listed by Primary Function

PRIMARY FUNCTION	CHEMICALS
Metal Source	nickel sulfate, copper sulfate, gold cyanide, palladium chloride, cobalt chloride, nickel chloride, copper acetate, gold chloride, palladium bromide, cobalt sulfate, copper carbonate, potassium aurate, copper formate, copper nitrate
pH adjustment	ammonium hydroxide, hydrochloric acid, potassium hydroxide, sulfuric acid, phosphoric acid, sodium hydroxide, caustic soda
Miscellaneous	sodium borohydride, Formate, sodium hypophosphite, Formaldehyde, Hydrazine, dimethylamine borane (DMAB), potassium borohydride, potassium cyanoborohydride, triethylamine borane, hydrazine sulfate, sodium phosphate, ammonia, rochelle salt, potassium citrate, methylamine, sodium citrate, EDTA, sodium borate, potassium tartrate, ammonium chloride, potassium tartrate, sodium acetate, sodium pyrophosphate, fluoride compounds, thiourea, Thiodiglycolic acid, thioorganic compounds (i.e urea), heavy metal salts, alkali hydrogen fluoride, mercaptobenzothiazole (MBT), acetylacetone, triethanolamine, vanadium oxide, thiocyanates, oxy anions (i.e. iodates), thallium salts, selenium salts
Cyanide Source	zinc cyanide, copper cyanide, sodium cyanide, potassium cyanide, potassium gold cyanide, potassium nickel cyanide, potassium copper cyanide, potassium silver cyanide
Cleaner	sodium sulfate, rochelle salts, sodium hydroxide, sodium carbonate (anhydrous), trisodium phosphate, ammonium bifluoride, sodium chloride, ferric chloride, nitric acid, hydrofluoric acid, sulfuric acid, molybdic acid, hydrofluosilic acid, phosphoric acid, acetic acid, chromic acid, hydrochloric acid citric acid, oxalic acid, sulfamic acid

Source: Metal Finishing Guidebook, 1991

finishing baths and their function. Based on the expected function, the PMN assessor can then reference Table 4-2 to determine the percent of the chemical component and PMN chemical in the bath.

If the submitter provides only enough information to determine that the new chemical is to be used in metal finishing operations then the “default metal finishing average” listed at the end of Tables 4-1 and 4-2 should be used.

4.2 Estimating Environmental Releases and Occupational Exposures

All wet metal finishing processes considered in this generic scenario require parts to be dipped into an open process bath for a period of time. Many of the operations also require a subsequent rinse. These process baths are usually situated in “lines” within a facility with several different baths and rinses on each line. A typical electroplating line, for example, would consist of an alkaline cleaning bath and following rinse, an electrocleaning bath and rinse, an acid treatment bath and rinse, an electroplating bath and rinses, and a final hot water rinse. It is assumed that the PMN is present in only one type of metal finishing operation. Environmental releases from these processes occur from both the occasional disposal of the process baths and from dragout. Dragout is the extra process solution that remains on parts leaving the process baths. The dragout is captured in subsequent rinses and discharged to on-site treatment. The methodology used to complete an IRER or to further assess a PMN for MP&M chemicals in the subgroup of "Metal Finishing" is described below. If the PMN is present in multiple types of metal finishing operations, releases and exposures must be calculated for each type separately, then added together for overall facility values.

Table 4-4 includes additional information needed to estimate the releases and exposures based on the calculations presented in Section 4.2. These data are a compilation of information from the Phase I DCP.

Table 4-4

Information Required for Metal Finishing Release and Exposure Calculations

Metal Finishing Operation	Average Number of Shifts of Operation/Day	Average Time of Operation (Hours/Day)	Days of Operation/ Yr	Average Number of Baths or Machines Containing PMN/ Facility	Average Number of Baths Containing PMN/Line	Average Number of Times a Bath is Changed/Yr
Plating Stripping	1	7.06	155.93	2.13	1	22.84
Electroless Plating	2	9.28	212.89	2.63	3	18.27
Electroplating	2	8.17	220.94	9.88	3	11.25
Electrolytic Cleaning	1	7.86	227.10	4.03	1	10.20
Corrosion Preventative Coating	2	12.68	238.84	2.89	1	16.08
Conversion Coating	1	7.07	201.27	3.88	3	67.43
Anodizing	2	11.94	234.58	8.76	3	23.46
Alkaline Cleaning	2	9.34	230.45	5.02	1	234.47
Alkaline Chemical Etching	2	14.44	231.64	2.37	1	8.78
Acid Cleaning	1	7.57	217.96	4.25	1	60.70
Acid Pickling	2	9.20	200.93	3.54	1	30.32
Acid Bright Dripping	2	10.26	213.87	3.39	1	44.77
Average Values for Metal Finishing	**2**	**9.6**	**220**	**4.4**	**1.7**	**46**

Source: MP&M detail questionnaire database and site visit reports.

4.2.1 General Facility Estimates

Number of Facilities

The number of MP&M facilities that can be expected to receive the PMN chemical can be estimated by dividing the PMN yearly production volume by the average yearly facility use rate. The use rate is dependent upon the PMN chemical lost from bath changes and dragout. It can be calculated based on results of the MP&M DCP questionnaire from the average number of baths per facility, average bath size, average number of bath changes per year, and the average percent PMN per bath. The calculation for the estimated number of facilities is presented below:

$$F = \frac{PV}{(C)(NB)(BS)(BC) + (C)(NB)(D)} \tag{4-1}$$

where:

BC	=	Number of times a bath is changed/yr from Table 4-4 (default value = 45.7)
BS	=	Average bath size (kg) (default value = 2,271 kg)
C	=	% PMN in bath from Table 4-1 or 4-2 (kg_{PMN}/kg_{BATH})
D	=	Dragout (kg_{BATH}/yr) (default value = 9,001 kg/yr-bath)
F	=	Number of facilities
NB	=	Average number of baths/facility containing PMN from Table 4-4 (default value = 4.4)
PV	=	PMN production volume (kg/yr)

Number of Workers

Occupational exposure will result from workers standing in front of the baths that contain the PMN chemical while parts are being processed. Metal finishing processes typically only require one worker per line. One maintenance worker per shift is also expected to be exposed to the PMN chemical. The total number of workers can be calculated below:

$$NW = \left(\frac{1\ \text{worker}}{\text{shift}\cdot\text{line}}\right)\frac{(NB)(F)(S)}{(NTP)} + \left(\frac{1\ \text{worker}}{\text{shift}\cdot\text{facility}}\right)(S)(F) \tag{4-2}$$

where:

F	=	Number of facilities (submission or Equation 4-1)
NB	=	Average number of baths/facility containing PMN from Table 4-4 (default value = 4.4)
NTP	=	Average number of baths containing PMN/line from Table 4-4 (default value = 1.7)
NW	=	The total number of workers required for the given PV
S	=	Number of shifts per day from Table 4-4 (default value = 2)

4.2.2 Water Releases

EPA estimates that 52.33% of facilities dispose of the wastewater from bath changes and dragout via an on-site wastewater treatment system consisting of chemical precipitation and sedimentation; 37.92% of facilities discharge their process baths and dragout to water without treatment; and 9.74% dispose of their process baths through either incineration, evaporation, or a variety of other methods (see Section 4.2.6). These (9.74%) facilities will send only the dragout amount of the PMN chemical to on-site wastewater treatment. The facilities that send wastewater from both bath changes and dragout to an on-site wastewater treatment system will send 100% of the PMN chemical to treatment. Process baths, although only discharged periodically throughout the year, are typically bled into the treatment system on a daily basis.

EPA is currently proposing to use total organic carbons (TOC) as an indicator for all organic constituents based on statistical analysis (MP&M Public Record, W-99-23, DCN 16030). Most new chemical substances used in the MP&M industry are expected to be a new form of organic constituent. This generic scenario assumes the efficiency of TOC removal, determined from the DCP survey, to estimate the amount of new chemical that is removed by wastewater treatment and subsequently released. Analytical results from MP&M sampling episodes have shown that chemical precipitation and sedimentation is typically used in the metal finishing wastewater treatment systems. Based on the MP&M data, this treatment provides 8.4% incidental removal of total organic carbons which is transferred to a filter cake residual that may be disposed through landfill or incineration (see Appendix A). The calculation required to estimate the amount of PMN remaining in wastewater discharged from facilities with on-site wastewater treatment systems (WR_{WWT}) is presented below:

$$WR_{WWT} = \frac{(0.5233)\ (0.916)\ (PV)}{(F)(DPY)} \tag{4-3}$$

where:

52.33	=	Percent of facilities that send process baths to on-site wastewater treatment
91.6	=	The percent of PMN that passes through the wastewater treatment system and is released to water
DPY	=	Days of facility operation/yr from Table 4-4 (default value = 216)
F	=	Number of facilities (submission or Equation 4-1)
PV	=	PMN production volume (kg/yr)
WR_{WWT}	=	Water releases (kg/site-day) for facilities sending process baths and dragout to wastewater treatment

The calculation required to estimate the amount of PMN in wastewater from facilities that treat their process baths through other methods (WR_{OT}) is presented below:

$$WR_{OT} = \frac{(0.0974)\ (0.916)\ (C)\ (NB)\ (D)}{(DPY)} \tag{4-4}$$

where:

9.74	=	Percent of facilities that send process baths to either incineration, evaporation, or other methods
91.6	=	Percent of PMN that passes through the wastewater treatment system and is released to water
C	=	% PMN in bath from Table 4-1 or 4-2 (default value for cleaners = 14.37%, others = 8.82%)
D	=	Dragout (kg_{BATH}/yr) (default value = 9,001 kg/yr-bath)
DPY	=	Days of facility operation/yr from Table 4-4 (default value = 216)

NB	=	Average number of baths/facility from Table 4-4 (default value = 4.4)
WR_{OT}	=	Water releases (kg/site-day) for facilities that treat process baths through other methods

The calculation required to estimate the amount of PMN in wastewater from facilities that discharge their process baths to water without treatment (WR_{NT}) is presented below:

$$WR_{NT} = \frac{(0.3792)(PV)}{(F)(DPY)} \tag{4-5}$$

where:

37.92	=	Percent of facilities that discharge process baths and dragout without treatment
DPY	=	Days of facility operation/yr from Table 4-4 (default value = 216)
F	=	Number of facilities (submission or Equation 4-1)
PV	=	PMN production volume (kg/yr)
WR_{NT}	=	Water releases (kg/site-day) from facilities that discharge their process baths and dragout to water without treatment

Total PMN release to water (WR_{TTL}) is then the amount of PMN that remains in wastewater from facilities that use on-site treatment systems (WR_{WWT}), and facilities that treat their process baths through other methods (WR_{OT}) (only dragout is discharged to treatment), plus PMN releases from facilities that discharge their process baths to water without treatment (WR_{NT}).

$$WR_{TTL} = WR_{WWT} + WR_{OT} + WR_{NT} \tag{4-6}$$

where:

WR_{NT}	=	Water releases (kg/site-day) from facilities that discharge their process baths and dragout to water without treatment
WR_{OT}	=	Water releases (kg/site-day) for facilities that treat process baths through other methods
WR_{TTL}	=	Total water releases (kg/site-day)
WR_{WWT}	=	Water releases (kg/site-day) for facilities sending process baths and dragout to wastewater treatment

4.2.3 Air Releases

Few MP&M PMN chemicals are expected to be volatile (most vapor pressures are less than 0.01 Torr at standard temperature and pressure). In cases where the PMN chemical is found to be volatile, the CEB Open Surface Model can be used to estimate the vapor generation rate and corresponding air release (AR_{OS}). The typical number of baths, corresponding surface area and hours of operation/day are needed as inputs for the calculation. The average (default) values are:

- Default Bath Surface Area = 1.4 m^2 (Ref. 13),
- Default Baths per Facility = 4.4 (from Table 4-4); and
- Default Hours of Operation/Day = 9.6 (from Table 4-4).

4.2.4 Releases to Incineration

As discussed in Section 4.2.2, 52.33% of facilities dispose of both their process baths and their process dragout via wastewater treatment. 9.74% of facilities dispose of only their process dragout to wastewater treatment. Based on MP&M data, wastewater treatment (chemical precipitation and sedimentation) will remove 8.4% of the PMN chemical as a filter cake (FC).

It was determined that 18.66% of facilities producing filter cake will dispose of the waste via incineration and that the remaining facilities (81.34%) will dispose of the waste via landfill. Additionally, 0.03% of facilities incinerate their process baths, and 1.6% of facilities send their process baths to evaporative treatment.

The calculation required to estimate the PMN release to incineration from facilities that incinerate their process baths (IR_{PB}) is presented below:

$$IR_{PB} = (0.0003)(C)(NB)(BS)(BC)(F) \quad (4\text{-}7)$$

where:

0.03	=	Percent of facilities that incinerate their process baths
BC	=	Number of times a bath is changed/yr from Table 4-4 (default value = 45.7)
BS	=	Average bath size, not including dragout (kg) (default value = 2,271 kg)
C	=	% PMN in bath from Table 4-1 or 4-2 (default value for cleaners = 14.37%, others 8.82%)
F	=	Number of facilities (submission or Equation 4-1)
NB	=	Average number of baths/facility from Table 4-4 (default value = 4.4)
IR_{PB}	=	Incineration releases (kg/yr) for facilities that incinerate their process baths.

Additionally, some facilities (1.6%) treat their baths through evaporation (see Section 2.3.3). This evaporation will add to the incineration release estimate. The calculation required to estimate incineration releases due to evaporation is presented below:

$$IR_{EV} = (0.016)(BS)(NB)(BC)(C)(F) \quad (4\text{-}8)$$

where:

1.6	=	Percent of facilities that treat their process baths through evaporation
BC	=	Number of times a bath is changed/yr from Table 4-4 (default value = 45.7)
BS	=	Average bath size, not including dragout (kg) (default value = 2,271 kg)
C	=	% PMN in bath from Table 4-1 or 4-2
F	=	Number of facilities (submission or Equation 4-1)
IR_{EV}	=	Incineration release (kg/site-day) due to evaporation
NB	=	Average number of baths/facility containing PMN from Table 4-4 (default value = 4.4)

The total PMN release in the filter cake (FC) is the sum of the releases from facilities that send process baths and dragout to wastewater treatment and dragout releases from facilities that dispose of their process baths through other means. Based on MP&M data, 8.4% of the PMN chemical will be removed by wastewater treatment (chemical precipitation and sedimentation) as filter cake. The calculation to estimate the PMN release to the filter cake is presented below:

$$FC = [(C)(NB)(D)(F)(0.0974) + (PV)(0.5233)](0.084) \quad (4\text{-}9)$$

where:

9.74	=	Percent of facilities that send process baths to either incineration, evaporation, or other methods
8.4	=	Percent of PMN that is released to the filter cake due to wastewater treatment
52.33	=	Percent of facilities that send process baths to on-site wastewater treatment
C	=	% PMN in bath from Table 4-1 or 4-2 (default value for cleaners = 14.37%, others = 8.82%)
D	=	Dragout (kg/yr) (default value = 9,001 kg_{BATH}/yr-bath)
F	=	Number of facilities (submission or Equation 4-1)
NB	=	Average number of baths/facility from Table 4-4 (default value = 4.4)
PV	=	PMN production volume (kg/yr)

The total release to incineration (IR_{TTL}) can be estimated as follows:

$$IR_{TTL} = (FC)(0.1866) + IR_{PB} + IR_{EV} \quad (4\text{-}10)$$

where:

18.66	=	Percent of facilities that dispose of filter cake via incineration
FC	=	Total PMN release to the filter cake (Equation 4-4)
IR_{PB}	=	Incineration releases (kg/yr) for facilities that incinerate their process baths
IR_{EV}	=	Incineration releases due to evaporation (kg/yr)
IR_{TTL}	=	Total incineration releases (kg/yr)

4.2.5 Land Releases

Based on the DCP survey, EPA estimates that 52.33% of facilities dispose of the wastewater from bath changes and dragout in rinse waters via an on-site wastewater treatment system consisting of chemical precipitation and sedimentation (where a filter cake is generated); 37.92% of facilities discharge their process baths and dragout to water without treatment (no filter cake); and 9.74% dispose of their process baths through either incineration (0.03%), evaporation (1.6%), or a variety of other methods(8.13%) (see Section 4.2.6). Facilities using these other methods will send only the dragout amount of the PMN chemical to on-site wastewater treatment (therefore, the quantity of PMN in the dragout will be transferred to the filter cake waste).

In addition, 81.34% of facilities producing filter cake will dispose of the waste via landfill. The remaining facilities (18.66%) will dispose of the waste via incineration. The total release to land (LR_{TTL}) can be estimated as follows:

$$LR_{TTL} = (FC)(0.8134) \qquad (4\text{-}11)$$

where:

81.34	=	Percent of facilities that dispose of filter cake via landfill
FC	=	Total PMN release to the filter cake (kg/yr) (Equation 4-4)
LR_{TTL}	=	Total land releases (kg/yr)

4.2.6 Other Disposal Methods

As previously stated, facilities may dispose of their process baths through a variety of methods besides evaporation, wastewater treatment, landfill, and incineration. The other remaining methods (8.13% of 9.74%) and the percent of facilities that use them are reported below as determined from the MP&M detailed questionnaire database:

Hazardous Disposal	4.32%
Reuse/Recycle/Recovery	3.81%

TOTAL	8.13%

4.2.7 Inhalation Exposures

Few MP&M PMN chemicals are volatile (most vapor pressures are less than 0.001 Torr at standard temperature and pressure).

Volatile PMN Chemicals

For metal finishing operations other than electroplating, inhalation exposure to non-volatile PMN chemicals are expected to be negligible. Inhalation exposure to volatile PMN chemicals and in electroplating operations are presented in this section. In cases where PMNs are found to be volatile, the CEB Open Surface Model and spreadsheet should be used to estimate the vapor generation rate and corresponding air release. Workers will be exposed to the chemicals as they are added to each bath. They will also be exposed to volatilized chemicals from open surface operations of each bath that contains the PMN chemical as they stand over it during processing. Note that not all baths will contain the PMN chemical.

$$I_{exp} = (C_M)(B)(NHP) \tag{4-12}$$

The number of baths per site containing the PMN chemical, and number of hours of worker exposure per day can be found in Table 4-4. The number of workers exposed per facility is calculated by Equation 4-2. The typical number of baths and corresponding surface areas are provided below:

- Default Bath Surface Area = 1.4 m^2 (Ref. 13), and
- Default Baths per Facility = 4.4 (Table 4-4).

Workers will not be exposed to each bath containing PMN chemical for the entire shift. Instead they will split their time by the number of total baths in each line. The average number of hours of worker exposure to each bath containing PMN chemical can be calculated based on data provided in Table 4-4. The calculation is presented below:

$$NHP = \frac{(NH)(NTP)}{(NT)} \quad (4\text{-}13)$$

where:

NTP	=	Average number of baths containing PMN chemical per line from Table 4-4 (default value = 1.7)
NHP	=	Average number of hours of worker exposure to the PMN chemical
NT	=	Average total number of baths/line (assume default value = 3)
NH	=	Average number of worker hours/day (assume default value = 8)

Electroplating

Inhalation exposure in electroplating operations is a result of fumes and mists that are generated from evolved hydrogen and oxygen gas rising from the submerged part, the anode, or the cathode. The airborne concentration of PMN in the mist can be estimated based on the measured airborne concentration of a known chemical. The following equation can be used to determine the airborne concentration of PMN:

$$C_M = C_{M,K} \, (C/C_K) \quad (4\text{-}14)$$

where:

C	=	% PMN in bath from Table 4-1 or 4-2
C_K	=	% of known chemical in bath from Appendix B (default value = 0.25)
C_M	=	Estimated airborne concentration of the PMN (mg/m^3)
$C_{M,K}$	=	Measured airborne concentration of the known chemical from Appendix B (mg/m^3) (default value = 0.5)

The measured airborne concentration of the known chemical can be assumed to be the maximum allowed OSHA limit as a worst case. Presented in Appendix B are airborne limits for constituents typically found in metal plating baths. For a default value, the OSHA value for chromium of 0.5 mg/m^3 is suggested. Typical values for metal concentrations in electroplating baths can also be found in Appendix B. For a default value, the chromium bath weight fraction of 0.25 is suggested.

To determine the inhalation exposure to the PMN in the mist the following equation is used:

$$I_{exp} = (C_m)(B)(NHP) \tag{4-15}$$

where:

I_{exp}	=	Inhalation exposure to PMN (mg/day)
C_m	=	Estimated airborne concentration of PMN (mg/m^3)
B	=	Inhalation rate (m^3/hour) (default value = 1.25)
NHP	=	Average number of hours of worker exposure to the PMN Chemical (Equation 4-13)

4.2.8 Dermal Exposure

Occupational dermal exposure will consist of contact with the new chemical substance during transfer operations as it is loaded into the process bath and also from contact with parts as they are transferred from one bath to another. CEB dermal estimates for routine contact, two hands (filling drums with liquid, unloading filter cakes, changing filters, maintenance operations) should be used to calculate dermal exposure (CEB Method for Screening, 2000). The calculation is presented below:

$$DE = (C)(\text{up to } 3{,}100 \text{ mg/day}) \tag{4-16}$$

where:

C	=	Percent concentration of PMN in bath from Table 4-1 or 4-2
DE	=	Dermal exposure in mg/day

5.0 ESTIMATION METHODOLOGIES FOR METAL SHAPING

This generic scenario contains several levels of detail that can be used for making release and exposure assessments, based on the amount of information provided by the submitter. The first step of the assessment methodology is to estimate the percent PMN chemical in the bath or trough. Section 5.1 presents the methodology for this estimate. Subsequent sections then discuss the methodology for release and exposure estimates. As previously stated, distinct assessment methodologies are presented for metal finishing and for metal shaping chemicals.

5.1 Percent PMN in Metal Shaping Fluids

If the submitter provides enough information to determine the metal shaping operation and the primary function of the new chemical component, then Table 5-1 should be referenced. Based on the specific metal shaping operation, the table contains the typical percent of the chemical component (e.g. lubricant, wetting agent, biocide) within the shaping fluid. The percentage of PMN in the shaping fluid can be determined by multiplying the percentage of PMN in the chemical component by the percentage from Table 5-1.

If the submitter does not provide a primary function for the new chemical, then as a reasonable worst case estimate it can be assumed that the PMN material is present at the highest possible component concentration which corresponds to corrosion inhibitors.

Table 5-1

Composition of Shaping Fluid Listed by Function of Chemical Component Containing PMN and General Metal Shaping Operation

Chemical Component	General Metal Shaping Operation			
	Concentrate	**Machining**	**Grinding**	**Pressure/Impact Deformation**
Lubricant	0 - 20%	0 - 1%	0 - 0.6%	0 - 2%
Petroleum	2 - 15%	0.1 - 0.75%	0.067 - 0.45%	0.2 - 1.5%
Wetting Agent	0 - 20%	0 - 1%	0 - 0.6%	0 - 2.0%
Corrosion Inhibitor	5 - 25%	0.25 - 1.25%	0.15 - 0.75%	0.5 - 2.5%
Biocide	< 5%	<0.25%	<0.15%	<0.5%
Defoamer	< 1%	<0.005%	<0.003%	<0.1%

Source: Metal Shaping Fluid MSDSs

5.2 Estimating Environmental Releases and Occupational Exposures

The methodology used to complete an IRER or to further assess a PMN for MP&M chemicals in the subgroup of "Metal Shaping" is described below.

Table 5-2 includes additional information needed to estimate the releases and exposures based on the calculations presented in the following sections. These data are a compilation of information from the Phase I DCP.

Table 5-2

Information Required for Metal Shaping Release and Exposure Calculations

Metal Shaping Operations	Average Number of Shifts of Operation/Day	Average Time of Operation/Day	Days of Operation/ Yr	Average Number of Troughs or Machines Containing PMN/Facility	Average Number of Times a Trough is Changed/Yr
Pressure Deformation	3	16.16	250.98	7.48	6.13
Machining	2	10.12	205.38	65.42	25.23
Grinding	2	9.3	202.19	15.04	15.83
Impact Deformation	2	15.16	215.24	8.11	8.47
Average Default Values for Metal Shaping Operations	**2**	**12.7**	**219**	**24.0**	**13.9**

Source: MP&M detail questionnaire database and site visit reports.

5.2.1 General Facility Estimates

Number of Facilities

The number of MP&M Metal Shaping facilities that can be expected to receive the PMN chemical can be estimated by dividing the PMN yearly production volume by the average yearly facility use rate. The use rate is dependent upon the PMN chemical lost from changes and dragout. It can be calculated based on results of the MP&M DCP questionnaire from the average number of troughs per facility, average trough size, average number of trough changes per year, and the average percent PMN per trough. The calculation is presented below:

$$F = \frac{PV}{(C)(NM)(TS)(TC) + (C)(NM)(D)} \qquad (5\text{-}1)$$

where:

C	=	% PMN in trough, from Table 5-1 (default value = 2.5 %)
D	=	Dragout (kg-trough/yr) from processes (default value = 8,998 kg/yr-machine)
F	=	Number of facilities
NM	=	Number of machines/facility, from Table 5-2 (default value = 24)
PV	=	PMN production volume (kg/yr)
TC	=	Number of times a trough is changed/year from Table 5-2 (default value = 13.9)
TS	=	Average trough size (kg) (default value = 151.42 kg)

Facility Description and Number of Workers

Metal Shaping operations, like metal finishing operations, can be performed either wet or dry. Grinding operations, for example, can include, but do not require the use of lubricant. If a metal-working fluid is necessary, it will be stored in a trough located within the machine. As needed, the fluid will be pumped from the trough and sprayed over the part for lubrication and cooling during operation. As it is used, the fluid will become full of tramp oils and metal fines. The bulk of these will be filtered out after use and the fluid will be recycled to the trough. As the fluid becomes unusable, it will be removed from the trough and sent through either a centrifugation or pasteurization unit to extend its life. These units thoroughly remove the metal fines and tramp oils and help to destroy any bacteria that is growing in the fluid. The metal-working fluids are then returned to the trough for further reuse. Dragout from these operations will remain on the parts as a rust preventative coating (see Section 3.4). Unlike metal finishing, dragout is not released into a rinse. Regardless of the type of operation, the metal-working fluid will eventually break down and need to be disposed, thus resulting in an environmental release. One worker will stand over each machine and be exposed to the spraying of the fluid during operation. The total number of workers is calculated below:

$$NW = \left(\frac{1\ \text{worker}}{\text{shift}\cdot\text{machine}}\right)(NM)(F)(S) + \left(\frac{1\ \text{worker}}{\text{shift}\cdot\text{facility}}\right)(S)(F) \qquad (5\text{-}2)$$

where:

F	=	Number of facilities (submission or Equation 5-1)
NM	=	The average number of machines/facility from Table 5-2 (default value = 24)
NW	=	The total number of workers required for the given PV
S	=	Number of shifts per day from Table 5-2 (default value = 2)

5.2.2 Water Releases

Of the facilities using emulsion based metal shaping fluids 65.8% of the facilities send their process wastewater to oil/water separation systems or ultrafiltration, 15.30% of the facilities discharge process solutions to water without treatment, and the remaining facilities (19.52%) dispose of their process solutions by various other means such as evaporation, incineration, etc. (see Section 5.2.6). No waste fluids, whether sent to treatment or disposed of by various other means, will include PMN chemical from dragout (D_{PMN}). The calculation required to estimate the PMN release to water from facilities that send their process solutions to water without treatment (WR_{NT}) is presented below:

$$WR_{NT} = \frac{(0.1530)}{(DPY)(F)}\left[(PV) - (D_{PMN})\right] \qquad (5\text{-}3)$$

where:

15.30	=	Percent of facilities that discharge their process solution to water without treatment
D_{PMN}	=	PMN losses due to dragout (kg_{PMN}/yr)
DPY	=	Days of facility operation/year from Table 5-2 (default value = 219)
F	=	Number of facilities (submission or Equation 5-1)
PV	=	PMN production volume (kg/yr)
WR_{NT}	=	Water releases (kg/site-day) for facilities that discharge process solutions to water without treatment

Wastewater treatment will remove 50% of the PMN chemical in the concentrate for oil/water separation and 70% of PMN chemical for ultrafiltration. The calculation required to estimate the amount of PMN remaining in wastewater discharged from facilities that send their process solutions to wastewater treatment (WR_{WWT}) is presented below:

$$WR_{WWT} = \frac{(0.6518)(PT)}{(DPY)(F)} \left[(PV) - (D_{PMN})\right] \qquad (5\text{-}4)$$

where:

65.18 = Percent of facilities that send process baths to on-site wastewater treatment
D_{PMN} = PMN losses due to dragout (kg_{PMN}/yr)
DPY = Days of facility operation/year from Table 5-2 (default value = 219)
F = Number of facilities (submission or Equation 5-1)
PT = Pass Through. The percent of PMN that passes through the on-site wastewater treatment system and is ultimately released from the facility (is not removed).
PV = PMN production volume (kg/yr)
Chemical Emulsion Breaking with Oil/Water Separation, PT = 50% [Default]; Ultrafiltration, PT = 30%
WR_{WWT}= Water releases (kg/site-day) for facilities sending process troughs to on-site wastewater treatment

Finally, the total release to water (WR_{TTL}) from facilities can be estimated as follows:

$$WR_{TTL} = WR_{WWT} + WR_{NT} \qquad (5\text{-}5)$$

where:

WR_{NT} = Water releases (kg/site-day) for facilities that discharge process solutions to water without treatment
WR_{TTL} = Total water releases (kg/site-day)
WR_{WWT}= Water releases (kg/site-day) for facilities sending process troughs to on-site wastewater treatment

5.2.3 Air Releases

Few MP&M PMN chemicals are volatile (most vapor pressures are less than 0.001 Torr at standard temperature and pressure). In cases where the PMN chemical is found to be volatile, the CEB Open Surface Model and corresponding spreadsheet can be used to estimate the vapor generation rate and corresponding air release (AR_{OS}). The typical number of troughs, corresponding surface area and hours of operation/day are needed as inputs for the calculation. The average (default) values are:

- Default Trough Surface Area = 0.19 m^2 (Ref. 13),
- Default Number of Troughs per Facility = 24 (Table 5-2); and
- Default Average Hours of Operation/Day = 12.7 (Table 5-2).

5.2.4 Releases to Incineration

Of the facilities using emulsion based metal shaping fluids, 65.18% of the facilities dispose of process solution via oil/water separation systems or ultrafiltration, and 15.30% of the facilities discharge process solutions to water without treatment. The remaining facilities (19.52%) using emulsion based metal shaping fluids dispose of their process solutions by various other means such as evaporation (3.4%), incineration (3.05%), etc. (see Section 5.2.6). No waste fluids, whether sent to treatment or disposed by other means, will include PMN chemical from dragout (D_{PMN}). Therefore, this quantity should be excluded from the estimate for incineration. The calculation to estimate losses due to dragout (D_{PMN}) is presented below:

$$D_{PMN} = (D)(C)(NM)(F) \tag{5-6}$$

C	=	% PMN in trough from Table 5-1 (default value = 2.5%)
D	=	Bath lost due to dragout (default value = 8,998 kg/yr - machine)
D_{PMN}	=	PMN losses due to dragout (kg_{PMN}/yr)
F	=	Number of facilities (submission or Equation 5-1)
NM	=	Average number of machines/facility from Table 5-2 (default value = 24)

The calculation required to estimate the PMN release to incineration from facilities that incinerate their process troughs (IR_{IN}) is presented below:

$$IR_{IN} = (0.0305)[(PV) - (D_{PMN})] \tag{5-7}$$

where:

3.05	=	Percent of facilities that incinerate their process troughs
D_{PMN}	=	PMN losses due to dragout (kg_{PMN}/yr)
IR_{IN}	=	Incineration releases (kg/yr) for facilities that incinerate process baths
PV	=	PMN production volume (kg/yr)

Wastewater treatment will remove 50% of the PMN chemical in the concentrate for oil/water separation or 70% of the PMN chemical in the concentrate for ultrafiltration. The calculation required to estimate the PMN release to incineration from facilities that send their process troughs to wastewater treatment (IR_{WWT}) is presented below:

$$IR_{WWT} = (0.6518)(R)[(PV) - (D_{PMN})] \tag{5-8}$$

where:

65.18	=	Percent of facilities that send process baths to on-site wastewater treatment
D_{PMN}	=	PMN losses due to dragout (kg_{PMN}/yr)
IR_{WWT}	=	Incineration releases (kg/yr) for facilities sending process baths to wastewater treatment
PV	=	PMN production volume (kg/yr)
R	=	Removal efficiency of waste water treatment (Chemical Emulsion Breaking with Oil/Water Separation, R = 50% [Default]; Ultrafiltration, R = 70%)

Additionally, some facilities (3.40%) treat their trough waste via evaporation. Sludge wastes collected from the evaporation treatment unit will be contract hauled offsite. This waste may be reclaimed for re-use or may be incinerated. Evaporation treatment may add to the incineration release estimate. The calculation required to estimate air releases due to evaporation is presented below:

$$IR_{EV} = (0.034)(TS)(NM)(C)(TC)(F) \qquad (5\text{-}9)$$

where:

3.4	=	The percent of facilities that evaporate their process baths
C	=	% PMN in trough from Table 5-1 (default value = 2.5%)
F	=	Number of facilities (submission or Equation 5-1)
IR_{EV}	=	Incineration release (kg/yr) due to evaporation
NM	=	Average number of machines/facility from Table 5-2 (default value = 24)
TC	=	Average number of times a trough is changed/yr from Table 5-2 (default value = 13.9)
TS	=	Average trough size (kg), default value = 151.42 kg

The total release to incineration (IR_{TTL}) can be estimated as follows:

$$IR_{TTL} = IR_{WWT} + IR_{IN} \qquad (5\text{-}10)$$

where:

IR_{IN}	=	Incineration releases (kg/yr) for facilities that incinerate process baths
IR_{TTL}	=	Total incineration releases (kg/yr)
IR_{WWT}	=	Incineration releases (kg/yr) for facilities sending process baths to wastewater treatment

5.2.5 Land Releases

Solid wastes are typically contract hauled and used for off-site fuel blending. Therefore, no land releases are expected from metal shaping processes.

5.2.6 Other Disposal Methods

As previously stated, facilities may dispose of their process troughs through a variety of methods besides wastewater treatment (65.18%) or discharge without treatment (15.3%). Evaporative Treatment (3.4% of facilities) and incineration (3.05% of facilities) have been discussed in Sections 5.2.3 and 5.2.4. The remaining methods and percent of facilities that use them are reported below as determined from the MP&M detailed questionnaire database:

Hazardous Disposal	1.21%
Reuse/Recycle/Recovery	11.86%
Evaporation	3.40%
Incineration	3.05%
TOTAL	19.52%

5.2.7 Inhalation Exposures

Metal working fluids will typically be sprayed over the part as it is being shaped. Therefore, the potential worst-case worker exposure will consist of exposure to mist. The standard CEB estimate for exposure to mist (found on page 4-14 of the current CEB engineering manual) should be used to calculate inhalation exposure:

$$IE = (B)(OSHA\ PEL)(8)(C) \qquad (5\text{-}11)$$

where:

8	=	Number of hours of worker exposure for TWA
B	=	Standard breathing rate = 1.25 m^3/hr
C	=	% PMN in trough from Table 5-1 (default value = 2.5%)
IE	=	Inhalation exposure (mg/day)
OSHA PEL	=	OSHA PEL (8-hr, TWA) for oil mists = 5 mg/m^3

5.2.8 Dermal Exposure

Occupational dermal exposure will consist of contact with the new chemical substance during transfer operations as it is loaded into the process bath and also from contact with parts as they are transferred from one bath to another. CEB dermal estimates for routine contact, two hands, (filling drums with liquid, unloading filter cakes, changing filters, maintenance operations) should be used to calculate dermal exposure (CEB Method for Screening, 2000). The calculation is presented below:

$$DE = (C)(\text{up to } 3{,}100 \text{ mg/day}) \tag{5-12}$$

where:

C = % PMN in trough from Table 5-1 (default value = 2.5 %)
DE = Dermal exposure in mg/day

6.0 REFERENCES

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Appendix A

TOC REMOVAL IN MP&M WASTEWATER TREATMENT SYSTEMS

The following TOC Removals information is based on data in the long-term average database for the MP&M Phase II proposed effluent guidelines. Only data points with no flags have been included. The data is separated by treatment system. Average influent and effluent TOC concentrations were calculated for each sampled site. The %TOC Removals for each site was calculated from the corresponding influent and effluent average concentration. The final Average Removals of TOC for each treatment system was calculated as the average of the %TOC Removals for each site. This is the same procedure used for the MP&M proposed effluent guidelines.

TOC % Removals by Treatment
(for CEB MP&M Generic Scenarios)

<u>Precipitation</u>
Average Removals = 8.35
Range of Removals = -44 to 56

<u>Chemical Emulsion Breaking with Oil Water Separation</u>
Average Removals = 50.4
Range of Removals = 32 to 82

<u>Ultrafiltration</u>
Average Removals = 70.3
Range of Removals = 11 to 97

Chemical Precipitation

Episode	Unit Operations	%TOC Removal (Average)
CP1	Grinding	47.6
	Impact Deformation	
	Machining	
	Acid Treatment	
	Alkaline Cleaning	
	Chemical Conversion Coating	
	Electroplating	
CP2	**Acid Treatment**	-16.1
	Alkaline Treatment	
	Anodizing	
	Chemical Conversion Coating	
	Electroplating	
CP3	Impact Deformation	17.9
	Machining	
	Pressure Deformation	
	Acid Treatment	
	Alkaline Cleaning	
	Chromate Conversion Coating	
	Electroplating	
CP4	Machining	26.9
	Acid Treatment	
	Alkaline Treatment	
	Electroplating	
CP5	**Conversion Coating**	30.4
	Electrocoating	
	Painting	
CP6	**Etcher Rinsewater**	30.6
CP7	**Acid Treatment**	55.8
	Alkaline Treatment	
	Electroplating	
CP8	**Alkaline Cleaning**	-7.3
	Acid Cleaning	
	Conversion Coating	
	Electroplating	
CP9	**Acid Treatment**	-26
	Alkaline Treatment	
	Conversion Coating	
CP10	Impact Deformation	0
	Acid Treatment	
	Alkaline Treatment	
	Electroplating	

Episode	Unit Operations	%TOC Removal (Average)
CP11	Impact Deformation **Aqueous degreasing** **Conversion Coating** **Acid Treatment** **Electroplating**	-15.4
CP12	**Aqueous Degreasing** **Conversion Coating** **Acid Treatment**	-4.9
CP13	**Alkaline Cleaning** **Acid Treatment** **Electroplating**	-44.5
CP14		21.9
	AVG % Removal =	8.35
	Median % Removal =	8.95

Chemical Emulsion Breaking with Oil/Water Separation

Episode	Unit Operations	%TOC Removal (Average)
OW1	**Grinding** **Machining** Alkaline Cleaning	41.5
OW2	**Grinding** Impact Deformation Machining Aqueous Degreasing	31.65
OW3	**Machining** **Impact Deformation** Chemical Conversion Coating	81.8
OW4	**Grinding** **Impact Deformation** **Machining** Alkaline Cleaning Aqueous Degreasing Solvent Degreasing	46.6
	AVG % Removal =	50.4
	Median % Removal =	44.0

Ultrafiltration

Episode	Unit Operations	%TOC Removal (Average)
UF1	**Grinding**	65
	Machining	
	Solvent Degreasing	
	Acid Treatment	
	Alkaline Cleaning	
UF2	**Impact Deformation**	89.8
	Alkaline Cleaning	91.1
UF3	**Grinding**	94.9
	Machining	
	Acid Treatment	
	Alkaline Cleaning	
UF4	**Machining**	93.9
	Grinding	
UF5	**Grinding**	97.4
	Impact Deformation	
	Machining	
	Pressure Deformation	
	Acid Treatment	
	Alkaline Treatment	
	Solvent Degreasing	
UF6	**Machining**	59.3
	Grinding	
UF7	**Machining**	92.2
	Grinding	
	Impact Deformation	
UF8	**Machining**	11.2
	Acid Treatment	
	Alkaline Cleaning	
UF9	**Machining**	64.8
UF10A	**Machining**	36.2
UF10B	**Machining**	48.2
	AVG % Removal =	70.3
	Median % Removal =	77.4

Appendix B

ELECTROPLATING BATH, METAL CONCENTRATIONS

Electroplating Bath, Metal Concentrations

Metal	Bath Type	Bath Conc, [1] g/L	Conc. Above Bath, mg/m
Brass	Yellow, regular	CuCN: 32 $Zn(CN)_2$: 10 NaCN: 50 Na_2CO_3: 7.5 $NaHCO_3$: 10 NaOH: -- NH_4OH: 2.5-5 mL/L	
	Yellow, high speed	CuCN: 75 $Zn(CN)_2$: 5 NaCN: 125 Na_2CO_3: -- $NaHCO_3$: -- NaOH: 45 NH_4OH:	
	White	CuCN: 10 $Zn(CN)_2$: 60 NaCN: 100 Na_2CO_3: 40 $NaHCO_3$: -- NaOH: 38 NH_4OH: --	
Bronze	Typical	CuCN: 32 Cu metal: 20-25 $Na2SnO_3.3H_2O$: 35-38 Sn metal: 14-17 NaCN: 54-64 NaOH: 7.5-10	
	Speculum	CuCN: 11 Cu metal: 8 $Na2SnO_3.3H_2O$: 90 Sn metal: 40 NaCN: 27 NaOH: 16	
Cd	Cyanide bath	Cd metal: 20-30 NaCN: 90-150 Na_2CO_3: 30-60 H_2SO_4: -- NH_4BF_4: -- NaOH: 10-20	NIOSH: 0.04 [2]
	Acid sulfate	Cd metal: 15-30 NaCN: -- Na_2CO_3: -- H_2SO_4: 45-90 NH_4BF_4: -- NaOH: --	

Metal	Bath Type	Bath Conc, [1] g/L	Conc. Above Bath, mg/m
	Fluoro-borate	Cd metal: 75-150 NaCN: -- Na_2CO_3: -- H_2SO_4: -- NH_4BF_4: 60-120 NaOH: --	
Cr, typical	Conventional	CrO_3: 240-260 SO^2_4: 2.4-2.6 SiF^2_6: -- CrO3:SO^2_4 ratio: 90-110:1	OSHA: 0.5 (HETA-87-353-1899 5/88)
		CrO_3: 150-180 SO^2_4: 0.9-1.0 SiF^2_6: 0.5-0.6 CrO3:SO^2_4 ratio: 170-180:1	
Cu, cyanide	CN, strike	Cu metal: 15-22 CuCN: 21-31 KCN: 31-70 KOH: 3-18 Rochelle salts: 10-20 Na_2CO_3: 10-15	OSHA: 0.5 (HETA-87-353-1899, 5/88)
	Rochelle	Cu metal: 22-36 CuCN: 31-51 KCN: 55-89 KOH: 12-18 Rochelle salts: 15-25 Na_2CO_3: 30-45	
	High speed	Cu metal: 56-71 CuCN: 79-100 KCN: 130-165 KOH: 20-25 Rochelle salts: 15-25 Na_2CO_3: 35-55	
Cu, acid	Sulfate, average range	Cu metal: 38-64 $CuSO_45H_2O$: 150-250 H_2SO_4: 30-75 Cl^-: 0.20-0.12 $Cu(BF_4)_2$: -- HBF_4: -- H_3BO_3: --	
	Fluoroborate, range	Cu metal: 60-120 $CuSO_45H_2O$: -- H_2SO_4: -- Cl^-: -- $Cu(BF_4)_2$: 225-450 HBF_4: 15-30 H_3BO_3: 15-30	

Metal	Bath Type	Bath Conc, [1] g/L	Conc. Above Bath, mg/m
Cu, pyrophosphate	Typical	Cu metal: 19-30 $Cu_2P_2O_7.3H_2O$: 53-84 $K_4P_2O_7.3H_2O$: 235-405 NH_4OH: 3.75-11 KNO_3: 3.0-6.0 P_2O_7:Cu ratio: 7.0-7.5:1	
Au	Alkaline	Au metal: 2-12 $Kau(CN)_2$: 3-18 KCN: 15-48 K_2CO_3: 0-45 K_2HPO_4: 0-45 KOH: 1-30	
	Neutral	Au metal: 4-16 $Kau(CN)_2$: 6-24 KCN: -- K_2CO_3: -- K_2HPO_4: 0-90 KOH: --	
	Acid	Au metal: 2-16 $Kau(CN)_2$: 3-24 KCN: -- K_2CO_3: -- K_2HPO_4: 0-100 KOH: --	
	Strike	Au metal: 0.5-2 $Kau(CN)_2$: 0.75-3 KCN: 15-90 K_2CO_3: -- K_2HPO_4: 15-45 KOH: --	
Ni	Watts	Ni metal: 82 $NiSO_4.6H_2O$: 300 $NiCl_2.6H_2O$: 60 $Ni(SO_3NH_2)_2.4H_2O$: -- H_3BO_3 35-45	
	Watts high chloride	Ni metal: 77 $NiSO_4.6H_2O$: 135 $NiCl_2.6H_2O$: 190 $Ni(SO_3NH_2)_2.4H_2O$: -- H_3BO_3 35-45	
	Sulfamate	Ni metal: 75 $NiSO_4.6H_2O$: -- $NiCl_2.6H_2O$: -- $Ni(SO_3NH_2)_2.4H_2O$: 410 H_3BO_3 35-45	

Metal	Bath Type	Bath Conc, [1] g/L	Conc. Above Bath, mg/m
Ag	Decorative	AgCN: 45-50 KCN: 65-72 K_2CO_3: 45-50 KNO_3: 40-80 KOH: 40-60	
	Strike	AgCN: 1.5-5.0 KCN: 75-90 K_2CO_3: -- KNO_3: -- KOH: --	
Zn-Co	Acidic	Zn: 25 Co: 4 Ni: -- Fe: -- chloride: 135 boric acid: 25 NaOH: --	
	Alkaline	Zn: 8 Co: 0.04 Ni: -- Fe: -- chloride: -- boric acid: -- NaOH: 90	
Zn-Ni	Acidic	Zn: 30 Co: -- Ni: 25 Fe: -- chloride: 240 boric acid: -- NaOH: --	
	Alkaline	Zn: 8 Co: -- Ni: 1.6 Fe: -- chloride: -- boric acid: -- NaOH: 130	
Zn-Fe	Alkaline only	Zn: 8 Co: -- Ni: -- Fe: 0.05 chloride: -- boric acid: -- NaOH: 90	T.L.V.: 1.0 [3]

Conversion from g/L to % known chemical in bath is:

C_K = (BC) / (1 kg/L) (1,000 g/kg))

where:	1	=	specific gravity of water
	BC	=	bath concentration from table (g/L)
	C_K	=	% known chemical in bath