Canada

Atlantic Region Metal Finishing Industry Pilot Project

Final Report

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Presented To:

Rodger Albright, P.Eng.
Head, Environmental Management and Technology
Environmental Protection Operations Directorate, Atlantic
Environment Canada

Michael Clapham
Senior Environmental Specialist - Recycling
International and Domestic Market Policy Division
Minerals and Metals Sector
Natural Resources Canada

By:

Marc Sider, Eng., M.A.Sc.
Coordinator – Pollution Prevention and Energy Efficiency
Canadian Association of Metal Finishers

F. Neil Brodie, P.Eng.
Director of Engineering
Conestoga-Rovers & Associates

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Project Partners

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Environment Canada, Atlantic Environmental Management & Technology Section
The Environmental Management & Technology Section of Environment Canada, Atlantic is a focus for Pollution Prevention and Environmental Technology in the four Atlantic Provinces and is involved in promoting pollution prevention to the private sector, government agencies, communities, and non-profit groups. It works with and through a variety of partners, providing information, advice and technical support as well as guidance in accessing funding for implementing pollution prevention and environmental technology programs.

Enhanced Recycling, Government of Canada Action Plan 2000 on Climate Change, Minerals and Metals Program
The Government of Canada Action Plan 2000 on Climate Change Minerals and Metals Program is working towards reducing Canada's greenhouse gas (GHG) emissions from the minerals and metals sector. By matching funds with other partners, this program supports initiatives that enhance recycling practices and provide GHG emission reductions. The project proponents would like to recognize the Natural Resources Canada, Minerals and Metals Sector for providing direction and input to the development of this project.

Atlantic Canada Opportunities Agency (ACOA) is a federal government agency. Headquartered in the Atlantic Region, ACOA's goal is to improve the economy of Atlantic Canadian communities through the successful development of business and job opportunities.

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EXECUTIVE SUMMARY

There were fewer metal finishers in Atlantic Canada (24) than indicated in the initial inventories (130) available at the start of the Atlantic Region Metal Finishing Industry Pilot Project. Twelve of the 24 companies took part in the project survey, with six participating in detailed eco-efficiency evaluations.

The survey made it possible to collect relevant baseline information on air, water and land releases of CEPA toxics and substances of concern and to determine the current environmental performance against relevant federal, provincial and municipal legislation or recognized Codes of Practice. Such information was provided as confidential.

Nine of the twelve companies had either Certificates of Approval or an Industrial Permit from the appropriate province (including three in the process of amending them) and the remaining three companies did not require permits. Four of the companies questioned held copies of relevant regulations and two had an Environmental Management System (EMS) in place.

Three of the twelve companies that took part in the survey report under the National Pollution Release Inventory. Two other companies report under NPRI in the Atlantic Region, however they did not take part in the survey. None of the companies had used the Canadian Association of Metal Finishers (CAMF) Emissions Calculator to produce its annual report. This calculator can be an important tool in a recording system of raw material consumption and waste generation. The Emissions Calculator was therefore included in the programs for the Workshops held in Moncton NB and Dartmouth NS in January 2005.

Seven of the twelve surveyed companies were in chrome electroplating and six of these facilities use fume suppressants to control atmospheric emissions of hexavalent chromium. This method is preferred over scrubber use because there is no need for high initial capital investment. Both methods for the control of atmospheric emissions are contained in the proposed **Chromium**

Electroplating, Chromium Anodizing and Reverse Etching Regulations from the federal government.

Among the important findings, we identified a lack of formal client training on WHMIS, transportation of dangerous goods, spills prevention and environmental emergency planning. Local resources are available to provide this training at reasonable costs.

There was also a lack in formal training on metal finishing science and good practices. This had a direct impact on the efficiency of processes, quality of production, waste generation and competitiveness. Therefore CAMF organized a metal finishing short course in Atlantic Canada on March 27 and 28, 2006 and there were eight participants, representing seven companies.

Based on the survey results and the NPRI reports, there were approximately 138.3 tons/year of metal waste (including sludge) generated in the Atlantic Region of which 131.7 tons/year of zinc bearing waste are already recycled, and 0.81 tons/year of chromium sludge are receiving offsite chemical treatment prior to disposal. Small companies generate only a few drums of sludge every year, generally avoiding sludge producing wastewater treatment by rinsing the coated parts directly over the electroplating tanks. Factors for converting tons of recycled sludge to CO_2 equivalents are presented.

The data collected was studied to evaluate the general feasibility of metal sludge recovery/recycling in the Atlantic Region. Recycling companies where the sludge could be sent have been identified for each metal. For the case of chromic acid waste, the economical threshold for switching from disposal to recycling has been examined. The approximate cost difference between the two options is 20% in favor of recycling, but a more detailed study would be needed in order to warrant starting a pilot program. The challenges to making recycling a viable option as well as how these challenges can be overcome have nevertheless been identified (e.g. the small volume of waste generated by each MF in Atlantic Canada and the need for consolidation at a transfer station in particular).

CAMF and Conestoga-Rovers & Associates (CRA) succeeded in getting six facilities involved in a detailed eco-efficiency evaluation. Many opportunities for improvement were identified and 19 Facts Sheets have been produced to summarize pollution prevention (P2) and energy efficiency options. Each of the six companies received two confidential reports: one on compliance, and another on eco-efficiency options.

Follow-up of the pilot project has shown that respondents have increased their environmental awareness, their level of compliance, and their environmental performance (P2 options). 71% of the respondents (5/7) reported changes in procedures or plant layout to improve their environmental performance. Others were planning to do this in 2006.

The metal finishing (MF) facilities surveyed in Atlantic Canada and the six participants of the detailed eco-efficiency evaluation in particular demonstrated a positive attitude toward pollution prevention and recycling in particular, as government messages and programs on pollution prevention, eco-efficiency and recycling are prominent in Atlantic Canada.

APC Coatings (formerly ARGO Protective Coatings Inc.) from Dartmouth (NS) was the recipient of the CAMF Pollution Prevention Award on November 8, 2005 for showing strong eco-efficiency leadership.

The numerous and varied recommendations on compliance and P2 which were implemented demonstrate that the pilot project was a success for the companies that chose to benefit from the assistance provided by CAMF and CRA through this program.

SOMMAIRE

Il y avait moins de finisseurs de métaux dans le Canada Atlantique (24) qu'indiqué dans les inventaires initiaux (130) disponibles au démarrage du Projet pilote de l'industrie de la finition des métaux de la région Atlantique. Douze des 24 compagnies ont participé au sondage du projet, avec six participants aux évaluations détaillées d'éco-efficacité.

Le sondage a permis de collecter de l'information de base pertinente sur les rejets dans l'air, l'eau et le sol des substances toxiques de la LCPE et de déterminer la performance environnementale actuelle vis-à-vis les législations fédérale, provinciale et municipale pertinentes ainsi que les codes de pratique reconnus. Cette information a été fournie confidentiellement.

Neuf des douze compagnies avaient un Certificat d'autorisation ou un Permis industriel de la province appropriée (incluant trois en cours de les amender) et les trois compagnies restantes n'avaient pas besoin de permis. Quatre des compagnies interrogées avaient des copies des règlements pertinents et deux avaient un système de gestion environnementale en place.

Trois des douze compagnies qui ont participé au sondage devaient soumettre une déclaration à l'Inventaire national des rejets de polluants. Deux autres compagnies rapportaient à l'INRP dans la région Atlantique, cependant elles n'ont pas participé au sondage. Aucune des compagnies n'utilisait le Calculateur d'émissions de l'Association canadienne des finisseurs de métaux (ACFM) pour produire son rapport annuel. Ce calculateur peut être un outil important dans un système de compilation de la consommation des matières premières et la génération des déchets. Le Calculateur d'émissions a par conséquent été inclus dans les programmes des ateliers organisés à Moncton NB et Dartmouth NÉ en janvier 2005.

Sept des douze compagnies sondées étaient dans l'électrodéposition du chrome et six de ces usines utilisaient des suppresseurs de fumées pour contrôler les émissions atmosphériques de chrome hexavalent. Cette méthode est préférée vis-à-vis les épurateurs parce il n'y a pas d'investissement en capital élevé requis. Les deux méthodes de contrôle des émissions

atmosphériques sont contenues dans le projet de **Règlement sur l'électrodéposition du chrome, l'anodisation au chrome et la gravure inversée** du gouvernement fédéral.

Parmi les observations importantes, nous avons identifié un manque de formation formelle sur le SIMDUT, le transport des matières dangereuses, la prévention des déversements et la planification en cas d'urgence environnementale. Des ressources sont disponibles localement pour fournir cette formation à un coût raisonnable.

Il y avait aussi un manque de formation formelle sur la science de la finition des métaux et les bonnes pratiques. Ceci avait un impact direct sur l'efficacité des procédés, la qualité de la production, la génération des déchets et la compétitivité. Par conséquent, ACFM a organisé un cours intensif de finition des métaux dans le Canada Atlantique les 27 et 28 mars 2006 et il a y eu 8 participants représentant 7 compagnies.

Basé sur les résultats du sondage et les rapports de l'INRP, il y avait approximativement 138.3 tonnes/année de déchets métalliques (incluant les boues) générés dans la région Atlantique; 131.7 tonnes/an de déchets contenant du zinc déjà recyclées et 0.81 tonnes/an de boues de chrome recevant un traitement chimique hors site avant l'élimination. Les petites compagnies génèrent seulement quelques barils de boues chaque année parce qu'elles évitent généralement le traitement des eaux usées produisant la boue en rinçant les pièces revêtues directement au-dessus des cuves d'électrodéposition. Les facteurs pour la conversion du tonnage de boues recyclées en tonnage équivalent de CO_2 sont présentés.

Les données collectées ont été étudiées pour évaluer la faisabilité générale de la récupération/recyclage dans la région Atlantique. Les compagnies de recyclage où les boues pourraient être envoyées ont été identifiées pour chacun des métaux. Dans le cas de déchets d'acide chromique, la limite économique pour passer de l'élimination au recyclage a été examinée. La différence de coût approximative entre les deux options est de 20% en faveur du recyclage, mais une étude plus détaillée serait nécessaire pour justifier le démarrage d'un programme pilote. Les défis pour faire du recyclage une option viable ainsi que les façons de les surmonter ont néanmoins été identifiés (en particulier le petit volume de déchets générés par chaque finisseur de métaux au Canada Atlantique et le besoin d'une consolidation dans une station de transfert).

ACFM et Conestoga-Rovers & Associates (CRA) ont réussi à faire participer six usines à une évaluation détaillée d'éco-efficacité. Plusieurs opportunités d'amélioration ont été identifiées et 19 fiches ont été rédigées pour résumer les options de prévention de la pollution (P2) et d'efficacité énergétique. Chacune des six compagnies a reçu deux rapports confidentiels: un sur la conformité et l'autre sur les options d'éco-efficacité.

Le suivi du projet pilote a montré que les répondants avaient augmenté leur conscience environnementale, leur niveau de conformité et leur performance environnementale (options P2). 71% des répondants (5/7) rapportaient des changements dans les procédures d'opération ou la conception de l'usine pour améliorer leur performance environnementale. Les autres planifiaient de réaliser cela en 2006.

Les usines de finition des métaux (FM) sondées dans le Canada Atlantique et les six participants à l'évaluation détaillée d'éco-efficacité en particulier ont démontré une attitude positive vis-à-vis la prévention de la pollution et le recyclage en particulier, puisque les messages et programmes gouvernementaux sur la prévention de la pollution, l'éco-efficacité et le recyclage sont importants au Canada Atlantique.

APC Coatings (précédemment ARGO Protective Coatings Inc.) de Dartmouth (NÉ) a été récipiendaire du Prix de prévention de la pollution de l'ACFM le 8 novembre 2005 pour avoir démontrer son dynamisme en éco-efficacité.

Les nombreuses recommandations variées sur la conformité et la P2 qui ont été implantées démontrent que le projet pilote a été un succès pour les compagnies qui ont choisi de bénéficier de l'assistance fournie par ACFM et CRA grâce à ce programme.

1.0 INTRODUCTION

On September 16, 2004, Canadian Association of Metal Finishers (CAMF) Chairman Paul Kuntz signed a Contribution Agreement with Environment Canada to conduct a Pilot Project on pollution prevention opportunities for Metal Finishers in Atlantic Canada. In October, a complementary agreement was signed by Natural Resources Canada (Government of Canada Action Plan 2000 on Climate Change). The combined initiative was to collect relevant baseline information on the metal finishing industry (MFI), assess the feasibility of metal sludge recovery/recycling from the regional finishers, identify and promote implementation of feasible eco-efficiency opportunities, build capacity within the MFI and consulting industry in the Atlantic Region to address environmental issues, and create awareness of CAMF services available to regional finishers. As part of the agreement, all interested Atlantic Region metal finishers were provided a complimentary CAMF membership until March 31, 2005. The final project was titled "Atlantic Region Metal Finishing Industry Pilot Project".

To ensure delivery of CAMF services to the MFI and its members in the Atlantic Region, CAMF Chairman Paul Kuntz signed a Partnership Agreement with Conestoga-Rovers & Associates (CRA) on September 16, 2004. MGI Limited, who assisted in delivering seminars and conducting the survey and eco-efficiency evaluations, was part of the CRA family of Companies.

2.0 INFORMATION COLLECTION

2.1 Inventory of Metal Finishing Companies in the Atlantic Provinces

Methodology

An inventory of companies in the MFI was prepared, as the first step of the pilot project. Metal finishing operations include: electroplating, anodizing, metal parts cleaning (aqueous and solvent cleaning), etching, galvanizing, chromate conversion (i.e. passivation) coatings, electropolishing, jewellery manufacturing, powder coatings and printed circuit board manufacturing. A list of MF companies in the Atlantic Provinces was provided to CAMF and CRA by Environment Canada. This was our base list for company contacts.

We added to this base list by consulting several government and private sources. These additional sources are listed in Table 1 on next page. An attempt has been made to contact all of the companies identified as potential metal finishers in the Atlantic provinces to determine what type of work they do and specifically if they do any metal finishing.

TABLE 1: INFORMATION SOURCES CONSULTED IN PREPARING THE INVENTORY OF METAL FINISHERS IN THE ATLANTIC PROVINCES

Source	Description of Search
Environment Canada's National Pollutant Release Inventory (NPRI)	The inventory was searched on-line for companies in New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland that report to the inventory.
Scotts Directories	This directory was searched on-line using the following key words: metal anodizing, metal coating, metal etching, metal fabricating, metal finishing, metal galvanizing, metal heat treating, metal pickling, metal stripping, metal surfacing, metal treating: carburizing, metal treating: nitriding, metallizing: electro chemical and metals: electroplated. The search included companies located in New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland.
Industry Canada	The Industry Canada web site was searched for companies listed under metal fabrication and metal finishing. The search included companies located in New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland.
Yellow Pages	The Yellow Pages in New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland were searched for companies listed under metal finishing, galvanizing, plating, and electroplating.
Business New Brunswick	The business New Brunswick web site was searched for companies listed under metal fabrication and metal finishing.
Prince Edward Island Business Guide	This guide was searched on-line for companies listed as Fabricated Metal Product Manufacturing and Coating, Engraving, Heat Treating, and Allied Activities.
Newfoundland and Labrador Business Sector Directories	The Manufacturing Directory was searched for companies indicating any type of metal finishing in their Products & Capabilities.
Nova Scotia Business Registry	This registry was searched on-line for companies listed as metal finishers, galvanizers and electroplaters.
New Brunswick Department of Environment and Local Government	The department was contacted by telephone and asked to provide a list of companies with approvals for metal finishing.
Nova Scotia Department of Environment and Labour	The department was contacted by telephone and asked to provide a list of companies with approvals for metal finishing.

Survey Inventory Results

A total of 130 companies were identified as potential metal finishers (43 in NB, 74 in NS, 13 in NL and 0 in PEI), but only 24 have been confirmed to do actual metal finishing. The lists for each of the 3 Provinces are presented on next page and in Appendix A.

TABLE 2: SUMMARY INVENTORY OF METAL FINISHERS IN THE ATLANTIC PROVINCES (2004)

	NB	NS	NL	TOTAL
Possible Metal Finishing Facilities	43	74	13	130
Active Metal Finishers	11	9	4	24
Participated in General Survey	3	7	2	12
Participated in Detailed Audit	2	3	1	6

The difference in the numbers of companies comes in part from the difficulty of companies in identifying to which class of activities they belong. For example, if a company is doing transformation of metals into final products, they may wrongly interpret this as metal finishing. Another example: a company may actually use metal finishing (coatings) but they contract this out.

2.2 Facilities Visits and Survey

Methodology

CAMF and CRA requested site visits from each facility manager and the survey presented in Appendix B was completed at 12 of the 24 locations. It was then possible to collect relevant baseline information on air, water and land releases of CEPA toxics and substances of concern; to determine the current environmental performance against relevant federal, provincial and municipal legislation or recognized Codes of Practice; and to evaluate the level of awareness and understanding of environmental and sustainable development issues. We also inquired about the metal sludge available for recovery and recycling (this is covered in detail in Section 3.0). Since this was a voluntary Project, the number of companies participating depended on the authorizations we could get from the managers.

During the visits, we conducted preliminary facilities evaluations, made some basic recommendations, explained the advantages of pollution prevention (P2) projects and discussed metal sludge recycling opportunities.

The general project objective was to promote eco-efficiency and sludge recycling whenever possible. There was also the more specific objective of getting as many companies as possible to complete the initial survey and getting six companies involved in a detailed evaluation. It should be noted that information provided by and discussions held with companies were considered confidential, and this report does not reveal such information except in an aggregated format.

Facilities Visit Results

Of the 24 companies in Atlantic Canada involved in metal finishing, twelve companies took part in the survey. Six of these companies were involved in hard chrome electroplating, one was in decorative chrome plating, two were galvanizers and three were applying various specialized coatings. Eight of the companies had less than five employees working directly in metal finishing.

Three additional visits were also conducted, but after discussions with the managers, it was determined these facilities did not fit the metal finishing classification.

Nine companies had either Certificates of Approval or an Industrial Permit (including three in the process of amending them) and the remaining three companies did not require provincial approvals and permits. Four of the companies questioned held copies of relevant regulations and two had an Environmental Management System (EMS) in place. Three of the companies which took part in the survey report under the National Pollution Release Inventory. Two other companies report under NPRI in the Atlantic Region; however they did not take part in the survey.

There was an even split (6-6) with regard to the control of air emissions using either ventilation to stack or reduction of surface tension. However, when considering just chrome electroplating (hard and decorative), six of the seven companies use reduction of surface tension. Only one company discharges process water directly into the sewer system.

The manufacturers producing hard chrome were interested in the proposed **Chromium Electroplating, Chromium Anodizing and Reverse Etching Regulations** from the federal government. The regulations will present a new lower limit for atmospheric emissions and enactment is anticipated to be in 2006. The surface tension reduction method is preferred by the companies surveyed over the installation of a scrubber (composite mesh pads) because there is no need for high initial capital investment (which is especially important for a small company) and both methods for the control of air emissions are contained in the proposed regulations. MF were not particularly worried about the reported effects of fume suppressant (surface tension reduction method) on the quality of chrome deposit. This attitude likely results from a lack in quality control, which itself results from a lack of detail in the customers specifications. Regional MF use visual observation (presence of foam at the surface of the bath) instead of measurement with a stalagmometer as a control method for the addition of fume suppressant into the electroplating solution. Generally, they were not aware that closer monitoring of surface tension would have the added benefit of saving chemical costs. Most of the metal finishers surveyed in the Atlantic Region rely almost entirely on remote chemical suppliers for their process control and their record keeping could be improved. This is all part of a lack in formal training on metal finishing science and good practices.

In some of the facilities in which we were authorized to conduct a preliminary evaluation, we observed the following problems: incomplete or outdated inventory of materials, material safety data sheets (MSDS) either lacking or expired (beyond three years), insufficient WHMIS labelling of containers, lack of spill kits, lack of berms or pans for storage of hazardous materials and wastes, storage of hazardous wastes for over 90 days without a permit, and lack of segregation of wastes.

We also identified a lack of formal client training on transportation of dangerous goods, spills prevention and environmental emergency planning, which contributes significantly to the problems mentioned above. These items were therefore included in the programs of the

Workshops held in Moncton NB on January 18, 2005 and Halifax NS on January 20, 2005 (see Appendix C). All the Power Point presentations prepared by CAMF and CRA for the Workshops are on the CD included with this report, which was also given to the MF workshop participants. Also information is available on the CAMF website (www.camf.ca), through annual regional workshops, monthly national newsletters and finally members can contact CAMF for questions and services requests.

Only two larger corporations with qualified personnel had an environmental management system. The smaller companies did not, and therefore, a copy of the CAMF EMS Manual was provided to them.

Many companies hoped to incorporate Pollution Prevention and Energy Efficiency projects in the future. The CAMF P2 Technologies Manual and CAMF Ninth Progress Report, which contains around 60 case studies, were also included on the CD.

<u>Positive Environmental Initiatives Identified</u>

It is important to mention that the MF facilities surveyed in Atlantic Canada and the six participants to the detailed eco-efficiency evaluation in particular (see Section 4.0) demonstrated a positive attitude toward pollution prevention and recycling, since it is their usual business practice to behave as good corporate citizens and to strive for quality and efficiency in the operation of their facilities. Many were eager to learn as much as possible on pollution prevention and how to improve their production processes.

The practice of recycling paper, cardboard, wood, plastics (especially clean containers), steel strapping and wires, and used oil is undertaken at most facilities. For example:

- One facility reported the elimination of 300-600 used plastic barrels and 300-600 wood pallets from its garbage stream, by reusing them for storage and shipment;
- Two facilities involved in painting in addition to MF also recycled waste paint containers so that they are diverted from landfill.
- One facility uses a centrifuge for metalworking fluid (coolant) recycling.

- Another facility has purchased a Solvent Recycler unit (distillation). The quality of solvent (Methyl Ethyl Ketone, MEK) recovered is high enough (95% plus) to be reused for the cleaning of parts and painting equipment. If the unit is operated at normal capacity (10 gallons per day) the payback is less than one year.

From these observations, it can be concluded that Government messages on recycling are well understood in Atlantic Canada. Recycling of metal wastes is further discussed in Section 3.0.

APC Coatings (formerly ARGO Protective Coatings Inc.) is a corporation which goes beyond environmental compliance. It has achieved significant environmental and economic gains (zinc waste recycling in particular), which were presented in success story sheets by the Dalhousie University Eco-Efficiency Centre, Dartmouth NS, in 2001 and 2006. Yet APC strives to keep implementing new processes into its facilities for hot dip galvanizing and painting of steel. For showing such leadership, APC (formerly ARGO) was the recipient of the CAMF Pollution Prevention Award at the CAMF Annual Conference & Exhibition in Niagara-on-the-Lake on November 8, 2005.

3.0 METAL SLUDGE RECOVERY/RECYCLING

Waste streams produced by the MFI include: wastewater effluents, spent process and stripping solutions, air emissions, and treatment plant sludge.

Depending on the type and size of MFI operation, there might be opportunities to recover and recycle metal sludge that can yield significant economic and environmental benefits. Recovery and recycling of metal sludge can also represent greenhouse gases (GHG) savings in terms of displacing the energy and process emissions associated with the mining, processing, transport, and manufacturing of primary metal and metal products.

Methodology

In order to assess the general feasibility of metal sludge recovery, we conducted the facility visits and asked the regional finishers to complete the survey as explained in the previous section. Additional data on emissions and sludge generation were already available from Environment Canada's National Pollutant Release Inventory (NPRI) website:
http://www.ec.gc.ca/pdb/npri/npri_home_e.cfm

Results

As indicated in Section 2.1, there were only 24 companies actually doing metal finishing in Atlantic Canada. At the date of this Final Report, a total of 11 MF had agreed to be surveyed regarding the generation of metal sludge. It is now doubtful that we will get this information from the remaining 13 companies identified as possible generators. However, current results indicate that in small facilities there is very little metal sludge being generated. Based on the type and size of the companies which did not participate in the survey, we do not anticipate identifying any major increases in the amount of sludge generated. The results of the survey are presented in Appendix A and are summarized in Table 3 on next page.

TABLE 3: SURVEY OF METAL SLUDGE GENERATION IN THE ATLANTIC PROVINCES (2004)

Province	# of Companies Surveyed	Approximate Amount of Sludge Generated per year	
		Recycled (Zn)	Not Recycled (Cr)
New Brunswick	3 of 11	None	0.21 m3
Nova Scotia	7 of 9	10.25 m3	2.67 m3
Newfoundland	2 of 4	386 kg	None

Some very important facts are not apparent in the aggregated data.

First, it is the common practice for small MF to indicate the amount of sludge using drums (205 L) as units of measurement. Depending on the dryness of the sludge, the weight of a drum can vary. However, as a first approximation, 1 m^3 of filtered sludge should not exceed 2 tons based on a study of metals precipitation from electroplating effluents with different hydroxides available on the web:
www.p2pays.org/ref/02/01206.pdf
www.usace.army.mil/usace-docs/eng-manuals/em1110-1-4012/chap3.pdf

The small companies doing chrome electroplating generate only a few drums of sludge every year. They avoid the sludge producing wastewater treatment by rinsing the coated parts directly over the electroplating tanks. By doing this, they minimize their raw material (hexavalent chromium) losses and they do not have any continuous rinse water flow to treat. Depending on the processes and metals used, higher production rate and more stringent specifications to meet, other larger companies would not have this option and would generate sludge.

Some facilities have also kept waste solutions in storage instead of treating it and this practice results in lower quantities of sludge generated annually. P2 options which are recommended (see Section 4.0), such as better control of bath chemistry, improved rinsing techniques and segregation of waste streams, will likely decrease significantly the volume of liquid chromic acid waste some MF have accumulated.

Second, the largest amount of sludge is generated at a big galvanizer facility. This sludge contains zinc which is already recycled. The galvanizer facilities generates an important quantity of other types of zinc containing wastes which are alternatively called ash, dust, dross and skimming. The company also has a very successful recycling system in place for all these other types of zinc wastes. It should be noted that the terms (sludge and others) used to identify the different wastes explain the discrepancy in the quantities reported by this galvanizer in Table 3 and Table 4. For calculation of total sludge generated in the Atlantic region, only the value from Table 4 was used for this galvanizer from Nova Scotia.

Table 4 on next page presents data on waste reported by companies to the NPRI. None of the companies had used the CAMF Emissions Calculator to produce their annual NPRI report. The Emissions Calculator is a computer program available, through purchase, from CAMF (www.camf.ca). It can be an important tool in recording raw materials consumption and waste generation. Therefore, the benefits of the Emissions Calculator were presented in the Workshop programs held in Moncton, NB on January 18, 2005 and Halifax, NS on January 17, 2005 (see Appendix C).

The survey did not identify a MF which produces sludge containing copper and nickel. Cadmium waste was reported at one company, in small quantity only.

TABLE 4: WASTE REPORTED TO THE NPRI FOR METAL FINISHING COMPANIES IN THE ATLANTIC PROVINCES (2004)

Company	Substance	Releases / Disposal / Recycling	Details	Amount
Pratt & Whitney	Hexavalent chromium compounds	Off-Site Disposal	Chemical Treatment	753.5 kg
	Zinc and its compounds	Off-Site Recycling	Recovery of Metals	67.813 tons
IMP	Cadmium and its compounds	Off-Site Disposal	Chemical Treatment	44.66 kg
	Hexavalent chromium compounds	Off-Site Disposal	Chemical Treatment	60.593 kg
Atlantic Hardchrome	Hexavalent chromium compounds	On-Site Release to Air	Stack	38.0 kg
Argo	Hydrochloric acid	Off-Site Disposal	Physical Treatment	148.72 tons
	Zinc and its compounds	Off-Site Recycling	Recovery of Metals	63.525 tons
Atlantic Industries	Hydrochloric acid	Off-Site Disposal	Land Farm	46.24 tons

Note: The total quantity of metal sludge reported to the NPRI is 132.2 tonnes.

Based both on the survey results and the NPRI reports, there were approximately 138.3 tons of metal waste (including sludge) generated in the Atlantic region, of which 131.7 tons of zinc bearing waste were already recycled (100%), and 0.81 ton of chromium sludge are already receiving chemical treatment prior to off-site disposal (out of a total of 6.57 tons).

Recyclers

Recycling companies where the sludge and other wastes can be sent have been identified for each metal and are listed in Appendix D. Credits paid by the recyclers to the MF are also indicated for typical metal contents of sludge and other wastes.

Metal Sludge Recycling: Preliminary feasibility study

In the case of chromic acid, the recycler Inmetco, located in Pennsylvania, (http://www.inmetco.com/) would charge a price which depends on the volume of liquid waste, concentration of Cr and presence of other metals. For example, the cost would increase from 0.63 $US/L to 0.73 $US/L (130 $US per drum to 150 $US per drum) for Cr concentrations of 2.5 g/L and 5 g/L respectively. In bulk shipment (tanker), the price would fall to 0.22 $US/L. Inmetco would also require a minimum shipment of 10-12 drums.

Information obtained during the Pilot Project shows that small metal finishers do not individually generate the quantity of metal sludge per year to produce one load, such as 10-12 drums. Therefore the periodical collection of waste generated by many participating facilities would be needed. Provincial permits for longer storage periods at facilities might also be needed. Analysis of each stream would ideally be completed and this would generate additional costs. All the metal sludge collected at a transfer station would then be shipped to Inmetco. Transportation by truck from Halifax to Pittsburg (Pennsylvania) would cost 2800 $Can for a load of 20 tons. There would be brokerage fees to go through the border between Canada and the USA and there might also be some taxes.

The federal regulations on Interprovincial Movement of Hazardous Waste can be found at:
http://www.ec.gc.ca/CEPARegistry/regulations/detailReg.cfm?intReg=68

The federal regulations on Export and Import of Hazardous Waste and Hazardous Recyclable Material can be found at:
http://www.ec.gc.ca/CEPARegistry/regulations/detailReg.cfm?intReg=84

It would be preferable to get a specialist involved to optimize the logistics and to complete the required forms to obtain authorization for such a multi-participants project (see for example www.networkenvironmental.net).

Disposal locations in the Atlantic Provinces for metal sludge

The hazardous waste contractors listed in the Yellow Pages for New Brunswick, Nova Scotia and Newfoundland were contacted to determine where metal impacted sludge generated in the Atlantic Provinces could be sent for disposal, in order to make a preliminary comparison with recycling. All of the companies that accept metal impacted sludge in the Atlantic Provinces are hazardous waste transfer stations and they send the waste to hazardous waste landfills located in either Quebec (see for example www.stablex.com) or Ontario. The final disposal location is dependant on analytical results for the waste sent for disposal (if available). If no analytical results are available for the waste, the worst case scenario is assumed for disposal. The results of this survey are presented in Table 4.

TABLE 5: DISPOSAL OPTIONS FOR METAL IMPACTED SLUDGE GENERATED IN THE ATLANTIC PROVINCES (2005)

Province	# of Companies Contacted	Disposal Costs per 45 gal Drum (205 L Drum)	Transport Costs	Disposal Location
New Brunswick	3	$285 ($1.39/L)	Incl. in disposal costs	Quebec or Ontario
Nova Scotia	1	$285 ($1.39/L)	Incl. in disposal costs	Quebec or Ontario
Newfoundland	2	$500 ($2.44/L)	Incl. in disposal costs	Quebec or Ontario
Prince Edward Island	1	$285 ($1.39/L)	Incl. in disposal costs	Quebec or Ontario

Preliminary comparison between recycling and disposal

In the case of chromic acid, the cost per drum would be approximately $230, taking into account only recycling ($146 per drum using an exchange rate of CDN$1.12 / US$1) and transportation ($84 per drum). This has to be compared to a cost of $285 per drum for disposal in 2005. Recycling being almost 20% less costly than disposal, the small volume of chrome waste generated each year appears once again to be the worst impediment to a sludge recovery/recycling pilot program in the Atlantic Region. A more detailed study would be needed in order to warrant starting a pilot program. It should include sampling of all types of chrome containing wastes generated (chromic acid solutions and sludge) and evaluation by the potential recycler to verify compatibility with its recycling process. Other costs listed in the preliminary feasibility study should also be established precisely. Evolution of chrome prices and the eventual presence of a chromic acid recycler in Canada would also have to be considered. The challenges to making recycling a viable option as well as how they can be overcome have nevertheless been identified. The economical threshold for switching from disposal to recycling has been examined.

<u>Greenhouse gases (GHG) - Linkage of the tonnages associated with increased recycling to the CO_2 equivalents</u>

The following are the factors provided by Natural Resources Canada which can be used for the calculations of CO_2 equivalents:

Cd and Zn = tonnage X 2.12	131.7 tons Zn correspond to 279.2 tons CO_2 equivalents
Cu = tonnage X 4.73	Nil
Cr = tonnage X 3.05	6.57 tons Cr correspond to 20.0 tons CO_2 equivalents
Ni = tonnage X 8.88	Nil

NOTE: These factors can be considered to be estimates and should be used only for preliminary calculations.

For example, in the case of the zinc currently recycled in the Atlantic Region (131.7 tons), 279.2 tons of CO_2 equivalents have already been saved. However, this calculation assumes all the waste reported is metal and all the metal can be recycled.

4.0 DETAILED VOLUNTARY ECO-EFFICIENCY EVALUATIONS OF COMPANIES

Methodology

The evaluations always began by completing the CAMF Metal Finishing Environmental Management System Manual check list, followed by conducting a comprehensive inspection of the facilities and property. Environmental documentation and records were reviewed, pertinent staff members were interviewed, production was observed and procedures and installations for the storage of chemicals, processes, environmental controls and waste disposal were checked.

A first confidential report on compliance and environmental management including observations and recommendations was produced for each company.

The work described above was used to identify and prioritize specific options for design and operational improvements, which could contribute to economic and environmental benefits. The results were the subject of a second confidential report on pollution prevention (P2) options for each company, which provided technical advice related to the implementation of the improvements.

Results

CAMF and CRA succeeded in getting six facilities involved in a detailed eco-efficiency evaluation. These facilities were:

- APC Coatings (formerly ARGO Protective Coatings Inc.) (NS)
- Atlantic Hardchrome Limited (NS)
- Custom Machine & Hardchrome Inc. (NB)
- EMM Hardchrome & Hydraulics Ltd. (NL)
- Fleet Maintenance Facility Cape Scott – Canadian Forces Base (NS)
- Topcoat Solutions Inc. (NB)

More information on these companies is available in Appendix A. It is important to note that at the time of the evaluations, the layouts in two electroplating shops were undergoing review and consideration was already being given to the implementation of P2 options during the planning stage by the two respective managers.

Generic versions of the Best Management Practices advocated in the detailed reviews are summarized in the form of the 19 Fact Sheets presented in Appendix E. These Fact Sheets are:

Fact Sheet #1 – Facilities Layout and Improved Design for Pits and Floor
Design to prevent infiltration of chromic acid and other metal finishing chemicals in the case of spills or tank failure is presented.

Fact Sheet #2 - Decrease in Chromic Acid Losses from Rinse and Spills
Proper rinsing techniques for decreasing raw materials consumption and liquid wastes generation are presented.

Fact Sheet #3 – Metals Recovery Technologies
The technical feasibility and economic evaluation of atmospheric evaporators, membrane and ion-exchange systems to decrease the volume of liquid wastes are discussed.

Fact Sheet #4 - Drag-out Reduction
The importance of minimizing drag-out is explained.

Fact Sheet #5 - Counter-Flow Rinsing
The principle of this rinsing technique is presented.

Fact Sheet #6 - Fresh Water Flowrate Optimization for Rinsing
The mathematical equation governing rinsing and how it should be applied in metal finishing processes are explained.

Fact Sheet #7 - Atmospheric Emissions Control

The options to meet the proposed **Chromium Electroplating, Chromium Anodizing and Reverse Etching Regulations** are presented. The use of variable speed drive on ventilation fans to improve energy efficiency is mentioned.

Fact Sheet #8 - Alkaline Electro-stripping Ventilation

Ventilation required to operate of this stripping bath is presented.

Fact Sheet #9 - Electroplating Baths Chemistry and Analysis

The optimization of baths compositions is explained. Testing methods to keep baths at these best concentrations are also presented.

Fact Sheet #10 - Electroplating Bath Life Extension

A list of basic techniques to increase baths life is given.

Fact Sheet #11 - Introduction to Metal Finishing Process Control

Process Control (PC) leads to higher quality of deposits and more efficient production. Other benefits include a decrease in the use of raw materials and waste minimization.

Fact Sheet #12 - Trivalent Chromium for Passivation of Aluminium Alloys and Zinc

New baths compositions are being developed by suppliers and both metal finishers and the environment should benefit from the toxic chemicals substitution.

Fact Sheet # 13 - Solvent Cleaner Substitution

The advantages and challenges of water based cleaners are discussed.

Fact Sheet #14 – Chromic Acid Bath Life Extension with a Porous Pot

In hexavalent chromium baths, a porous pot should be used to decrease raw materials consumption.

Fact Sheet #15 - Controlling the Ratio CrO_3 / SO_4

Another chemical technique to keep the chrome plating bath working well is explained.

Fact Sheet #16- Pickling (Hydrochloric Acid) Bath Life Extension

The technical feasibility and economic evaluation of different chemical and physical techniques to decrease the volume of liquid acid wastes are discussed.

Fact Sheet #17 - Cooling Water Recirculation

The use of closed-loop water instead of once-through water for cooling of electroplating baths leads to huge water savings.

Fact Sheet #18 - Compressor Replacement for Air Agitation *(Energy Efficiency)*

Design of air spargers for agitation in process and rinse tanks is explained.

Fact Sheet #19 - Rectifier Performance Improvement *(Energy Efficiency)*

Simple energy saving tips related to rectifiers are presented.

5.0 REGIONAL TRAINING

In October 2004, CAMF provided the following training material to CRA staff, in order to build capacity within the consulting industry in the Atlantic Region:

- Metal Finishing Environmental Management System Manual
- Metal Finishing P2 Technologies Manual
- Ninth Progress Report – 2003 (including P2 case studies)
- Metal Finishing Environmental Compliance Manual
- NPRI Emissions Calculator
- Pollution Prevention and Control in the Metal Finishing Industry video series (total time of 96 min)

CRA staff studied the training material and the CAMF coordinator provided additional explanations on metal finishing processes, in order to develop regional expertise.

The first five facilities visits for the survey and four detailed voluntary eco-efficiency evaluations were conducted under the leadership of the CAMF coordinator. However, the seven other facilities visits were conducted by the CRA employees, with the two other detailed voluntary eco-efficiency evaluations completed with the CAMF coordinator as an observer. Work on the P2 options nevertheless required the technical assistance of the CAMF coordinator because of his experience in metal finishing.

CRA employees were also strongly involved with the CAMF coordinator in presenting two workshops in Moncton NB and Halifax NS in January 2005, described in Section 2.2 and Appendix C.

During the client surveys, a lack in formal training on metal finishing science and good practices was identified. This had a direct impact on the efficiency of processes, quality of production and competitiveness of the regional MFI. It had also a direct impact on the environment, since better operation practices are needed to achieve waste minimization.

Therefore CAMF and CRA organized a course on “Chromium Plating for Engineering Applications”. The course was given in Dartmouth NS by an American Electroplaters and Surface Finishers Society (AESF) Certified Trainer on two consecutive days (March 27 and 28, 2006), based on industry–recognized documentation from AESF. The course was designed specifically to meet the needs of metal finishing shop owners, engineers, technicians and production foremen. The course outline is presented in Appendix F.

A binder with almost 500 pages of information was given to each participant. In particular, the binder included information on atmospheric emissions control (which will be required in the Chromium Electroplating, Chromium Anodizing and Reverse Etching Regulations) and bath life extension (which is an important pollution prevention practice).

The course had good attendance since eight persons from seven companies attended it (see Appendix F). People made comments about the very good quality of the course and the trainer Frank Altmayer, formerly Technical Director of AESF. People also made comments on the practical know-how which was presented to them and corresponded very much to their industrial needs.

6.0 FOLLOW-UP OF THE PILOT PROJECT

Methodology

The Follow-up Questionnaire presented in Appendix G was sent to all MF who were participants to the pilot project in the Atlantic Region (12 companies). There were approximately 6-8 months between the time of the detailed site visit and the associated follow-up. This allowed time for facilities to evaluate and make preliminary or final decisions on implementing site specific recommendations. Detailed questions were included to assess any progress on environmental compliance issues and P2 projects. The Questionnaire was also used to evaluate the usefulness of the activities (the workshops in particular) organized by CAMF and CRA during the pilot project, in order to better plan future initiatives.

When the MF was a participant of the detailed eco-efficiency evaluations, it was visited on-site or interviewed extensively on the telephone to assess implementation of the recommendations made in both the compliance and P2 reports. CRA staff conducted this activity. The method for conducting the follow-up visits is presented in Appendix H.

Follow-up Results

The results of the follow-up are presented in detail in Appendix I and summarized below:

- 58% of the facilities (7/12) which participated in the pilot project responded to the Follow-up Questionnaire. All but one of the respondents were participants to the detailed eco-efficiency evaluation.
- 100% of the respondents reported an increased environmental awareness or a reinforcement of an already high awareness following the pilot project.
- 100% of the respondents reported that they made some changes to their facilities or to their procedures to increase their level of compliance or that they maintained an already high level of compliance.

- 71% of the respondents (5/7) reported changes in procedures or plant layout to improve their environmental performance (P2 options). Others respondents were planning to do this in 2006.

Participation to this pilot project was on a voluntary basis. The numerous and varied recommendations on compliance and P2 which were implemented, as shown above, demonstrate that the pilot project was a success for the companies that chose to benefit from the assistance provided by CAMF and CRA under this program.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

There are 24 metal finishers in Atlantic Canada. Of the 24, eleven are in NB, nine in NS, and four in Newfoundland and Labrador. Twelve companies (50%) took part in the general survey, with six receiving detailed evaluations.

The survey made it possible to collect relevant baseline information on air, water and land releases of CEPA toxics and substances of concern; to determine the current environmental performance against relevant federal, provincial and municipal legislation or recognized Codes of Practice.

Nine of the twelve companies surveyed had either Certificates of Approval or an Industrial Permit (including three in the process of amending them) and the remaining three companies did not require permits. Four of the companies questioned held copies of relevant regulations and two had an Environmental Management System (EMS) in place.

Three of the twelve companies which took part in the survey report under the National Pollution Release Inventory. Two other companies report under NPRI in the Atlantic Region; however they did not take part in the survey. None of the companies had used the CAMF Emissions Calculator to produce their annual NPRI report. The calculator can be an important tool in a recording system of raw material consumption and waste generation.

Seven of the twelve surveyed companies were in chrome electroplating and six of these facilities use fume suppressants to control atmospheric emissions of hexavalent chromium. This method is preferred over scrubber use because there is no need for high initial capital investment. Both methods for the control of atmospheric emissions are contained in the proposed federal regulations.

Formal training on metal finishing science and good practices was lacking. This had a direct impact on the efficiency of processes, quality of production, waste generation and competitiveness. CAMF organized a metal finishing short course in Atlantic Canada on March 27 and 28, 2006 and there were eight participants from seven companies.

Based on the survey results and the NPRI reports, there were approximately 138.3 tons/year of metal waste (including sludge) generated in the Atlantic Region, of which 131.7 tons of zinc bearing waste are already recycled, and 0.81 ton of chromium sludge are receiving offsite chemical treatment prior to disposal. Small companies generate only a few drums of sludge every year, generally avoiding sludge producing wastewater treatment by rinsing the coated parts directly over the electroplating tanks.

The data collected was studied to evaluate the general feasibility of metal sludge recovery/recycling in the Atlantic Region. For the case of chromic acid waste, the economical threshold for switching from disposal to recycling is 20% in favor of recycling, but a more detailed study would be needed in order to investigate any ‘hidden’ costs and warrant starting a pilot program. The challenges to making recycling a viable option have been identified, as well as how several of these challenges can be overcome. Specific issues/concerns relate to the small volume of waste generated by each MF in Atlantic Canada and the need for consolidation at a transfer station.

CAMF and CRA succeeded in getting six facilities involved in a detailed eco-efficiency evaluation. Many opportunities for improvement were identified and 19 Facts Sheets have been produced to summarize pollution prevention and energy efficiency options.

Follow-up of the pilot project has shown that respondents have increased their environmental awareness, their level of compliance, and their environmental performance (P2 options). 71% of the respondents (5/7) reported changes in procedures or plant layout to improve their environmental performance. Others were planning to do this in 2006.

The metal finishing (MF) facilities surveyed in Atlantic Canada and the six participants of the detailed eco-efficiency evaluation in particular demonstrated a positive attitude toward pollution prevention and recycling in particular, as government messages and programs on pollution prevention, eco-efficiency and recycling are prominent in Atlantic Canada.

APC Coatings (formerly ARGO Protective Coatings Inc.) from Dartmouth (NS) was the recipient of the CAMF Pollution Prevention Award on November 8, 2005 for showing strong eco-efficiency leadership.

The numerous and varied recommendations on compliance and P2 which were implemented demonstrate that the pilot project was a success for the companies that chose to benefit from the assistance provided by CAMF and CRA through this program.

Recommendations

Among the important findings, we identified a lack of formal training on WHMIS, transportation of dangerous goods, spills prevention and environmental emergency planning. Local resources are available to provide this training at reasonable costs.

This report was prepared by Marc Sider of CAMF and reviewed by F. Neil Brodie of CRA.

Marc Sider, Eng., M.A.Sc.
Coordinator – Pollution Prevention & Energy Efficiency
Canadian Association of Metal Finishers

F. Neil Brodie, P.Eng.
Director of Engineering
Conestoga-Rovers & Associates

APPENDIX A

INVENTORY OF METAL FINISHERS IN THE ATLANTIC PROVINCES

	Name	Address	Telephone/Fax	Contact Name	Telephone Contact Details	Sludge Generated
Companies that do Metal Finishing						
1	**Anotec**	242 Parker Road Scoudouc, NB E4P 3R3	(506) 532-3601 FAX (506) 532-3622 E-mail: anotec@nb.aibn.com.	Norman Bérubé President	Sent survey and workshop information. Several follow-up calls were made. No response.	Unknown
2	**Atlantic Industries Ltd**	PO Box 1006 Dorchester, NB E4K 3V5	(506) 379-2428 FAX (506) 379-1097 gjackson@ail.ca	Gord Jackson Operations Engineer (379-9238)	They do mainly galvanizing. They have some acid waste but no metal sludges. They are not interested, as they belong to a galvanizers association. May be interested in the workshop. Workshop information sent. Follow-up call made. They are not interested.	None
3	**Atlantic Powder Coating**	1377 Hanwell Rd. Fredericton, NB E3C 1A6	(506) 457-2238	Cedric Munn	They do powder coating. They requested more information. Survey and workshop information sent. Several calls made. No response.	Unknown
4	**G.E. Canada Inc.**	1880 Connolly Ave BATHURST, NB E2A 4W7	(506) 548-8848 FAX (506) 546-8025	André Lagacé	They do mainly machining and welding with some minor silver plating (connection tips). He doesn't think they need any help with their environmental issues as they are a large company and have internal staff for this. Finishing is a very minor part of their work. He will however participate in the survey by filling out the questionnaire but is not interested in a site visit or a detailed audit. Survey and workshop information sent. Several follow-up calls made. No response.	None
5[abc]	**Custom Machine & Hardchrome Inc.**	85 Melissa St. Building 15, Unit 1 Fredericton, NB E3A 6V9	(506) 459-2220 FAX (506) 459-2247	Glen Allen President	Site visit and general survey completed Nov.29, 2004. They have one chrome tank and do mostly chrome repair work (4 employees). He has recently purchased the company and is not aware of all regulatory requirements. A detailed audit was completed here on December 9, 2004. Lorne Goodine attended the workshop.	Less than 45 gal/year.
6[ac]	**Maritime Hydraulic Repair Centre**	270 MacNaughton Ave. Moncton, NB E0A 1R0	(506) 858-0600	Kim Carruthers General Manager	Site visit and general survey completed Nov. 17, 2004. They have one hardchrome plating tank. Kim Carruthers attended the workshop.	Less than 45 gal/year.
7	**Minto Machine & Welding Ltd**	860 Pleasant Drive Minto, NB E4B 2V5	(506) 327-3361 FAX (506) 327 6740	Peter Gaddess	They have two hardchrome plating tanks. They are interested in participating. He will check with the staff member that takes care of the tanks and get back to mCAMF with a time for a site visit. Workshop information sent. Several follow-up calls made. No response.	Unknown
8	**R J's Gold & Graphics**	3068 Route 180 South Tetagouche, NB E2A 7C2	(506) 548-3586 FAX (506) 546-8611		Does very little gold plating and generates very little waste. Not really interested, but sent him the survey and workshop information. He will contact us if he changes his mind. No response.	None
9	**Roger's Welding & Rental Ltd**	557 Rue Principale PO Box 62 Beresford, NB E0B 1H0	(506) 542-9602 FAX (506) 542-9283	Daniel Aube	He does little finishing and is on the verge of closing due to the current economy. He is not interested at this time. If he is still in business in the spring, he may be interested then.	Unknown
10[abc]	**Topcoat Solutions Inc.**	181 Edinburgh Drive Moncton, NB E1E 2K9	(506) 388-5552 FAX (506) 388-5559 e-mail info@topcoatsolutions.com	Perry Colpitts President	They do coating work. Site visit and general survey completed Nov. 16, 2004. A detailed audit was completed on Jan. 17, 2005. Perry Colpitts attended the workshop.	None
11	**Versatile Powder Coating Inc.**	209 Edinburgh Drive Moncton, NB E1E 2K9	(506) 384-8881 FAX (506) 388-8883	Bob King	He was interested and was receiving newsletters from CAMF. He wanted to discuss it with his partner first. He was also interested in the detailed audit. All information was sent by mail and several follow-up calls were made. No response was received.	Unknown
Companies that may or may not do Metal Finishing - Contact attempted but no response						
12	**Carleton Metal Works Ltd.**	Florenceville, NB E0J 1K0	(506) 392-6217		Made several calls and left messages. No response.	Unknown
13	**Forgeron Sylvain Ltd**	188 Boul St Peter E Caraquet, NB E1W 1B1	(506) 727-2538 FAX (506) 727-2583		Made several calls. No answer and no answering service.	Unknown

Note: "a" Company participated in the general survey portion of the pilot project.
"b" Company participated in a detailed audit.
"c" Company participated in one of the Workshops held in January 2005.

	Name	Address	Telephone/Fax	Contact Name	Telephone Contact Details	Sludge Generated
Companies that may or may not do Metal Finishing - Contact attempted but no response						
14	**Technical Heat Treatment SVCS**	PO Box 3187, Stn B Fredericton, NB E3A 5G9	(506) 658-0699 FAX (506) 648-1986	Ted Pond President	Made several calls and left messages. No response.	Unknown
15	**Thomas Equipment**	Centreville NB	(506) 276-4161	Robyn Hathaway	Made several calls and left messages. No response.	Unknown
Companies that do no Metal Finishing						
16	**Arvin Machine Works**	Miramichi, NB	(506) 773-5887		No Metal Finishing	Unknown
17	**BFC Atlantic**	Saint John, NB	(506) 633-3235		Phone number out of service.	Unknown
18	**Bathurst Machine Shop Ltd.**	1040 Route 430 BIG RIVER, NB E2A 6P9	(506) 548-4479 FAX (506) 546-5438 bms@nb.aibn.com	Gerald	No Metal Finishing	None
19	**Bernard Victor & Sons Ltd.**	P.O. Box 2006 Charlo, NB E8E 2W8	(506) 684-3791		They don't do any metal finishing. The only thing close is welding.	None
20	**Blackhawk Enterprises**	605 Charters Settlement Road Charters Settlement, NB E3C 1V8	(506) 462-0005		They ship their products to Dartmouth to be hot dip galvanized. They only do minor welding here.	None
21	**Bourque Industrial Ltd.**	85 Industrial Drive Saint John, NB E2R 1A4	(506) 633-7740	John Bourque (633-9650)	They only do minor painting. No Metal Finishing	None
22	**Brass N'Things**	51 Canterbury St. Saint John, NB E2L 2C6	(506) 634-0606 FAX (506) 636-9105	Marcel Doucet	They don't do any plating or anything with chemicals anymore. They only do polishing and cleaning. This generates no waste as he uses no solutions. Not interested.	None
23	**Byron MacDonald Ltd.**	714 South Napan Rd. NAPAN, NB E1N 4W5	(506) 773-5845 FAX (506) 773-7220 byron@nbnet.nb.ca	Stephen MacDonald	Do some sandblasting and painting. No metal sludges. Not interested.	None
24	**Castle Machine Works Ltd.**	142 Roger St. Nelson-Miramichi, NB E1V 1H1	(506) 622-0752	David Allen	Site visit completed Oct. 16, 2004. No Metal Finishing	None
25	**Dugas J.L. & Son Ltd**	945 Blvd des Acadiens Bertrand, NB E1W 1H5	(506) 727-3053 FAX (506) 727-7607		They are in the process of closing. They will be out of business by Nov. 6, 2004.	None
26	**Dick's Repair Shop Ltd.**	Carmen Ave. Fredericton, NB E3A 3X1	(506) 472-6517 FAX (506) 459-3238	Richard Boudreau	They do mostly welding and repair work with minor painting. No Metal Finishing	None
27	**Enflo Canada Ltd**	73 ch Industrial Grand Falls, NB E3Y 3V1	(506) 473-3711 FAX (506) 473-2307		They do no metal finishing. They apply Teflon.	None
28	**F&N Sheetmetal Ltd.**	620 Charters Settlement Road Charters Settlement, NB E3C 1X8	(506) 450-7903 FAX (506) 455-9759	Floyd or Nancy	Do metal fabrication (cutting and bending, etc..) only. No Metal Finishing	None
29	**Galva Industries**	1201 Mountain Rd. Moncton, NB E1C 2T4	(506) 866-2490	Terry Odishaw	They sell systems to the end user. They do no finishing here.	None
30	**Gordon Elroy Welding Ltd.**	38 Mount Pleasant. St. George, NB E0G 2Y0	(506) 755-2729	Elroy Gordon	Mainly does welding. No Metal Finishing. He is in the process of retiring and closing shop.	None
31	**Harris Rebar**	390 Rothesay Ave. Saint John, NB E2J 2C4	(506) 658-1959 FAX (506) 658-0468	Mike Ruggles Branch Manager	No Metal Finishing. Strictly rebar.	None
32	**Imperial Sheet Metal Ltd**	40 Industrial Dr. RICHIBUCTO, NB E4W 4A4	(506) 523-9117 Fax (506) 523-9024 ncaissie@imperialgroup.ca	Charles Finnigan	Do some painting but no metal finishing.	None
33	**Kaycan Ltd.**	83 Reynolds St. Fredericton, NB E3A 9L1	(506) 458-8870 FAX (506) 450-2195	Corey Miller Manager	They do distribution of the products only at this location. All finishing is done in Ontario.	None

Note: "[a]" Company participated in the general survey portion of the pilot project.
"[b]" Company participated in a detailed audit.
"[c]" Company participated in one of the Workshops held in January 2005.

	Name	Address	Telephone/Fax	Contact Name	Telephone Contact Details	Sludge Generated
Companies that do no Metal Finishing						
34	**Kaycan Ltd.**	80 Rideout St. Moncton, NB E1E 1E2	(506) 857-8420	Claudette Donaldson Manager	They do distribution of the products only at this location. All finishing is done in Ontario.	None
35	**North Eastern Enterprises**	PO Box 874 Stn Main Bathurst, NB E2A 4H7	(506) 548-4246 FAX (506) 458-5094		They do fitting and welding with minor painting. No Metal Finishing	None
36	**Ocean Steel**	400 Chesley Dr. Saint John, NB E2M 3S3	(506) 632-2600 FAX (506) 632-7689	Graham Smith	They do mostly painting and have a paint shop. No Metal Finishing. He will review the information sent to him and will contact us if they are interested.	None
37	**Olympic Metals Ltd**	100 ch. St-Simon Caraquet, NB E1W 1A8	(506) 727-3174 FAX (506) 727-6673	Gilles Gallien	They do mainly cutting and some preparation. No Metal Finishing	None
38	**Piper's Welding & Repair**	25 Thomas Road. Centreville, NB E7K2H3	(506) 276-4225 FAX (506) 276-4223	Gladwin Piper	They do welding and repair. No Metal Finishing	None
39	**Precision Metal Works Ltd**	PO Box 3611 Stn B Fredericton, NB E3A 5L7	(506) 363-3066 FAX (506) 363-3851	Tim Brown	They do mainly machining and polishing (no chemicals). They make stainless steel vacuum chambers.	None
40	**Sabian Ltd**	219 Main Street Meductic, NB	(506) 272-2019	John Teague	No Metal Finishing. Buffing only.	None
41	**Scott Irving Sheet Metal Ltd**	PO Box 7108 Riverview, NB E1B 4T8	(506) 387-4728 FAX (506) 387-4728	Scott Irving	This is a small 2 men operation that does mainly duct work. No Metal Finishing	None
42	**Sunny Corner Enterprises**	259 Dalton Ave. Miramichi, NB E1V3C4	(506) 622-5656 FAX (506) 622-5657	Rod MacAskill	Site visit completed Oct. 16, 2004. They don't do any metal finishing.	None
43	**York Steel Inc.**	550 Wilsey Road Fredericton, NB E3B 7K2	(506) 444-7989	Andrew Mackenzie Plant Manager	They do some painting but no real metal finishing.	None

Note: "[a]" Company participated in the general survey
"[b]" Company participated in a detailed audit
"[c]" Company participated in one of the Workshops held in January 2005

	Name	Address	Telephone/Fax	Contact	Telephone Contact Details	Sludge Generated
Companies that do Metal Finishing						
1[a]	**Bruce Enterprises Limited**	6 Kyle Ave. Mount Pearl, NL	(709)739-1871 FAX (709) 739-1875	Herman Bruce	Job shop with 3 employees. They do galvanizing. Send sludge to local company who in turns sends it out of province for recycling. They completed the general survey by fax.	650 lbs - bottom sludge 200 lbs - top ash
2	**Island Manufacturing and Galvanizing**	Bell Island	(709)488-3301	Kevin George	They do galvanizing. Some interest but declined site visit. Survey and workshop information sent. Several follow up phone calls made. No response.	Unknown
3[abc]	**EMM Hardchrome & Hydraulics Ltd**	38 Pearson St. Suite 118 St. John's, NL A1A 3R1	(709) 753-8875 Fax 753-8880	Jim Martin	They do hard chrome plating and brush plating. Detailed audit completed on March 2, 2005. Jim Martin attended the workshop.	Unknown - No disposal in 7 years.
4	**G. Pelley Ltd**	PO Box 610, Springdale, QC A0J 1T0	(709) 673-4296 FAX (709) 673-3601	Ray Pelley	They do galvanizing. Some interest but declined site visit. Survey and workshop information sent. Follow up phone call. Looking at information but still looking at their operation internally, when they are ready to move to external input they will consider this. No further response.	Unknown
Companies that do no Metal Finishing						
5	**Atlantic Industries Ltd.**	P.O. Box187 Mount Pearl, NF A1N 2C2	(709) 738-2772		Site Visit Dec. 2, 2004. Owned by AIL in NB. They do no galvanizing in Newfoundland. Mainly just repairing parts that come from NB. Will pass information along to NB office.	None
6	**D.F. Barnes Ltd.**	22 Sudbury St. ST. JOHN'S, NL A1C 5X4	(709) 579-5041 Fax: (709) 579-5043 info@dfbarnes.com		Fabricate metals. No Metal Finishing	None
7	**Eastern Foundry Limited**	3 Wharf Rd. CLARENVILLE, NL A5A 2B2	(709) 466-3814 Fax: (709) 466-7454 efl@easternanode.nf.ca		Not Involved with metal finishing.	None
8	**Harris Rebar**	55 Moffatt's Road Mount Pearl, NF A1N 5B9	(709) 368-8541		Fabricate metals. No Finishing	None
9	**Kaycan Ltd.**	22 Dundee Ave. Mount Pearl, NF A1N 4R7	(709) 368-8996		Fabricate metals. No Finishing	None
10	**Metal World**		(709)726-3880		Fabricate metals. No Finishing	None
11	**Superior Waterproof Coatings of Nfld. & Labrador Inc**	150 Roe Ave. GANDER, NL A1V 1W6	(709) 256-7634 1(888) 256-7634 Fax: (709) 256-7695 info@rubberproof.com		Fabricate metals. No Finishing	None
12	**Shemetco Ltd**	PO Box 1242 Wabush, NF A0R 1B0	(709) 282-5422 FAX (709) 282-5422		Fabricate metals. No Finishing	None
13	**Terra Nova Marine Company Ltd.**	119 Clyde Ave. Mount Pearl, NF A1N 4R9	(709)747-1565		Metal work. No Finishing	None

Note: "[a]" Company participated in the general survey portion of the pilot project.
"[b]" Company participated in a detailed audit.
"[c]" Company participated in one of the Workshops held in January 2005.

	Name	Address	Telephone/Fax	Contact	Telephone Contact Details	Sludge Generated
Companies that do Metal Finishing						
1[ab]	**Argo Protective Coating Inc.**	160 Joseph Zatzman Dr. Dartmouth, NS B3B 1P1	(902) 468-1040 FAX (902) 468-2643	Mike Lynch	Site Visit and general survey completed Nov.18, 2004. They have two locations. Galvanizing at one location and blasting at the second. Invited to workshop. Did not attend. Detailed P2 audit completed March 3, 2005	50 x 45 gal drums/year
2[abc]	**Atlantic Hardchrome Limited**	5 Notting Crt, Burside Ind Park Dartmouth, NS B3B 1N2	(902) 469-3606 FAX (902) 464-1951	Paul Fergusson/Jim Muir	Site visit completed Nov. 19, 2004. They do hard chrome plating and have 4 tanks. Detailed audit completed Dec. 6-7, 2004. Jim Muir and Paul Ferguson attended workshop.	None
3	**Canadian Medals and Mounting Shop**		(902) 468-6378		No response.	Unknown
4[abc]	**DND Formation Environment (Fleet Maintenance Facility Cape Scott)**	DND Marlant Formation Environment Building S-90, 3rd Floor Halifax, NS B3B 1W8	(902) 427-8624	Deb Clements	They do some metal finishing and would like to get involved. Site visit and detailed audit completed Jan. 21, 2005. Rob Hendrie, Glen Shea and Les Boudreau attended workshop.	12 x 45 gal drums/year
5[ac]	**Hydrachrome Services Inc**	2525 Hwy 1, Upper Sackville, NS B4E 3B7	(902) 865-7323 FAX (902) 865-7329	Sylva Sokolovsky	They do chrome plating and a site visit with general survey was completed Nov. 19, 2004. Sylva Sokolovsky attended workshop.	less than 45gal/year
6[ac]	**IMP Group**	120 Thornhill Dr. Dartmouth, NS B3B 1S3	(902) 468-2111	Kelly Lively-Jones/Rodger Cruickshank	Generate paint stripping sludge. Kelly Lively-Jones and Rodger Cruickshank attended workshop. Not interested in detailed audit. Completed the survey over the phone. No detail on quantities of sludge available.	Unknown
7[ac]	**MIT Sales Ltd.**	71 Wright Avenue Dartmouth, NS B3B 1H4	(902) 468-2667 FAX (902) 468-2817	Cyril Forbes	Site visit and general survey conducted February 10, 2005. Dan Bolovar and Cyril Forbes attended workshop.	Estimate 0.25 X 45 gal drum /year
8	**Pratt and Whitney**		(902) 873-7191		They do metal finishing. Invited to workshop. Did not attend. Not returning calls.	Unknown
9[ac]	**Zenith Plating (1995) Limited**	20 Wright Av, Dartmouth, NS B3B 1G6	(902) 468-4848 FAX (902) 468-3798	Doug Derby	Site visit and general survey conducted March 10, 2005. Doug Derby attended workshop.	Estimate 0.25 X 45 gal drum /year
Companies that do no Metal Finishing						
9	**A & B Marine 2002 Limited**	3854 Highway 3 BARRINGTON PASSAGE, NS B0W 1G0	(902) 637-2206 Fax: (902) 637-2716		No Metal Finishing	None
10	**A-Tech Welding**	P.O. Box 21062 RPO Cole Harbour Dartmouth, NS B2W 6B2	(902) 435-6800		No Metal Finishing	None
11	**Bridgewater Engine & Machine Services**	150 Logan Rd. BRIDGEWATER, Nova Scotia B4V 3J8	(902) 543-8071 Fax: (902) 543-4957	Lynn Stewart	No Metal Finishing	None
12	**Campbell's Sheet Metal & Crafts**	110 Pond Road Sydney Mines, NS B1V 2X4	(902) 736-0299 FAX (902) 736-0566		Bad phone number. Unable to locate.	None
13	**Canadian Maritime Engineering**	90 Thornhill Dr. Dartmouth, NS B3B 1S3	(902) 468-1888 FAX (902) 468-1890	Brian Conrad	Site visit completed Nov. 18, 2004. Interested in ISO. No Metal Finishing.	None
14	**Cape Breton Hydraulics Ltd**	1600 Bedford Hwy, Sunnyside Place Suite 100-175, Bedford, NS B4A 1E8	(902) 564-9699 FAX (902) 562-0899		Now part of Hydrachrome. No MF at CB location	None
15	**Caribou Propeller & Welding**	758 Division Rd. PICTOU, NS B0K 1H0	(902) 485-6620 Fax: (902) 485-6620		No Metal Finishing	None
16	**Cherubini Metal Works Ltd.**	50 Joseph Zatzman Dr. Dartmouth, NS B3B 1N8	(902) 468-5630 FAX (902) 468-5742		No Metal Finishing	None
17	**Cheticamp Welding & Machine Shop Ltd**	15447 Cabin Trail CHETICAMP, NS B0E 1H0	(902) 224-2810 Fax: (902) 224-2810		No Metal Finishing	None
18	**Clare Machine Works Limited**	6816 Main Hwy Digby Cnty. METEGHAN CENTRE, NS	(902) 645-2216 Fax (902) 645-2994		No Metal Finishing	None

Note: "[a]" Company participated in the general survey portion of the pilot project.
"[b]" Company participated in a detailed audit.
"[c]" Company participated in one of the Workshops held in January 2005.

	Name	Address	Telephone/Fax	Contact	Telephone Contact Details	Sludge Generated
Companies that do no Metal Finishing						
19	**Concorde Metal Erectors Ltd.**	CFB Greenwood, Kingston, NS B0P 1R0	(902) 765-9174		Bad phone number. Unable to locate	None
20	**Cooperheat of Canada Ltd**	24 Simmonds Dr, Suite 12, Dartmouth, NS B3B 1R3	(902) 468-5868 FAX (902) 468-5869		No Metal Finishing	None
21	**Corkum's K & A Pipe Culvert**	272 Windemere Road Berwick, NS B0P 1E0	(902) 538-8066 FAX (902) 538-7877		No Metal Finishing	None
22	**Coxweld Ltd.**	131 Shore Rd. BADDECK, NS B0E 1B0	(902) 295-3300 Fax: (902) 295-1801		No Metal Finishing	None
23	**Cross Ornamental Iron & Welding**	11 Melva St Dartmouth, NS B2W 1A1	(902) 463-6699		No Metal Finishing	None
24	**Custom Machine & Tool Co**	122 Hwy 1 MOUNT UNIACKE, NS B0N 1Z0	(902) 866-2420 Fax: (902) 866-0182		No Metal Finishing	None
25	**D.J. Manufacturing Inc.**	12486 Highway 217 DIGBY, NS B0V 1A0	(902) 245-5900 Fax: (902) 245-4599 http://www.screentitan.com		Sandblasting only.	None
26	**D. Loomer Machine Shop Ltd**	1445 Marshall Rd. KINGSTON, NS B0P 1R0	(902) 765-2258		No Metal Finishing	None
27	**Dalton Industries**		(902) 463-7789		No Metal Finishing	None
28	**Dwight MacGillivary Welding & Metal**	P.O. Box 35 Advocate Harbour, NS B0M 1A0	(902) 392-2997		No Metal Finishing	None
29	**E. & M. Welding**	2376 Hwy. 334 WEDGEPORT, NS B0W 3P0	(902) 663-4444 Fax: (902) 663-2768		No Metal Finishing	None
30	**Eastcoast Hydraulic & Machinery Ltd**	Main St. Government Wharf Mulgrave, NS B0E 2G0	(902) 747-3133 Fax: (902) 747-2388 echm@ns.sympatico.ca		No Metal Finishing	None
31	**Eastern Canadian Structures Ltd.**	422 Queen St. Truro, NS B2N 2C6	(800) 565-2046 (902) 897-9553		No Metal Finishing	None
32	**F.E. Veinot & Sons Machine & Welding Co. Ltd**	1620 Hammond Plains Rd. HAMMONDS PLAINS, NS B4B 1P5	(902) 835-2754 Fax: (902) 835-5787	Christine Veinot	No Metal Finishing	None
33	**Fabco Industries Limited**	45 Raddall Ave. DARTMOUTH, NS B3B 1L4	(902) 468-3222 Fax: (902) 468-3328		No Metal Finishing	None
34	**Frank's Universal Machine Shop Ltd.**	175 Rocky Lake Rd BEDFORD, NS B4A 2T4	(902) 835-7397 Fax: (902) 835-7397		No Metal Finishing	None
35	**Harris Rebar**	150 Joseph Zatzman Dr Dartmouth, NS B3B 1P1	(902) 468-2526 FAX (902) 468-2675		No Metal Finishing	None
36	**J.A. Macleod Sheet Metal**	R.R. 2 RIVER JOHN, Nova Scotia B0K 1N0	(902) 351-2878		No Metal Finishing	None
37	**Kaycan Ltd.**	91 Wright Ave. Halifax, NS B3B 1K6	(902) 468-2646		No Metal Finishing	None
38	**King Metal Fabricators Ltd.**	219 Waverley Road. Dartmouth, NS B2X 2C3	(902) 434-7110		No Metal Finishing	None
39	**L.E. Cruickshanks Sheet Metal Ltd.**	1-3378 Kempt Rd. Halifax, NS B3K 4X5	(902) 453-6122		No Metal Finishing	None
40	**Liftow Limited**	11 Acadia St. DARTMOUTH, NS B2Y 2N1	(902) 469-6721 (888) 794-7474 Fax: (902) 464-3874		No Metal Finishing	None

Note: "a" Company participated in the general survey portion of the pilot project.
"b" Company participated in a detailed audit.
"c" Company participated in one of the Workshops held in January 2005.

	Name	Address	Telephone/Fax	Contact	Telephone Contact Details	Sludge Generated
			Companies that do no Metal Finishing			
41	**MacDonald G M Welding Ltd.**	P.O. Box 249 Whycocomagh, NS B0E 3M0	(902) 756-2575		No Metal Finishing	None
42	**MacDonell Welding & Metal Working Ltd.**	5845 Hwy 14 Upper Nine Mile River, NS B2S 2Y2	(902) 833-2340		No Metal Finishing	None
43	**MacGregor Custom Machining Ltd.**	140 Maclellans Brook Rd. NEW GLASGOW, NS B2H 5C7	(902) 922-2029 Fax: (902) 922-2324		No Metal Finishing	None
44	**MacLellan Metal Finishing**	Antigonish, NS B2G 2K9	902-872-0431	Rodney MacLellan	Do polishing and buffing only. Interested in expanding into plating and in the workshop. Workshop information to be sent.	None
45	**Mariner Forge Enterprises Ltd.**	20 Neptune Cres Dartmouth, NS B2Y 4T2	(902) 465-4877		No reply.	None
46	**Maritime Stress Contracting Ltd.**	P.O. Box 2898 Dartmouth, NS	(902) 468-7873 FAX (902) 468-2304		No Metal Finishing	None
47	**Metal Pro Machine Works 1991 Ltd**	P.O. Box 91 Arcadia, NS B0W 1B0	(902) 742-1176		No Metal Finishing	None
48	**Millennium Engin Rebuilder**	3587 Percy St. HALIFAX, NS B3N 2R5	(902) 421-1172 Fax: (902) 421-1775		No Metal Finishing	None
49	**Mobile Valve Repairs Ltd**	140-142 Hwy 1 MOUNT UNIACKE, NS B0N 1Z0	(902) 866-0719 Fax: (902) 866-1091		No Metal Finishing	None
50	**Mulgrave Machine Works Limited**	149 Mill St. MULGRAVE, NS B0E 2G0	(902) 747-2157 Fax: (902) 747-2227		No Metal Finishing	None
51	**Nova Automotive Machine Co. Ltd.**	15 Waddell Ave. DARTMOUTH, NS B3B 1K4	(902) 468-1686 Fax: (902) 468-4031		No Metal Finishing	None
52	**Nova Millwrights Ltd.**	11 Freeman St. MIDDLETON, NS B0S 1P0	(902) 825-2318 Fax: (902) 825-4768 novamill@ns.sympatico.ca		No Metal Finishing	None
53	**Parsons Hydraulics Inc.**	132 McWilliam Rd. TRURO, NS B2N 5B3	(902) 897-6620 Fax: (902) 893-7234		No Metal Finishing	None
54	**Parsons Hydraulics Inc**	7-55 Akerley Blvd. DARTMOUTH, NS B3B 1M3	(902) 468-5582 Fax: (902) 468-3383	Barry Parsons	No Metal Finishing	None
55	**Pothier R H**	10 Haskell St Yarmouth, NS B5A 3M3	(902) 742-7891		No Metal Finishing	None
56	**Quality Machining Services Ltd.**	98 Morrison Dr Windsor West Hants Industrial Park WINDSOR, NS B0N 2T0	(902) 798-8605 Fax: (902) 798-5915 michael@qualitymachine.ns.ca		No Metal Finishing	None
57	**Rafuse Equipment & Supply Co. Ltd**	150 Logan Rd. BRIDGEWATER, NS B4V 3J8	(902) 678-7910 1(800) 872-3873		No Metal Finishing	None
58	**R.E. McLellan's Machine Shop Ltd**	880 Fort Belcher Rd. E. TRURO, NS B2N 5B3	(902) 662-3393 Fax: (902) 843-3150		No Metal Finishing	None
59	**RF Ironworks Ltd. Partnership**	67 Atlantic St. DARTMOUTH, NS B2Y 4P4	(902) 461-1000 Fax: (902) 461-1001 pmulrooney@rfironworks.ns.ca		No Metal Finishing	None
60	**Riverside Machine Works Limited**	170 College St. ANTIGONISH, NS B2G 2L6	(902) 863-1632 Fax: (902) 863-2362	Allister MacEachern	No Metal Finishing	None
61	**Rod's Machine Shop Ltd.**	114 Wright Ave Dartmouth, NS B3B 1R6	(902) 468-2046 Fax (902) 468-7226		No Metal Finishing	None
62	**R K O Steel Ltd**	85 MacDonald Ave Dartmouth, NS B3B 1T8	(902) 468-1332 FAX (902) 468-2644		Bad phone number. Unable to locate.	None

Note: "[a]" Company participated in the general survey portion of the pilot project.
"[b]" Company participated in a detailed audit.
"[c]" Company participated in one of the Workshops held in January 2005.

	Name	Address	Telephone/Fax	Contact	Telephone Contact Details	Sludge Generated
Companies that do no Metal Finishing						
63	**R.P. Hawboldt Machining (1998) Ltd**	29 Greens Point Rd. TRENTON, NS B0K 1X0	(902) 752-6934 Fax: (902) 928-1519		No Metal Finishing	None
64	**Scotia Machining Services Ltd**	7-11 Calkin Dr. KENTVILLE, NS B4N 3V7	(902) 678-1100 Fax: (902) 678-1100		No Metal Finishing	None
65	**Scotia Trawler Equipment Limited**	280 Montague St. LUNENBURG, NS B0J 2C0	(902) 634-4914 Fax: (902) 634-8358		No Metal Finishing	None
66	**Spraytech Finishes**	170 Joseph Zatzman Dr Dartmouth, NS B3B 1L9	(902) 468-8894 FAX (902) 468-643		Number disconnected.	None
67	**Steel & Engine Products Ltd**	P.O. Box 1120 Liverpool, NS B0T 1K0	(902) 354-3483		No Metal Finishing	None
68	**Tesma**	53 Memorial Dr. NORTH SYDNEY, NS B2A 3M3	(902) 794-1400 Fax: (902) 794-4088 http://www.tesma.com		No Metal Finishing	None
69	**Truro Machine Works**	42 Meadow Dr. TRURO,NS B2N 5V4	(902) 893-8441		No Metal Finishing	None
70	**Waldale Manufacturing Limited**	17 Tantramar Cres. AMHERST, NS B4H 4J6	(902) 667-3307 Fax: (902) 667-2049		Produces license plates: aluminum is covered with vinyl after a hot wash bath, plates are embossed and roll painted. No major waste stream created.	None
71	**Wile's Welding Ltd**	5 Water St. CLARKS HARBOUR, NS B0W 1P0	(902) 745-3284 Fax (902) 745-1301	Craig Wile	No Metal Finishing	None
72	**Weld-Pro Ltd.**	1 Weston Court Dartmouth, NS B3B 2C8	(902) 468-7191		No Metal Finishing	None
73	**West Nova Industries Limited**	160 Starrs Rd. YARMOUTH, NS B5A 4B3	(902) 742-8595 Fax: (902) 742-0134		No Metal Finishing	None
74	**York Steel Inc**	34 Isnor Dr. Halifax, NS B3B 1W3	(902) 468-6288		No longer at this location.	None

Note: "[a]" Company participated in the general survey portion of the pilot project.
"[b]" Company participated in a detailed audit.
"[c]" Company participated in one of the Workshops held in January 2005.

APPENDIX B

INITIAL FACILITIES VISIT QUESTIONNAIRE

Survey Questionnaire (Add sheets as required.)

Date:

1. Identification of Metal Finishing Company

a) Name:

b) Address:

c) Phone and Fax:

d) E-mail:

2. Contacts

a) President:

b) Production Manager:

c) Environmental Coordinator:

3. Description of Metal Finishing Company

a) Is it a “Job Shop” or a “Captive Shop”?

b) Number of employees?

c) List of metal finishing processes (anodization, electroplating, galvanizing, coatings, etc.)
(for example: decorative or hard chrome, electroless nickel, zinc cyanide, etc.)…

4. Environmental situation

a) Do you have your Certificate of Approval?

b) Do you have a copy of regulations related to your activities (for example: sewer releases by-laws)?

c) Do you have an Environmental Management System (ISO 14001 or other)?

d) What environmental training do you provide to your employees?

e) Do you have a Spills and Environmental Emergency Plan?

f) Do you have to report to NPRI? If so, list what…

g) How do you control air emissions?

h) How do you control wastewater effluents, spent process and stripping solutions?

i) How do you control solid wastes?

j) What are the metal sludges available for recovery and recycling: type (Cadmium, Copper, Chrome, Nickel, Zinc), quantity (per year) and quality (mixed or segregated, metals %)?

k) What pollution prevention (P2) projects have you realized in the last few years?

l) What P2 projects do you want to conduct in the next year?

Thank you for the information! CAMF will keep it confidential.

APPENDIX C

ECO-EFFICIENCY WORKSHOP PROGRAMS

Eco-efficiency Workshop: January 18th, 2005 in Moncton, New Brunswick

Location

Holiday Inn Express Hotel & Suites
2515 Mountain Road (Exit 450)
Moncton, NB
E1C 8R7
Tel: (506) 384-1050
Fax: (506) 859-6070

Program

9:00 am – Compliance

Introduction to the Canadian Association of Metal Finishers [25 min.]
Marc Sider, Eng., M.A.Sc., P2 & E2 Coordinator, CAMF

Federal Regulations:
Proposed Chromic Acid Used in Chromium Electroplating, Chromium Anodizing or Reverse Etching Regulations [60 min.]
Peter J. Paine, M.Eng., P.Eng., Senior Program Engineer, National Office of Pollution Prevention

Provincial Regulations:
Overview of the Permitting Process in New Brunswick [20 min.]
Mike Cormier, P.Eng., NB Department of Environment and Local Government

10:45 am – Break [15 min.]

Municipal Regulations:
Overview of the Existing Moncton Sewer Use By-Law (By-Law # P-202) [20 min.]
Richard R. Landry, P.Eng, City of Moncton

Transportation of Dangerous Goods - Overview of Applicable Regulations [30 min.]
Monique Pelletier, P.Eng., MGI Limited

National Pollutant Release Inventory & Emissions Calculator [25 min.]
Marc Sider, Eng., M.A.Sc., P2 & E2 Coordinator, CAMF

12:15 – Free Lunch

1:15 pm - Eco-Efficiency

Case Studies [20 min.]
Marc Sider, Eng., M.A.Sc., P2 & E2 Coordinator, CAMF

Waste Reduction and Recycling Technologies [20 min.]
Marc Sider, Eng., M.A.Sc., P2 & E2 Coordinator, CAMF

Environmental Emergencies & Spills Prevention [30 min.]
Robert Weed, B.Sc., MGI Limited

Energy Efficiency [60 min.]
Marc Sider, Eng., M.A.Sc., P2 & E2 Coordinator, CAMF

3:25 pm – Questions and Discussion

Note

CAMF wants to thank the following financial supporters of the Atlantic Region Metal Finishing Industry Pilot Project:

- Government of Canada Action Plan 2000 on Climate Change, Minerals and Metals Program;
- Atlantic Canada Opportunities Agency – Moncton Office;
- Environment Canada HQ – Sustainable Consumption Division;
- Environment Canada Atlantic – Environmental Management and Technology Section.

Eco-efficiency Workshop: January 20th, 2005 in Dartmouth, Nova Scotia

Location

Parkplace Ramada Hotel
240 Brownlow Avenue
Dartmouth, NS
B3B 1X6
Tel: (902) 468-8888
Fax: (902) 468-8765

Program

9:00 am - Compliance

Introduction to the Canadian Association of Metal Finishers [25 min.]
Marc Sider, Eng., M.A.Sc., P2 & E2 Coordinator, CAMF

Federal Regulations:
Proposed Chromic Acid Used in Chromium Electroplating, Chromium Anodizing or Reverse Etching Regulations [60 min.]
Peter J. Paine, M.Eng., P.Eng., Senior Program Engineer, National Office of Pollution Prevention

Provincial Regulations:
Overview of the Permitting Process in Nova Scotia [20 min.]
Steve Westhaver, P.Eng., NS Department of Environment and Labour

10:45 am – Break [15 min.]

Municipal Regulations:
Overview of the HRM Sewer Use By-Law (By-Law # W101) [20 min.]
John Sibbald, Pollution Prevention Coordinator, Halifax Regional Municipality

Transportation of Dangerous Goods - Overview of Applicable Regulations [30 min.]
Monique Pelletier, P.Eng., MGI Limited

National Pollutant Release Inventory & Emissions Calculator [25 min.]
Marc Sider, Eng., M.A.Sc., P2 & E2 Coordinator, CAMF

12:15 – Free Lunch

1:15 pm - Eco-Efficiency

Case Studies [20 min.]
Marc Sider, Eng., M.A.Sc., P2 & E2 Coordinator, CAMF

Waste Reduction and Recycling Technologies [20 min.]
Marc Sider, Eng., M.A.Sc., P2 & E2 Coordinator, CAMF

Environmental Emergencies and Spills Prevention [30 min.]
Robert Weed, B.Sc., MGI Limited

Energy Efficiency [60 min.]
Marc Sider, Eng., M.A.Sc., P2 & E2 Coordinator, CAMF

3:25 pm – Questions and Discussion

Note

CAMF wants to thank the following financial supporters of the Atlantic Region Metal Finishing Industry Pilot Project:

- Government of Canada Action Plan 2000 on Climate Change, Minerals and Metals Program;
- Atlantic Canada Opportunities Agency – Moncton Office;
- Environment Canada HQ – Sustainable Consumption Division;
- Environment Canada Atlantic – Environmental Management and Technology Section.

Attendance

The following companies had employees attending the workshop in Moncton NB on January 18, 2005:

Custom Machine & Hardchrome Inc. - Lorne Goodine
Maritime Hydraulic – Kim Carruthers
Topcoat Solutions Inc. – Perry Colpitts

The following companies had employees attending the workshop in Dartmouth NS on January 20, 2005:

Atlantic Hardchrome Ltd – Paul Ferguson and Jim Muir
EMM Hardchrome & Hydraulic Ltd – Jim Martin
Fleet Maintenance Facility Cape Scott – Les Boudreau, Rob Hendrie and Glen R. Shea
Hydrachrome Services Inc. – Sylva Sokolovsky
IMP Group – Rodger Cruickshank and Kelly Lively-Jones
MIT Sales Ltd – Dan Bolovar and Cyril Forbes
Zenith Plating Ltd – Doug Derby

APPENDIX D

RECYCLERS

Recyclers

Chromium

Recycler: Inmetco (1 Inmetco Drive, Ellwood City, PA, USA, 724-758-2800)
http://www.inmetco.com/

Waste: chromic acid liquid

Typical Contents: Cr = 5.0%

$: no credit, MF has to pay only a per Litre price and shipping to the recycler

Zinc

Recycler: John Ross & Sons Ltd (171 Chain Lake Drive, Halifax, NS, 902-450-5633)

Waste: Skimming, dross and dust

Typical Contents: Zn = 89%

$: credit for the Zn which is around 42-46% of the London Metals Exchange (LME) price and without any additional refining and transportation costs

Iron

Recycler: Brunswick Mining and Smelting Corporation Ltd (Bathurst, NB, 506-546-6671)

Many parts coated by metal finishers in Atlantic Canada are made of steel. Prior to receiving their coating of another metal or paint, they might be blasted with grit or shot. Wastes from this operation can be tailings from automated or manual blasting equipments and dust collected by air filtration units. These wastes can be mixed to get at least 70% Fe content which can be recycled by this facilities.

Copper ***(survey suggests sludge not produced in the Atlantic Region)***

Recycler: Noranda – Canadian Copper and Recycling
http://www.norandarecycling.com/

Waste: copper hydroxide sludge (filter cake)

Contents Requirement: there has to be a minimum of 15% Cu (on dry weight basis) to receive a payment for this Cu

Humidity: up to 70% (above 15%: penalty)

$: credit for the Cu which is around 50% the New York Commodities Exchange (COMEX) price minus penalties for humidity and heavy metals and minus transportation charges

Nickel ***(survey suggests sludge not produced in the Atlantic Region)***

Recycler: INCO (Thompson, Manitoba)
http://www.inco.com/

Recycler: Falconbridge
http://www.falconbridge.com/

Waste: nickel hydroxide sludge (filter cake)

Typical Contents: Ni = 24.0% and Cu = 1.1%

Contents Requirement: Ni / Cu Ratio of 15

Humidity: 45 – 55 % (above: penalty; below: dusting problem)

$: credit for the Ni, based on a formula involving a percentage of the London Metals Exchange (LME) price minus refining and transportation charges

Recycler: Agmet Metals Inc. (7800 Medusa Road, Oakwood Village, Ohio, USA, 440-439-7400)
http://www.agmetmetals.com/

Waste: Nickel Copper Stripping Solution (Nitric Acid)

Typical Contents: Ni = 5.7% and Cu = 3.6%
$: credit for the Ni, based on a formula involving a percentage of the LME price minus processing and shipping costs

APPENDIX E

FACT SHEETS

Disclaimer

This report does not endorse specific companies and products. The suggested websites of companies are examples only.

Fact Sheet #1

Facilities Layout and Improved Design for Pits and Floor

Ideally, if floor space constraint could be overcome, facilities layout should be such that all the tanks are positioned as per the process flow [1, 2]. This would decrease movement of the employees and the quantity of spills on the floor. Tanks being as close to each other as possible, drain boards should be installed between them to recover drips and decrease spills [3, 4]. Spills reduction would decrease losses of valuable metals and also decrease the pollutants load.

Process tanks should be installed in pits or pans or they should be surrounded by berms of sufficient size to contain the contents of the tank in the event of an emergency.

Concrete is not sufficient to prevent the infiltration of chromic acid in the case of spills or tank failure and therefore the following options should be considered when designing the walls of a pit for a new tank:

- A flexible PVC liner (thickness 3/16 in) can be fitted inside the pit, as shown on http://www.unitliner.com/ for example;
- Rigid PVC sheets (thickness ¼ - 3/8 in) can be welded in place; or
- Fibreglass – resin (like epoxy, polyesters, vinyl ester) can be applied on the concrete surface. Typically this composite coating has 5 layers: resin – mat - resin – mat – resin.

The floor should be coated with fibreglass – resin, or a polymer system as shown on http://www.stonhard.com/ for example.

Rehabilitation of an old pit should be done before the installation of liner or coating. This should consist of decontamination of the concrete and filling of the cracks to prevent infiltration of chromic acid. The floor should be repaired similarly.

Grating made of steel or reinforced plastics should be used if there are stairs and catwalks around the process tanks, as wood can become contaminated by chemical spills.

If a new chrome electroplating tank is built, it could be lined for example with Koroseal from Polycorp (http://www.poly-corp.com/protectivelinings.asp).

References

[1] *Electroplating Engineering Handbook*, *4th Edition.* L. J. Durney. Van Nostrand Reinhold, New York (NY), 1984.

[2] http://www.wmrc.uiuc.edu/main_sections/info_services/library_docs/manuals/finishing/design.htm

[3] *Metal Finishing P2 Technologies Manual.* Metal Finishing Industry Pollution Prevention Project Task Force, 2003.

[4] *Ninth Progress Report.* Metal Finishing Industry Pollution Prevention Project Task Force, 2003.

Fact Sheet #2

Decrease in Chromic Acid Losses from Rinse and Spills

Proper rinsing techniques for electroplated parts consist of rinsing over the chrome tank, and should be used to enable reuse of rinsed chromic acid and reduce losses from parts dripping onto the floor. Also, segregation of pre-plating wash water should be completed to ensure that no cross contamination between the wash water and rinsed chromic acid occurs. Otherwise, there will be higher costs related to raw material losses and also higher costs related to disposal of a higher volume of liquid waste.

It is a priority to provide the space and equipment as well as adequate procedures and training for rinsing electroplated parts. This has been described in previous case studies reported by CAMF [1].

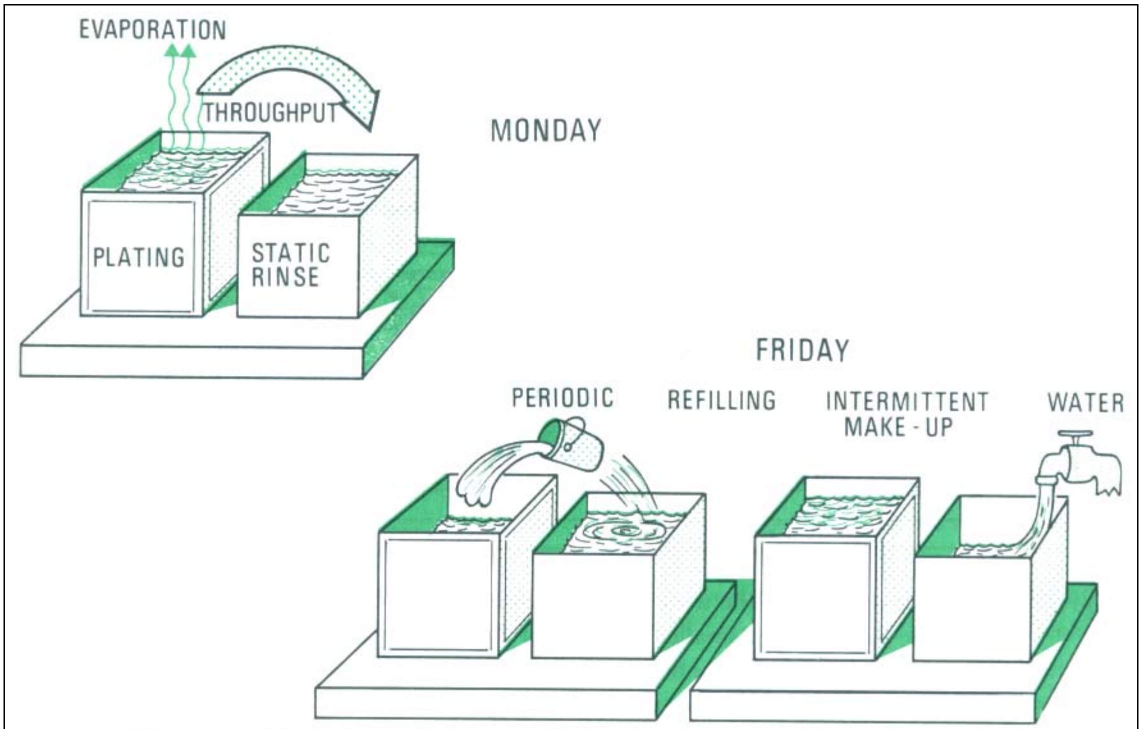
It is recommended that the chrome plating area be designed to reduce the amount of waste rinse water generated. A pre-plating wash tank should be installed to provide segregation of wash water and rinse water. The untreated wash water might be sent to the sewer if it only contains soap and pumice. A tank with grill/filter and pump should be installed for adequate rinsing of chromic acid from the plated parts and for washing down tape, brackets and clamps.

Rinsing options include static rinsing and spray rinsing which are described on the next pages [2 - 6].

With either rinsing options, as the concentration of hexavalent chromium builds up in the rinse water, this water should be returned to the chrome plating tank to compensate for water evaporation. No chrome-containing untreated wastewater should be discharged to the sewer.

Static (Still) rinsing

For static rinsing, the operator should let the parts drip over the plating tank to minimize drag-out and then immerse the parts in the rinsing tank. Drain boards should be installed between the plating tank and the rinse tank located next to it.



Schematic design of a static recovery rinse

(Source: United Nations Environment Programme 1993)

Static rinsing means simply a rinse tank that is not continually being replenished.

Advantages:

- Can be returned to the plating tank to make up for evaporative losses

Disadvantages:

- Static rinsing allows for contaminants to concentrate with time and therefore, rinse water quality diminishes.

Spray rinsing

For spray rinsing, a vertical shower station with doors could be installed, with nozzles (“shower heads”) located at different heights. It should have a pan of sufficient height at the bottom to act as a reservoir and allow water recirculation with a pump. Before rinsing, the operator should let the parts drip over the plating tank to minimize drag-out.

Often used over plating baths, spray rinsing can increase the efficiency of rinsewater use by allowing rinsewater to drain directly back to the plating tanks and at the same time, make up for evaporative losses. Two or four rows of high velocity spray-jet nozzles are mounted.

Factors affecting efficiency of spray rinsing are: arrangement of nozzles to work pieces, water pressure, specific flow rate, spray time and the mechanical design of the delivery system.

Advantages:

- Uses less water than rinse water baths
- Can recover 75% of the dragout materials
- Requires less space than other methods of rinsing (i.e. counter-current)

Disadvantages:

- Is not an effective rinsing technique for parts with more complex designs (such as those with recessed areas).
- Cannot be used for small racked parts that could be displaced from the rack or with plating barrels.

References

[1] *Ninth Progress Report.* Metal Finishing Industry Pollution Prevention Project Task Force, 2003.

[2] *Metal Finishing P2 Technologies Manual.* Metal Finishing Industry Pollution Prevention Project Task Force, 2003.

[3] *Environmental Aspects of the Metal Finishing Industry: A Technical Guide.* United Nations Environment Programme – Industry and Environment / Programme Activity Centre, 1993.

[4] http://www.wmrc.uiuc.edu/main_sections/info_services/library_docs/manuals/finishing/rinsing.htm

[5] http://www.nmfrc.org/bluebook/sec253.htm

[6] http://www.cdphe.state.co.us/el/Documents/Metal/Electroplating.pdf

Fact Sheet #3

Metals Recovery Technologies

To decrease the cost of disposal, waste chromic acid could be concentrated either by evaporation or membrane separation, or the metal could be separated by ion exchange as explained on the next pages [1, 2]. Case studies have been reported by CAMF [3].

However, technical feasibility and economic evaluation [4 - 6] of these technologies should be undertaken only after P2 options to decrease chromic acid losses from rinse and spills have been implemented. The much smaller volume of liquid wastes which would be generated each year might no longer justify investment in one of these costly technologies or might affect sizing of recovery equipment.

More information on evaporators [7 - 10], membrane and ion exchange [11] systems can be obtained respectively from these three suppliers:

- http://www.aqualogic.com/
- http://www.esperantoenv.com/
- http://www.eco-tec.com/

Atmospheric / vacuum evaporation

Evaporation of rinse waters is used to increase the concentration of metals contained in the rinsewaters. The concentrated solution can then be purified and reused in plating baths.

A typical evaporative recovery system consists of an evaporator, a feed pump and a heat exchanger. Adequate cooling is essential.

There are two types of evaporators, atmospheric and vacuum.

- Atmospheric evaporators are the most common that operate by evaporating the liquid as it is passed counter-current to the air stream. Relative humidity has a direct effect on the evaporation rate of room temperature baths.
- Vacuum systems are a more expensive alternative (approximately 10x more than atmospheric systems) that take advantage of the lower boiling point of the liquids in low pressure conditions. Vacuum evaporators are more energy efficient and are able to recover the water vapour for use as make-up water.

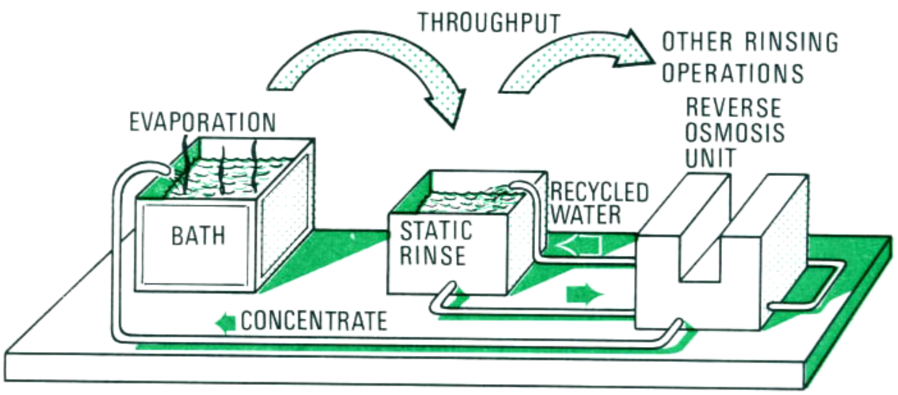
Advantages:

- Atmospheric evaporators have high recovery rates (i.e. 90-100%), do not require additional reagents and generate little to no sludge.
- May be used with other recovery systems such as ion exchange to form a closed loop system which reuses all rinse waters.
- Larger facilities may have the ability to recover chromium, nickel and cyanide and realize considerable savings if conventional wastewater treatment is avoided.
- Atmospheric evaporation is a relatively simple technology and is therefore easier to install, operate and maintain than other recovery methods.

Disadvantages:

- Evaporation is a costly process due to higher capital costs and energy required to generate steam.
- Method is not suitable for dilute streams due to high energy requirements
- Solutions susceptible to foaming (like cyanide) may not be suitable for atmospheric evaporation.
- Evaporation is most cost-effective for high temperature baths, such as chromium plating baths, but may not be as effective for other plating baths.
- Vacuum evaporation requires significant expertise to operate efficiently.

Reverse Osmosis (RO)



Application of reverse osmosis : the dragged out chemicals are re-cycled to the treatment bath.

(Source: United Nations Environment Programme 1993)

Reverse osmosis (RO) is a separation process that is used to purify incoming water, recover plating chemicals from rinsewater and polish wastewater effluent (for closed loop systems).

Reverse osmosis functions most efficiently on very dilute solutions. High pressure is used to force the water through the membrane, while the membrane retains most dissolved salts.

High temperatures should be minimized as RO membranes are sensitive and the payback when keeping a close eye on temperatures ends up being even better!

The concentrated components can be recovered and then returned to the process bath, and the treated water (permeate) can be reused as a high quality source of rinse water.

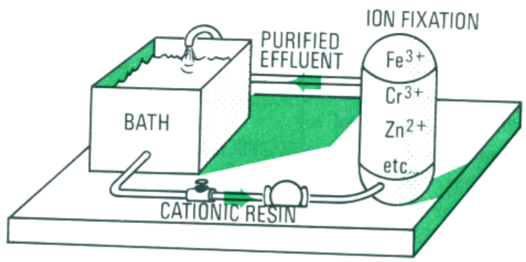
Advantages:

- RO Systems have a 95 percent recovery rate.
- Relatively inexpensive and requires little floor space to operate.
- May be applied to any dilute waste stream
- Energy requirements are low
- Pure water is produced as a by-product which can be used as rinse water
- Pay-back periods of about three years have been traditionally realized by metal finishers

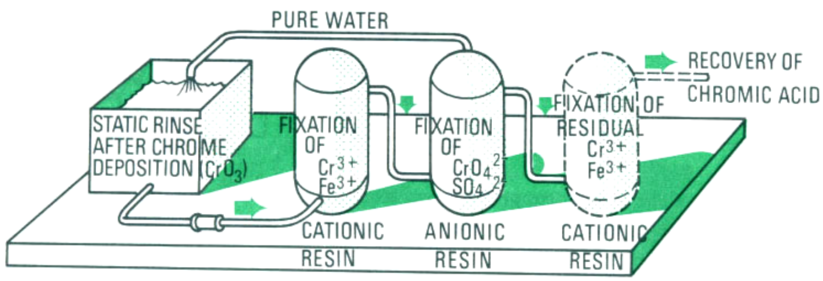
Disadvantages:

- Narrow operating temperature and pH range at which RO is effective
- Membrane is only expected to last 1-4 years due to strong acids, bases and particulates
- Replacement costs for membranes, high pressure pumps and other parts may be high
- Additional water is required for backwashing the membrane

Ion exchange (IX)



Use of ion exchange : regeneration of a treatment bath by the removal of metal ions results in a significantly extended life time of the bath, reduced consumption of chemicals, and an enhanced level of product quality.



Ion exchangers in sequence for the recycling of metal ions, of rinsing water, and of chromic acid.

(Source: United Nations Environment Programme 1993)

Ion exchange (IX) units employ cylindrical columns filled with polymeric beads with a chemical affinity for either cations (metallic) or anions. Wastewater enters the top of the column under pressure, passes downward through the resin bed, and is removed at the bottom. As the rinse is passes through the resin bed, the desired ions are extracted from the flow together with other ions of similar charge which may also be present in the stream. When the resin capacity is exhausted, the column is backwashed to remove trapped solids and then regenerated.

Ion exchange can be used for chemical recovery, water recycling or effluent polishing. Commercial applications include acid-copper, acid-zinc, tin, cobalt, nickel and chromium plating baths. An ion exchange system usually consists of a wastewater storage tank, pre-filters to prevent fouling the exchange resins, cation or anion exchange vessels, and caustic or acid regeneration equipment.

Advantages:

- Effective technology for removing a wide range of metals from the waste stream.
- Resulting de-ionized water can be reused in the rinsing system.
- May be used in conjunction with evaporation to complete a closed loop system.
- Low energy requirements.

Disadvantages:

- Moderate capital expenditures for initial set-up
- Regenerating resin on-site requires either a shut-down period or multiple ion exchangers
- Regeneration agents contain metals and other targeted materials often need to be treated before disposal.

References

[1] *Metal Finishing P2 Technologies Manual.* Metal Finishing Industry Pollution Prevention Project Task Force, 2003.

[2] *Environmental Aspects of the Metal Finishing Industry: A Technical Guide.* United Nations Environment Programme – Industry and Environment / Programme Activity Centre, 1993.

[3] *Ninth Progress Report.* Metal Finishing Industry Pollution Prevention Project Task Force, 2003.

[4] http://www.wmrc.uiuc.edu/main_sections/info_services/library_docs/manuals/finishing/rinsing.htm

[5] http://www.pfonline.com/articles/pfd0336.html

[6] http://es.epa.gov/techinfo/facts/nc/tips2.html

[7] http://www.nmfrc.org/bluebook/sec321.htm

[8] http://www.nmfrc.org/bluebook/sec331.htm

[9] http://www.p2pays.org/ref/02/01055.pdf

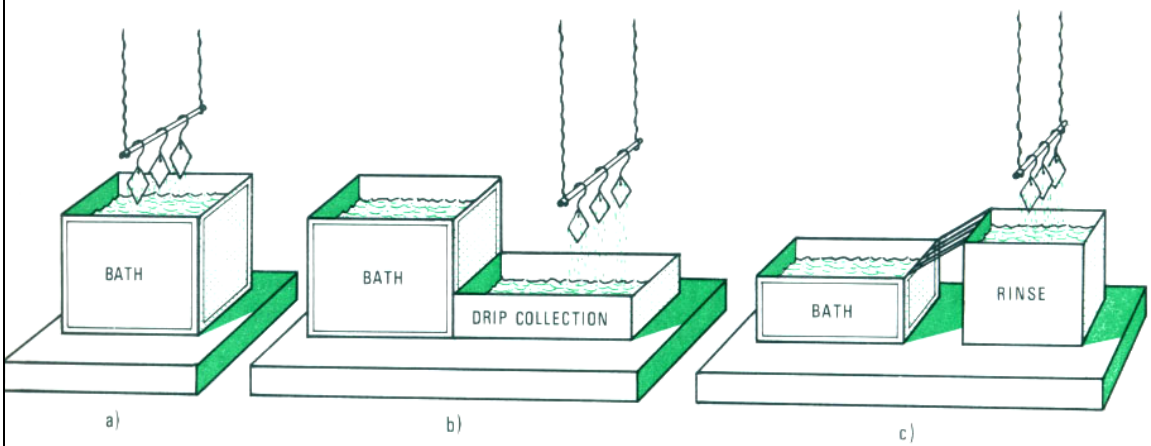
[10] http://www.ddpsinc.com/Recovery/tirp.html

[11] http://www.p2pays.org/ref/33/32235.pdf

Fact Sheet #4

Drag-out Reduction

To decrease raw materials consumption, drag-out of solutions from process tanks should be minimized. The use of drain boards helps return drips to the baths when parts are transferred between tanks as described on the figure below.



Allowing sufficient dripping time for treated work pieces is the simplest and most cost-efficient method of pollution control : (a) over the treatment bath, (b) over a special drag-out recovery tank and, (c) after every rinsing over the rinsing bath. Baths which are close together reduce the opportunity for spillage. The use of drain-boards made of corrosion resistant material helps to return drips to the baths when parts are transferred between tanks.

(Source: United Nations Environment Programme 1993)

Drag-out recovery is one of the most important source reduction practices. Technology is simple and low-cost and is effective at returning plating chemicals back to the original bath before they are integrated into waste streams. Up to 60 percent of the materials carried out of plating tanks can be recovered for reuse, therefore reducing material and waste management costs.

Additionally, installation of two counter flow static (still) tanks can capture over 80% of the metal drag-out. For optimum efficiency, the entire drag-out recovery process can be automated by level controllers in the plating and reclaim tanks. A low level in the plating tank calls in a transfer pump from the reclaim tank while a low level in the reclaim tank calls for fresh water.

Other techniques to minimize drag-out are:

- Slower movement of racks / withdrawal from tanks – may be used to allow more of the plating solution to drain back to the process tanks. The slower withdrawal helps minimize the amount of drag-out adhering to the parts.
- Increase drip / drain time – to allow solution to drip back into the process tank and reduce the amount of chemical introduced in rinse water
- Rack design – position work to avoid fluid pockets, to maximize drip and reduce drag-out. Don't position parts directly over one other. Experiment with the parts to determine in which of the various orientations a part drains best. The results may lead to unexpected savings in water, metals, chemicals, and waste treatment costs, both capital and operating.

References

[1] *Metal Finishing P2 Technologies Manual.* Metal Finishing Industry Pollution Prevention Project Task Force, 2003.

[2] *Environmental Aspects of the Metal Finishing Industry: A Technical Guide.* United Nations Environment Programme – Industry and Environment / Programme Activity Centre, 1993.

[3] http://www.wmrc.uiuc.edu/main_sections/info_services/library_docs/manuals/finishing/rinsing.htm

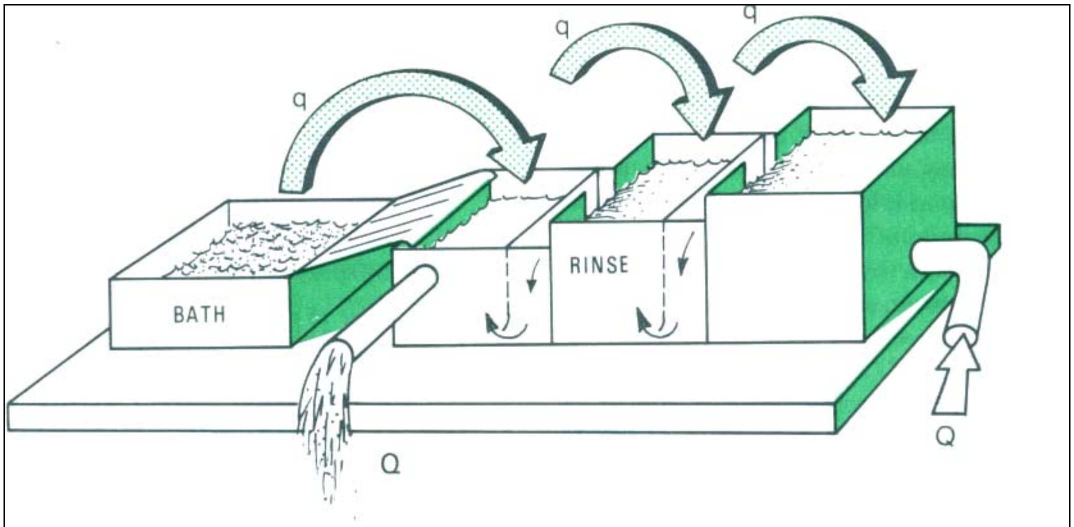
[4] http://www.nmfrc.org/bluebook/sec2423.htm

[5] http://www.p2pays.org/ref/04/03983.pdf

Fact Sheet #5

Counter-Flow Rinsing

Counter-flow rinsing is the best way to conserve water as explained on the figure below. In these tanks, rinse water flows in a direction opposite to the movement of parts. Counter flow water should enter the bottom of the tank and exit at the top. Plumbing to get the fresh water in and the dirty water out of the tanks should be installed appropriately.



Schematic design of cascade rinsing. Water consumption is reduced by use of the counter-current principle : the effluent of the downstream rinse bath serves as water supply; C_o = concentration of the treatment bath, C_1, C_2, ..., C_n = concentrations of the 1st, 2nd, ...and last rinsing bath within the cascade; q = drag out ratio specified as volume per hour; Q = water flow rate.

(Source: United Nations Environment Programme 1993)

The water required for effective rinsing is reduced by a factor of ten for each added counter-current rinse tank. The optimal number of tanks used is usually three. The effectiveness of counter-flow rinsing depends on complete mixing, agitation of the rinse tank with air, or by mechanical means.

Advantages:

- May reduce rinse water flows by up to 95% over single tank rinsing
- Reduces wastewater treatment costs
- Is a simple technique that requires very little maintenance after installation

Disadvantages:

- The series of tanks requires additional floor space
- Additional rinsing increases production time

References

[1] *Metal Finishing P2 Technologies Manual.* Metal Finishing Industry Pollution Prevention Project Task Force, 2003.

[2] *Environmental Aspects of the Metal Finishing Industry: A Technical Guide.* United Nations Environment Programme – Industry and Environment / Programme Activity Centre, 1993.

[3] http://www.wmrc.uiuc.edu/main_sections/info_services/library_docs/manuals/finishing/rinsing.htm

[4] http://www.nmfrc.org/bluebook/sec253.htm

Fact Sheet #6

Fresh Water Flowrate Optimization for Rinsing

How much fresh water should be used for rinsing? To answer this question, many characteristics and requirements of the metal finishing process have to be considered:

- Quality of the rinse water available (city water or treated water)
- Quality of rinsing (the concentration of contaminants in the final rinse tanks) required, which is determined by the required deposits quality and the kind of process used
- Production rate
- Amount of Drag-out from the baths
- Kind and number of rinse tanks

Drag-out reduction should always be the first option to be implemented [1]. Rinsing is used to remove chemicals from the parts before putting them in the next bath. Less drag-out obviously requires less rinse water. The rinse water flowrate is proportional to the production rate (number of parts per unit time) multiplied by the volume of drag-out for each part.

The use of static rinse tanks to replenish the baths and recover metals is important. It also decreases the amount of chemicals going into the continuous rinse water.

Counter-flow rinsing (CFR) with 2 or 3 tanks uses water much more efficiently than a single continuous rinse tank. Since fresh water consumption is order of magnitude lower in the CFR, flowrate optimization will be discussed below for this case.

The most commonly applied CFR model (or equation) [2 - 6] is:

$$\mathbf{Rr = (Ct/Cr)^{1/n}}$$

Rr = rinsing ratio = Q/D = ratio of fresh water flowrate over drag-in flowrate

Ct = concentration in the preceding tank and Cr = required concentration in the last rinse tank (Ct/Cr is called the rinsing criterion and the reciprocal Cr/Ct is a dilution factor indicative of rinsing quality)

n = number of rinse tanks

This approximate model does not predict required rinse rates accurately when the value of Rr falls below 10. Also, complete rinsing will not be achieved unless there is sufficient agitation in the rinse tank and the residence time for the parts is long enough.

There are other more detailed equations available for all kinds of rinsing [2] and computer modelling of rinsing has also been conducted [7]. ProcessPro is software available commercially from METALAST [8], which allows users to analyze the causes and effects of process changes. Some modeled changes include: water stream flow and composition, rinse capabilities, ventilation, material, chemistry usage and utility costs. However, the equation above is enough for preliminary estimates.

To determine how much rinse water is needed, the following steps should be followed:

1) Setting Cr which is the allowable concentration of contaminants in the final rinse. Different values have been proposed [2], such as 15 ppm after chromium. Each metal finisher might have his preferred values according to the quality of electroplating he wants and his experience of the process (10 ppm Cr is also proposed).
2) Determine D which is the drag-in per unit time and for a given production rate. Different drag-out values are available [2, 10], such as a minimum of 16.3 mL/m^2 for well drained vertical parts. For poorly drained parts the value is 5 times higher and for very poorly drained parts the value is 10 times higher! This shows that reliance on published values is not always the best way to design. Preferably, the drag-out from the process tank (which becomes the drag-in to the rinse tank) should be measured experimentally by rinsing a number of parts in a static rinse and analysing the concentration of the metal or another chemical component [2, 9]. Other characteristics could also be measured during the same experience such as conductivity [4] or pH. They might become control parameters for the rinse water.
3) Since the composition of the process bath preceding the rinse is known, the rinsing criterion Ct/Cr can be inserted in the equation.
4) The required rinsing ratio Rr and fresh water flowrate Q can finally be calculated, considering the number of CFR tanks installed (n = 2 or 3) in the available space of the facilities.

It is obvious that if the number, size or shape of the parts produced change, the fresh water flowrate has to be changed also to keep the same rinsing quality while conserving as much water as possible. This means that an adjustable valve has to be installed on the water pipe connected to CFR tanks. If the parts are always the same and the production rate is very regular, than a flow restrictor and a simple on-off valve should be installed.

The case of a variable production brings the issue of how to control rinsing [5, 11 - 14] One method could be to analyse the metal concentration in the final rinse tank. The problems are that there is a significant cost involved and also (even worst!) a long delay if the analysis has to be done in an outside laboratory. Another method to overcome these problems would be to measure a parameter such as conductivity of the rinse water. Acceptable values in microsiemens/cm (micromhos/cm) for rinsing after different metals plating and other process baths have been published [14]. Correlations of conductivities with concentrations are also available [15]. All those values should be used with caution, because de-mineralized (DM) water or low total dissolved solids (TDS) water used for making process baths has an initial conductivity from 1 to 25 microsiemens/cm (1 ppm TDS as $CaCO_3$ = 2 µs/cm) while city water (tap water) can vary from 50 ppm TDS to 1200 ppm TDS. Once again, conductivity testing should be conducted at the facilities to optimize rinsing instead of relying only on published values. Finally it is important to note that conductivity can not be applied well to chrome rinsing. The use of colorimetry or simple analysis on-site has been reported.

In Canada and the USA, automatic control of the fresh water flowrate by a conductivity meter sending a signal to a valve in the water line has been implemented in some big MF facilities [16 - 18]. The fresh water flow increases depending on whether or not the conductivity in the rinse water tank is above a preset value. Many suppliers offer instruments and systems [19 - 21]. However, it is very important to understand that the principle of using conductivity to optimize or control rinsing can also be applied in smaller shops with a low cost handheld instrument and an ordinary manual valve. Measurements are only taken when production rate changes enough to require rinsing water flowrate adjustments and for check-ups.

References

[1] http://es.epa.gov/techinfo/facts/nc/tips2.html

[2] *Electroplating Engineering Handbook*, *4th Edition.* L. J. Durney. Van Nostrand Reinhold, New York (NY), 1984.

[3] http://www.pfonline.com/articles/web070001.html

[4] http://www.nmfrc.org/bluebook/sec253.htm

[5] http://www.p2pays.org/ref/04/03987.pdf

[6] http://www.remco.com/an2.htm

[7] http://www.gewater.com/library/tp/791_Case_Study.jsp%20

[8] http://www.metalast.com/software/processpro.html

[9] http://www.cdphe.state.co.us/el/Documents/Metal/Electroplating.pdf

[10] http://www.p2pays.org/ref/04/03983.pdf

[11] http://www.wmrc.uiuc.edu/main_sections/info_services/library_docs/manuals/finishing/rinsing.htm

[12] http://www.nmfrc.org/bluebook/sec252.htm

[13] http://www.mntap.umn.edu/intern/projects/techplating.htm

[14] http://www.p2pays.org/ref/04/03097.pdf

[15] http://www.pprc.org/cpc/CONTENTS/OPPS/ConductivityMetre.XLS

[16] http://www.pfonline.com/articles/020005.html

[17] http://www.nmfrc.org/pdf/rf-2clr.pdf

[18] http://www.wmrc.uiuc.edu/main_sections/info_services/library_docs/TN/00-72.pdf

[19] http://www.emersonprocess.com/raihome/documents/Liq_AppData_3300-14.pdf

[20] http://www.serfilco.com/ftp/Literature/bulletin/A-305.pdf

[21] http://www.moranlord.co.uk/updaterinse%20tek.html

Fact Sheet #7

Atmospheric Emissions Control

The proposed **Chromium Electroplating, Chromium Anodizing and Reverse Etching Regulations** [1-5] from the federal government will present a new lower limit for atmospheric emissions and it is anticipated they will be enacted in 2006. Any air emissions control method implemented should be in accordance with the future regulations. There are three possible options to choose from.

One method contained in the new regulations is the addition of fume suppressant to the chrome tanks. A stalagmometer [3] is used to measure/control surface tension and fill in the required records. One such instrument can be seen on:
http://history.nih.gov/exhibits/galleries/instrument/2.html

This monitoring brings savings by allowing lower additions of fume suppressant, since it is more precise than visual observation of the foam at the surface of the electroplating solution. Information on the possible effects of fume suppressant on the quality of chrome deposits should be obtained from chemical suppliers before implementation of this control method.

A list of fume suppressants suppliers is available on:
http://www.aqmd.gov/prdas/ChromePlating/ChromePlating.htm#

For example, in Canada, Fumetrol 140 from Atotech (http://www.atotech.com/) is distributed by Empire Buff (http://www.empirebuff.com/).

A second method is the installation of a closed tank cover.

The last method is the installation of a scrubber (composite mesh pads) which will require stack testing [3] to meet the new regulations.

Ventilation of many large chrome tanks at a flowrate of 250 SCFM (Standard Cubic Feet per Minute) per ft^2 of bath surface poses some *energy efficiency* challenges. Heated air make-up and the use of a variable speed drive for the ventilation fan motor should be considered.

The surface tension reduction method is often preferred over the other methods because there is no need for high initial capital investment, which is especially important for small and medium sized companies.

References

[1] *Proposed Chromic Acid Used in Chromium Electroplating, Chromium Anodizing or Reverse Etching Regulations – Summary.*
http://www.ec.gc.ca/nopp/DOCS/consult/chromiumReg/en/summary.cfm

[2] *Chromium Electroplating, Chromium Anodizing and Reverse Etching Regulations.* http://canadagazette.gc.ca/partI/2004/20041106/html/regle1-e.html

[3] Presentation: *Proposed Regulations on the Use of Hexavalent Chromium Electroplating or Chromium Anodizing – Information Sessions to Canadian Industry.* Peter J. Paine. National Office of Pollution Prevention, Environment Canada, 2001.

[4] *Regulations on Hexavalent Chromium used in Chromium Electroplating/Anodizing – Stack Testing: Fundamentals.* MGI Limited, Fredericton (NB), 2001.

[5] *Hard Chrome Fume Suppressants and Control Technologies.* Office of Research and Development, U.S. Environmental Protection Agency, Washington, DC, 1998.
http://www.epa.gov/ORD/NRMRL/pubs/625r98002/625r98002.htm

[6] *Electroplating Engineering Handbook*, *4th Edition.* L. J. Durney. Van Nostrand Reinhold, New York (NY), 1984.

[7] *Industrial Ventilation – A Manual of recommended Practice 23rd Edition.* American Conference of Governmental Industrial Hygienists (ACGIH), Cincinnati (Ohio), 1998.

Fact Sheet #8

Alkaline Electro-stripping Ventilation

Sometimes, it is necessary to strip the chrome from a part and an alkaline stripper has to be used (such as Electro 245 from Atotech (http://www.atotech.com/) and distributed for example by Empire Buff (http://www.empirebuff.com/)). Ventilation should be installed, which will provide a flowrate of 150 SCFM per ft^2 of bath surface area. A scrubber is not required but the flow should be directed to a stack.

The hood, fan and stack for such a ventilation flowrate could probably be designed, built and installed by a local supplier of industrial ventilation products. It is recommended to use rigid polyvinyl chloride (PVC) duct. The fan and electrical motor could be sized for higher capacity to accommodate future needs. To change the fan flowrate, pulleys and belts could be changed. A small drain at the bottom of the stack would prevent rainwater from coming in the system. It is important to check with the building owner and municipality if installation is approved and in compliance with regulations.

Information on exhaust system design and no–loss stack is available:

- http://www.midwestair.com/exhaustsystem.html
- http://www.midwestair.com/pr_Duct.html

For example, Canadian suppliers include the following:

- http://www.cy-bo.com/
- http://www.empirebuff.com/
- http://www.fabcoplastics.com/

Chemicals are also available to reduce any Cr+6 in the stripping bath into less hazardous Cr+3, such as Reducer 800 from Atotech (http://www.atotech.com/) which is distributed for example by Empire Buff (http://www.empirebuff.com/).

References

[1] *Electroplating Engineering Handbook*, *4th Edition.* L. J. Durney. Van Nostrand Reinhold, New York (NY), 1984.

[2] *Industrial Ventilation – A Manual of recommended Practice 23rd Edition.* American Conference of Governmental Industrial Hygienists (ACGIH), Cincinnati (Ohio), 1998.

Fact Sheet #9

Electroplating Baths Chemistry and Analysis

It is obvious that optimization of metal finishing processes (baths chemistry in particular) and better operation should lead to better use of raw materials and waste minimization. The table below describes typical baths for the plating of hard chrome [1 - 5] over steel parts and typical conditions at which they are operated:

TABLE 1: Hard Chrome Bath

	Range
Chromic Acid CrO_3	250-400 g/L
Ratio CrO_3 / H_2SO_4	100
Cr by analysis	130-208 g/L
Anode	Lead, or Lead - 7% Tin or Lead – 6% Antimony
Temperature	49-60 °C
Current Density	2250-5000 A/m^2
Current Efficiency	10-18 %
Voltage	6-12 V

Note: Maximum trivalent chromium at 3-4 g/L

It is very important to understand that there are other bath chemistries which are also in use: a bath catalysed by fluoride for chrome (in which Ratio of 200-300 is used) for example. These baths have been developed to improve some properties of deposits or increase plating speed. Improvement in Health & Safety and protection of the environment can also be a reason for bath development: decorative chrome electroplating from trivalent chromium Cr^{+3} (less toxic than hexavalent chromium Cr^{+6}) is now available commercially [5].

Suppliers of proprietary chemicals for plating processes have selected compositions to get maximum plating efficiency and quality of deposits. They also provide analysis methods to check the baths on a regular schedule to keep that desired performance.

Metal salts and common chemicals (acids, bases, salts for buffering and conductivity) are also present in baths, the methods used to measure their concentrations are usually similar to those taught to chemical technicians and chemists during their analytical chemistry courses.

What are the main classes of methods? There are wet methods like the volumetric (titrimetric) and gravimetric methods [1, 3] and there are instrumental methods [6]. Often there are many ways to determine the concentration of a bath component. One will obviously prefer a method that is the most simple and rapid. The choice of the method will depend on the frequency and required accuracy of the measurements, as well as the costs (both in personnel time and acquiring the laboratory equipment). Thus, there can be different methods used by big and small enterprises. Indeed, many of the smaller MF actually send bath samples to private analytical labs as they do for treated wastewaters, because their number of analysis does not justify buying advanced instruments. Even the big MF sometimes do it when facing uncommon impurities.

The most used method of analysis in the MF industry is the volumetric method. Determined volumes of standard titration solutions are added to the samples to react completely with one of their components. That reaction can be acid-base, complexation, oxido-reduction and precipitation. Indicators are used to show the endpoint of the titration, which can be a color change, the appearance or disappearance of turbidity.

The most important gravimetric method is precipitation. It is applied to compounds of very limited solubility. The precipitate is filtered, dried and weighted.

There are many different instrumental methods, since there are many different physical properties of solutions which can be measured [6]. The main classes are electroanalytical, chromatographic, photometric and spectroscopic methods. Only one or a few instruments of each class will be described below.

Electroanalytical methods are based on the same electrochemical principles as electroplating, so some of them are obvious choices for MF. In potentiometry, an electrode gives an electrical potential in relation to the activity of an ion in solution. The activity is itself a thermodynamical value related to the concentration. This potential is measured with a reference electrode and a high resistance voltmeter. The glass electrode is used in many MF facilities to determine the pH of baths and treated wastewaters. But there are also ion selective electrode (ISE) for the determination of many other anions and cations. However, they require special care as to the calibration and the risk of interferences and drift with time. Electroanalytical instruments are relatively cheap when compared to spectroscopic alternatives and the running costs are also lower.

In chromatography, the separation of substances is realized by passing the mixture through a chromatographic column (adsorbent). The different substances are adsorbed at different rates. Detectors (conductivity, electrochemical and UV-visible) can distinguish one species among the others. Chromatography can achieve the fast analysis of many substances in one sample. In addition to analysis of metals and anions commonly found in plating baths, it can measure organic additives (brighteners and surfactants).

Photometry analyses a substance by measuring its absorption of ultraviolet or visible light. The quantity absorbed is proportional to the concentration of the substance in the solution. Colorimetry compares the color of the sample to the color of a standard. To avoid limitations from the sensitivity of the eye, the comparison can be done by measuring the monochromatic light which is absorbed. Colorless substances can also be analysed if they are coloured beforehand by reaction with an additive. There are photometric methods and even many chemical kits available on the market for different substances (metals in particular). In Atomic Absorption (AA), the sample is vaporized in an acetylene-air (or nitrous oxide) flame and absorbs the light from a lamp specific to the element being analysed. These lamps have a high cost and many are needed for the various elements. There is a problem when there are elements in solutions with close absorption wavelengths (spectral interference).

Spectroscopy analyses an element by measuring its emitted light. When an atom is excited by the addition of energy, it gives it back in the form of photons at wavelenghts which are characteristic of the atom. The intensity emitted can be measured and is proportional to the concentration of the analysed species. In Inductively Coupled Plasma (ICP), the sample is vaporized in high temperature argon gas. The plasma results from ionization by a radio frequency field. The detection limits are low (part per billion), there is simultaneous analysis of many elements and there are no interferences as in AA. However, ICP does not differentiate between oxidation states (Cr^{+3} and Cr^{+6} for example).

When baths are not plating well, analysis will measure how far components of the baths are from the optimum concentrations. Analysis will identify what are the contaminants and it will then be possible to track them to their source and prevent their entry in the process. For example, maybe improvements in the rinsing of parts or more frequent activated carbon treatments would be required.

References

[1] *Electroplating Engineering Handbook*, *4th Edition.* L. Durney. Van Nostrand Reinhold, New York (NY), 1984.

[2] *Modern Electroplating, 3rd Edition.* F. A. Lowenheim. John Wiley & Sons, New York (NY), 1974.

[3] *Nickel and Chromium Plating.* J. K. Dennis and T. E. Such. Newnes-Botterworths, London (UK), 1972.

[4] http://www.pfonline.com/articles/040002.html

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Fact Sheet # 10

Electroplating Bath Life Extension

In order to decrease raw materials consumption and achieve waste minimization, one of the most recommended best practices is extending bath life. This can be achieved by:

- Removing product that has fallen from the barrel or rack.
- Maintaining baths at minimum effective concentrations – you can greatly reduce your chemical costs and the costs associated with disposal or treatment.
- Keeping bath temperatures as high as possible – Evaporates bath water so relatively clean waste rinse water can be reused as bath makeup water. Reduces solution viscosity so more chemical drains back to process tank during dragout. Do Not Use On Cyanide or Hexavalent Chromium Baths. The disadvantage to this method is the accompanying greater energy bill.
- Installing recirculating lines with filters on process baths – to remove impurities on a continual basis. These filter systems are relatively inexpensive and can increase the useful life of the baths significantly. However, the systems generate a new waste — spent filter cartridges. Depending on the bath being filtered, the spent filters may be classified as a hazardous waste.
- Conducting carbon treatment to remove organics – the carbon adsorbs organics and the carbon filters themselves are replaced periodically and disposed.
- Using De-ionized Water.
  Using contaminated water shortens bath life, reduces bath efficiency, causes rejects and contributes to the wastewater treatment load.
  The benefits of using purified water outweigh the costs:
    - Money saved by producing fewer rejects, including lower stripper consumption and waste disposal costs;
    - Reduction in scrap parts from repeated stripping and plating;
    - Reduction of labour in reject salvage;
    - Extension of plating bath life.

- Removing metal contamination by dummying – this can be achieved for most copper, zinc, iron and lead contaminants.
- Precipitating contaminants – by conventional wastewater treatment methods.
- Conducting consistent timely analysis.
- Reducing Drag-in.
- Controlling anode purity and using anode bag.

References

[1] *Metal Finishing P2 Technologies Manual.* Metal Finishing Industry Pollution Prevention Project Task Force, 2003.

Fact Sheet #11

Introduction to Metal Finishing Process Control

It is obvious that optimization of metal finishing processes (choosing the best baths chemical compositions in particular) and better operation lead to higher quality of deposits and more efficient production. Other benefits include a decrease in the use of raw materials and waste minimization. However, to get those savings, it is necessary to keep all process parameters at their optimized values and to respect the recommended operation practices all the time. This very important task is called Process Control (PC) [1, 2]. It also contributes to extending baths life.

For example, this means making sure that the pre-treatment and electroplating baths are at their specified chemical compositions and free from contaminants. Otherwise, parts below customers' specifications are produced and a lengthy and costly troubleshooting is required to bring back the process online [3 - 5].

Why are baths compositions changing during operation? There are many reasons: drag-out, evaporation, chemical decomposition (of organic additives in particular) and differences in the current efficiencies of anodes and cathodes. The last one results in changes of metal concentration and pH, the changes being obviously more important in the case of a non-soluble anode! Unless there is a human mistake during additions of chemicals to the baths (lack of respect of dilution factors for example) or contamination from parts fallen to the bottom of the tanks, those changes will be gradual and in proportion to the rate of production. Thus maintaining the baths compositions can be very well planned.

There is always a range for each bath component and operating parameter. Depending on the parts to be plated, quality of deposits required by customers and production rate, each metal finisher has his preferred values for bath composition and his preferred ways to operate. However, the optimum is usually around the middle of the range. The range being sometimes rather large, this means that it can be difficult to establish the control band width which is really required at a given facilities.

It is obvious that if the MF lets the metal concentration in the electroplating bath drift too low while attempting to increase current density (to increase production rate), he will lose deposits quality. If the MF lets the metal concentration drift too high, he will lose too much metal in the rinse waters (and ultimately to the sewer or sludge) because of drag-out. If the MF lets the impurities concentration get too high or the additives concentration get too low, he will again lose deposits quality. Therefore, it is the interaction between bath composition and other parameters which makes the width of the control band much smaller than the range presented in the tables above or in data sheets from suppliers. Maintaining a narrower control band results in additional cost for more frequent baths analysis.

One important way to establish the control band at a given facilities is production experience. There should be recording of bath components analysis and other process parameters on a regular schedule. The records should be correlated with production problems (poor quality of deposits in particular). Therefore, the control band will tell if a correction should be made and how much it should be to avoid problems.

Another way is laboratory testing with baths of different compositions and steel panels. Well documented laboratory equipment for these tests is the Hull Cell [6 - 8]. The goal is to establish how far away from the optimum values electroplating can be operated without losing the deposits quality required by the customers. Keeping the panels or photographs will also allow comparison with panels prepared during process upsets in order to identify the causes, such as bath impurities or additives imbalance. The Hull Cell can be a valuable tool for troubleshooting. However, process control goes beyond troubleshooting since it is done on a regular schedule precisely to prevent upsets. This is the best way to manage production.

The table below is a partial description of the actual process control program of an aerospace company in Canada for the plating of hard chrome over special steel parts. This is presented as an example only, since the specifications for aircraft parts are very critical. More severe specifications result in narrower control band. A higher production rate can also require more frequent testing.

TABLE 1: Hard Chrome

Parameters	Frequency	Min	Max
Hexavalent Chromium as CrO_3	Weekly	224	262 g/L
SO_4	Weekly	2.2	2.6 g/L
Temperature	Weekly	55	60 °C
Trivalent Chromium	Monthly		4 g/L
Silicate	Monthly	0	80 ppm
Impurities (Fe, Cu, Ni, Zn)	Monthly	0	5000 ppm

Finally, it is important to understand that if PC improves the quality of production, it is not a substitute for Quality Control of electrodeposits. Many properties of metal deposits might have to meet customers' specifications, such as thickness, adhesion, hardness, ductility, wear resistance, corrosion resistance and visual appearance [3, 9 - 12].

References

[1] www.pfonline.com/articles/clinics/0503cl_plate2.html

[2] www.metalast.com/documents/Other/Bene_Process_Control.pdf

[3] *Electroplating Engineering Handbook*, *4th Edition.* L. Durney. Van Nostrand Reinhold, New York (NY), 1984.

[4] http://www.pfonline.com/articles/pfd0308.html

[5] http://www.pfonline.com/articles/pfd0016.html

[6] http://www.pfonline.com/articles/110502.html

[7] http://www.pfonline.com/articles/120504.html

[8] http://www.kocournet.com/cells.htm

[9] *Modern Electroplating, 3rd Edition.* F. A. Lowenheim. John Wiley & Sons, New York (NY), 1974.

[10] *Nickel and Chromium Plating.* J. K. Dennis and T. E. Such. Newnes-Botterworths, London (UK), 1972.

[11] http://www.pfonline.com/articles/040102.html

[12] www.astm.org

Fact Sheet #12

Trivalent Chromium for Passivation of Aluminium Alloys and Zinc

One metal finisher in Atlantic Canada uses Alodine to produce a protective coating on aluminium and its alloys used by the metal finisher's aerospace clients. This coating is also an excellent bond for organic coatings. This conversion coating system produced by Henkel (http://www.loctiteaero.com/) contains hexavalent chromium.

Another MF in Atlantic Canada uses Chromicoat L-25 to produce a protective coating on aluminium and zinc for marine applications. This conversion coating system produced by Chemetall Oakite (http://www.oakite.com/) also contains hexavalent chromium.

Since hexavalent chromium is toxic, it is common pollution prevention practise to look for a less hazardous substitute raw material. Trivalent chromium is a potential candidate both for the passivation of aluminium and its alloys and the passivation of zinc. This substitution has already been reported in the case of zinc coatings [1].

The Managers of these two companies already know the Henkel and Chemetall Oakite products well. SurTec International GmbH (http://www.surtec.com/) offers the chromitAL TCP process for aluminium (mainly) and zinc which is based on trivalent chromium.

However, the aerospace industry has established specifications (USA Military specifications in particular) for the metal finishing of parts. Substitution becomes possible only if the new finish is approved by the Original Equipment Manufacturers (OEM).

References

[1] *Ninth Progress Report.* Metal Finishing Industry Pollution Prevention Project Task Force, 2003.

Fact Sheet #13

Solvent Cleaner Substitution

An organic solvent (such as varsol) is often used for the cleaning of parts such as hydraulic cylinders. Water based cleaner would be a more environmentally friendly substitute.

For example, more information on cleaners can be obtained from these two suppliers:

- Magchem (http://www.magchem.com/) offers both aqueous based products (645DX, 150X and 149X) or safer solvents (Skysol and MagKleen 4).
- Wechem (http://www.wechem.com/) offers Citro Kleen which is based on D-Limonene.

In considering a replacement solvent for varsol, it is important to understand that safer solvents cost three times as much as varsol, while the aqueous based cleaners are available at a cost similar to varsol. However, cleaning with aqueous based products results in the generation of wastewater contaminated with oils and greases, which requires treatment before discharge to the sewer. Aqueous cleaner tank needs to have strong agitation and to be heated to 160°F. A rinsing tank is also required. For example, Proceco (http://www.proceco.com/) is a supplier of washers and cleaning systems. The use of aqueous based products is not a simple substitution; it requires investment in additional equipment but does represent an environmentally friendly alternative which is also of benefit to the health and safety of workers.

Fact Sheet #14

Chromic Acid Bath Life Extension with a Porous Pot

General information on contaminants removal can be found in references [1, 2].

In the case of hexavalent chromium baths, a porous pot should be used [1] to decrease bath contaminants (Fe and Cu ions in particular), oxidize Cr^{+3} into Cr^{+6}, increase plating efficiency and quality, and get lower energy cost.

The porous pot [3, 4] uses a high silica-alumina ceramic vessel as the "membrane" to separate the interior catholyte and exterior anolyte (plating bath). Two lead-alloy anodes are positioned outside the vessel, and a third lead-alloy cathode is positioned in the catholyte. The porous pot is 40-percent porous, with pores 1 to 2 microns in diameter. The porous pot acts like a filter in a limited sense. It uses electricity (DC voltage) to drive the impurities through the pores. This action separates dissolved impurities from the chrome solution. The metallic contaminants are collected as sludge in the catholyte and as deposit on the cathode which can be scrapped off. Unwanted trivalent chromium ions are oxidized to the hexavalent state at the anode surfaces. Typically, a clean porous pot will draw about 200-300 amps at 6-9 VDC. The current will drop as the porous pot works, and the rate at which impurities are removed will drop also [5]. It is important, therefore, to clean the pot regularly.

However, there are other methods available for impurities removal [6]. Dummying to extract metallic contaminants is well known by MF [1, 2]. In decorative chrome electroplating, if there are more anodes in the tank to keep the anodic surface around twice the cathodic surface (the plated parts surface), keeping the Cr^{+3} at low concentration should not be a problem.

References

[1] http://www.wmrc.uiuc.edu/main_sections/info_services/library_docs/manuals/finishing/plating.htm

[2] http://www.nmfrc.org/bluebook/sec422.htm#s4225

[3] http://www.hard-chromesystems.com/

[4] http://www.nmfrc.org/crexpert.cfm - February 2002

[5] *Practical & Theoretical Aspects of Regeneration of Chromic Acid Plating Solutions via Electrolytic Purification (Porous Pot Method)*. N.V. Mandich, C.-C. Li and J.R. Selman, Plating and Surface Finishing Magazine, Dec. 1997, p.82.

[6] http://www.plating.com/

Fact Sheet #15

Controlling the Ratio CrO_3 / SO_4

Keeping the Ratio CrO_3 / SO_4 around 100 in hard chrome electroplating requires chemical treatment. It is important to note that in fluoride catalyst baths for hard chrome plating, Ratio of 200-300 is used.

When the Ratio CrO_3 / SO_4 is too low, the excess sulphate should be removed by precipitation with barium carbonate according to the chemical reaction below:

$BaCO_3 + H_2SO_4 \rightarrow BaSO_4$ (solid) + CO_2 (gas) + H_2O

100 g of barium carbonate will remove 50 g of sulphuric acid [1]. Barium sulphate is insoluble.

The total amount of barium carbonate to be added (slowly and carefully with good stirring) is calculated from the bath chemical analysis, volume of solution to be treated and how much H_2SO_4 has to be removed to control the ratio to its optimum value. Chemical suppliers to the MF industry can analyse the Ratio CrO_3 / SO_4 and provide barium carbonate. Since the analysis of sulphuric acid in a chrome bath is not always accurate, it should be used as a guide only and the additions should be made in steps.

Health & Safety

Handling of chemicals and additions of chemicals to process baths should be made according to the best Health & Safety practices [2 - 6]. In particular, workers should wear their personal protective equipment (safety glasses with side shields or safety goggles, rubber gloves and aprons, etc). Advice on the use of chemicals should be requested from suppliers.

References

[1] http://www.finishing.com/Library/Whitelawchrome.html

[2] *Electroplating Engineering Handbook*, *4th Edition.* L. Durney. Van Nostrand Reinhold, New York (NY), 1984.

[3] http://www.ilo.org/public/english/protection/safework/cis/products/hdo/htm/elctroplater.htm

[4] http://www.ohcow.on.ca/resources/handbooks/chrome_plating/Electroplating.pdf

[5] http://www.safetyline.wa.gov.au/pagebin/guidwswa0053.pdf

[6] http://www.osh.dol.govt.nz/order/catalogue/pdf/electroplating.pdf

Fact Sheet #16

Pickling (Hydrochloric Acid) Bath Life Extension

Pickling is the chemical removal of surface oxides (rust) and mill scales from steel parts by immersion in an aqueous acid solution. When a pickling bath is spent, it has to be disposed of and replaced with new chemicals (hydrochloric acid or sulphuric acid). Since 30 to 70% of original acid can be lost in bath dumping before being used, it is obvious that there are significant costs related to acid consumption and waste treatment (even if the dumped bath is further used for stripping of chains and baskets). It is a good practice, both for pollution prevention and economics to try to extend a process bath life and maximize the use of raw materials it contains [1].

Pickling baths become contaminated with dissolved iron through use. As the iron concentration increases, the free acid concentration decreases and pickling efficiency drops. Any technology which decreases the frequency of bath dumping has also the added benefit of consistent bath chemistry which assures pickling performance and decreases generation of sludge and fumes.

Many technologies exist to extend pickling bath life, which are based either on preventing the iron from going into solution; precipitating and filtering the iron once it has gone into solution; or separating the acid from the iron by ion exchange or evaporation or distillation.

Corrosion Inhibitor

During pickling the acid attacks both surface oxides and bare steel. This second unwanted reaction leads to increased acid consumption and iron contamination of bath. An inhibitor for steel such as IRONSAVE developed by Soprin srl and distributed by Zaclon Inc. (http://www.zaclon.com/) can be added to the bath (at 0.3% per volume) to prevent the corrosion of the parts during pickling.

Precipitation Agent

A precipitation agent such as PRO·pHx (http://www.pro-phx.com/) from Wagner Environmental Technologies and distributed in Canada by Westbrook Technologies Inc. (http://www.wti-world.com/) can be added to the pickling bath (at 0.5-1% per volume) to maintain the acid at optimum effectiveness. PRO·pHx is non-flammable, non-toxic and non-hazardous. PRO·pHx drops metals, organics and impurities out of solution and encapsulates them into a non-leaching constituent which allows filtration (minor capital investment). It has been reported to decrease acid requirements by up to 89% [2 - 4]. PRO·pHx is a proprietary blend of soluble silicates which allows for the effective immobilization of soluble metals by reacting with them to form insoluble metal silicates.

Ion Exchange

The Acid Purification Unit (APU) from Eco-Tec Ltd (http://www.eco-tec.com/) eliminates bath dumping by removing metals as they dissolve into the pickling acid. It works on the principle that free acid is absorbed by a special resin while dissolved metal salts pass through. A simple water wash can recover the acid which is returned to the pickling tank [5 - 6].

Evaporation

Equipment offered by Beta Control Systems Inc. (http://www.betacontrol.com/) can evaporate the more volatile hydrochloric acid from the spent pickling solution. A ferrous chloride concentrate is generated and after condensation the acid and water are returned to the pickling tank.

Distillation

Phoenix Systems Inc. (http://www.phoenixsystemsinc.com/) offers conventional distillation equipment and new technologies to recover acids.

It is recommended that the first two alternatives be considered initially because of their simplicity and low investment required. Laboratory tests should be conducted to establish feasibility and performance. Ion Exchange is one of the most widely used acid recovery system in the world, but not specifically in galvanizing facilities. The last two alternatives are relatively not as promising because of the complexity (higher investment and higher energy cost) of equipments handling hot concentrated acid solution and corrosive hydrogen chloride (HCl) gas.

References

[1] *Metal Finishing P2 Technologies Manual.* Metal Finishing Industry Pollution Prevention Project Task Force, 2003.

[2] *The Acid Test.* D. French. http://www.cleantechcentral.com/, April 2005, p. 26-30.

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Fact Sheet #17

Cooling Water Recirculation

In hard chrome electroplating, bath temperature is set at 55°C (130°F). When a current is introduced to the part, cooling is required, especially when plating parts with a large surface area. It is preferable that a closed loop recirculation system be installed to provide this cooling instead of using once through municipal water. Water is recirculated for cooling through the use of either a cooling tower (usually) or a chiller, as described in case studies previously reported by CAMF [1]. For example, Cimco (http://www.cimcorefrigeration.com/) is a supplier of cooling towers and refrigeration systems. Water savings are considerable and "simple payback" times of less than one year have been reported, depending on local conditions.

Payback calculations require municipal water costs, local electricity costs, the typical current used (related to the size of parts being plated), which determines the typical flowrate of cooling water needed, and the operation time per day/week.

Temperature control on chrome tank with display of temperature and capacity to control cooling system is required.

References

[1] *Ninth Progress Report.* Metal Finishing Industry Pollution Prevention Project Task Force, 2003.

Fact Sheet #18

Compressor Replacement for Air Agitation *(Energy Efficiency)*

In many MF facilities, air sparging is used to provide agitation in process baths. Sparging is very efficient to improve flow and mass transfer to an electrode, but it is recommended that the air be supplied by a lower pressure blower rather than by a compressor since energy savings of 90% have been reported [1]. A blower can be used for air sparging even in deep tanks. Blower models are available that can provide 21.5 m^3 per minute of air at a pressure of 51710 Pa (relative), which is equivalent to a head of 5.28 m of water [2]. The use of a blower eliminates possible solution contamination from the oil of a compressed air system.

Air agitation is also a means of achieving good mixing in a rinse system [3]. It is, in most respects, better than high water flow rates. Air agitation should be as turbulent as possible without overflowing the tank or dislodging the parts from the racks. The source of the air should again be a low-pressure blower.

For agitation of nickel and chrome plating baths, it is recommended to use 0.3 to 0.6 m^3 per minute of air / m^2 of solution surface [4, 5], at a delivered pressure of 12926 Pa (relative) for each 1 m depth of solution (typical density of 1.2). Air sparging could also be used to improve agitation in rinsing tanks and air flowrates from 0.15 to 1.2 m^3 per min / m^2 have been proposed.

To distribute such an air flowrate of 0.6 m^3 per min, a 2.5 cm diameter PVC pipe placed 5 cm off the bottom of the tank directly under the parts to be plated could be used. With staggered 1.5 mm diameter holes drilled 3 cm apart along two rows on the underside of the pipe at an angle of approximately 45° from the vertical, the required length of such a perforated pipe would be 1.5 m.

Since total required flowrate of air varies with tank size, tables and simple design rules exist to determine the pipe diameter, holes diameter and number, distance between holes and total length [4, 5]. It is advisable to manifold the air from both sides of the tank, to avoid excessive air pressure drop and ensure balanced sparger air supply.

It is obvious that some experimentation could be conducted to adjust the air flowrate and the air sparger design to get better results in plating and rinsing.

Additional tables and simple design rules can also be used to select the blower's size according to total required flowrate and tank depth [2, 5].

Air sparging has the disadvantage of increasing mist generation from the plating tank. Therefore newer MF installations are using liquid eduction systems to agitate the solutions. An eduction system includes a pump, piping and a nozzle. It does not create mist [6].

References

[1] *Good Practice Guide 270 – Reducing Energy Costs for Aqueous-based Metal Treatment Processes.* Energy Efficiency Enquiries Bureau, ETSU, Oxfordshire (UK) 1999.

[2] *Guide to Air Agitation in Electroplating.* EG&G Rotron (USA).

[3] http://www.p2pays.org/ref/04/03987.pdf

[4] *Electroplating Engineering Handbook*, *4th Edition.* L. Durney. Van Nostrand Reinhold, New York (NY), 1984.

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[6] *Ninth Progress Report.* Metal Finishing Industry Pollution Prevention Project Task Force, 2003.

Fact Sheet #19

Rectifier Performance Improvements *(Energy Efficiency)*

Regular maintenance of the rectifiers will improve their performance and will be reflected in both the quality of electroplating and in energy efficiency [1-4]. The rectifiers should be cleaned, calibrated and, if necessary, upgraded.

The quality of the busbars, cables, racks and all electrical contacts should be verified. The rule of thumb is 1000 A can be carried by 1 in^2 (6.45 cm^2) of copper busbar (intermittent operation without excessive heat buildup). For aluminium busbar, a cross-sectional area of 1.6 in^2 (10.32 cm^2) is needed to carry 1000 A.

Dirty or loose connections, corrosion of contacts and undersized conductors lead to higher resistance, higher voltage, poor current distribution to parts being electroplated, and wasted energy.

Polymeric flexible tubing could be used to protect the horizontal copper rods from corrosion over the tanks for chrome electroplating.

For chrome electroplating, AC ripple is important and should be no more than 5% maximum.

References

[1] *Electroplating Engineering Handbook*, *4th Edition.* L. J. Durney. Van Nostrand Reinhold, New York (NY), 1984.

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APPENDIX F

AMERICAN ELECTROPLATERS AND SURFACE FINISHERS SOCIETY COURSE:

CHROMIUM PLATING FOR ENGINEERING APPLICATIONS

American Electroplaters and Surface Finishers Society (AESF)
Montreal's Branch

Chromium Plating for Engineering Applications

Course Outline:

Day 1

1. Basic Chemistry for Chromium Plating
2. Electrochemistry
3. Electricity
4. Metallurgy
5. Equipment Used for Chromium Plating

Day 2

6. Stop-Off Materials and Rack Coatings
7. Mechanical Surface Preparation
8. Chemical Surface Preparation
9. The Chromium Plating Process
10. Analysis and Control of Solutions
11. Troubleshooting and Purifying Solutions

More information on AESF courses can be found on:

http://www.aesf.org/trainingcourses/index.html

The following persons attended the course in Dartmouth, NS on March 27 and 28, 2006:

Atlantic Hardchrome Ltd – Glenn Ferguson
Custom Machine & Hardchrome Inc – Lorne Goodine
EMM Hardchrome & Hydraulic Ltd – Jim Martin
Fleet Maintenance Facility Cape Scott – Kay Roberts
Fleet Maintenance Facility Cape Scott – Glen R. Shea
Maritime Hydraulic - Warren Fowler
Pratt & Whitney – Sheila Diamond
Zenith Plating Ltd – Wayne Hartlin

APPENDIX G

FOLLOW-UP QUESTIONNAIRE

Follow-up Questionnaire (Add sheets as required.)

Date:

Preamble:

Your company accepted to reply to a questionnaire as part of the project above and you may have received a visit from us during the last year to discuss environmental compliance and pollution prevention. You may have also attended the CAMF Eco-Efficiency Workshops held in New Brunswick and Nova Scotia in January 2005.

CAMF is now trying to evaluate the usefulness of these activities for you to better plan future initiatives.

1- Identification of Metal Finishing Company

a) Name:

2- Contacts

a) President / Production Manager / Environmental Coordinator:

3- Environmental situation

a) Did the questionnaire and/or visit and/or Eco-Efficiency Workshops help raise your awareness of your environmental situation?

b) Have you conducted a review of your environmental management since?

c) Have you created or updated your environmental file?

d) Have you reviewed the environmental laws and regulations related to your activities?

e) What did you do to achieve compliance?

- Obtain or modify your Certificate of approval
- Provide training to your employees on Health and safety in the workplace and/or Transportation of dangerous goods

- Improve the labelling and storage of dangerous goods and update the Material Safety Data Sheets (MSDS)

- Implement or improve your Spills and environmental emergencies plan

f) Have you reviewed your facilities design and production activities to find pollution prevention opportunities?

g) What have you changed in your facilities design and production activities to improve your environmental performance?

- Substitute some raw materials for less toxic ones

- Reduce consumption of raw materials (process optimisation)

- Reuse materials if possible

- Recycle wastes

4- Future Eco-Efficiency Workshop

a) What was the most useful information you received at the workshop?

b) What new information would you like to receive at a future workshop?

Thank you for providing answers! CAMF will keep them confidential.

APPENDIX H

METHOD FOR CONDUCTING FOLLOW-UP VISITS TO ECO-EFFICIENCY EVALUATION PARTICIPANTS

Method for conducting the follow-up visits to the eco-efficiency participants

It is important to check for progress in both compliance and P2 issues.

The Follow-up Questionnaire already lists many pertinent questions, especially for compliance issues.

However, in the case of audit participants, it is important to look at their specific situation. There should be questions to each participant related to the recommendations in the compliance and P2 reports.

An example of question: Have you applied or do you intent to apply the recommendation in the future?

In the case of P2 in particular, if they did not apply the recommendation or have no intent to apply the recommendation in the future, they should be asked: What is the impediment?

- Lack of financial resource?
- Lack of technical resource?
- Need for better demonstration of the benefit of the P2 recommendation?

Any achievement in P2 should be noted, even if it is based on the participant own initiative instead of the report presented.

Any modernization of the facilities should also be noted, even if the original intent was productivity improvement and if the environmental improvement was collateral.

The Eco-Efficiency evaluation may have stimulated them in improving their facilities.

APPENDIX I

FOLLOW-UP RESULTS

Company	Environmental awareness increased?	Compliance	P2 Initiatives	Most useful information from workshop	New information interests
#1	Yes	• Are now using sticky labels on anything removed from original packaging and have provided training to staff. • Now ask all suppliers to provide MSDS with all shipments. • Plan to implement new spills procedure soon. • Wastewater sampling to be completed on a regular basis.	• Currently doing manually counter-flow practice, but plan to change the tank configuration in 2006. • They have repaired some leaks in the compressed air system and are continuing to look at this.	• Information on counter-flow rinsing and energy efficiency related to compressed air.	• Energy efficiency
#2	Yes	• Reduced the amount of hazardous waste in storage. • Looking into a written spills plan.	• Have not yet implemented any of the recommendations; however plan to look at them in 2006.	• Can't think of any.	• New Regulations after they come out.
#3	Helped to keep momentum moving forward.	• No changes, since all was in compliance originally.	• They have made changes to additives to the pickling bath and got longer bath life.	• Did not attend.	• Emergency response
#4	Yes	• Completed environmental management review and currently working on Certificate of Approval. • Have provided Health & Safety and/or TDG training. • Have improved labeling and storage of hazardous materials. • Have improved their spills plan.	• Major modernization of facility ($250,000.00) in 2006 which includes recommended P2 options.	• P2 Ideas (i.e. rinsing water).	• No response
#5	Helped to keep momentum moving forward.	• No changes, since all was in compliance originally.	• Looking at incorporating better shop practices with respect to waste reduction and extended chemical solution life. • Looking into possible alternatives for replacement of the Oakite L25 chromicoat to a less toxic substance. • Physical changes to shop layout in the future only.	• No response	• Training in basic metal finishing techniques for new employees.
#6	Yes	• Have reviewed environmental laws and regulations.	• Plan to review design for P2 options and have used information to establish required budget.	• No response	• No response
#7	No response				

#8	Yes	• Have reviewed environmental laws and regulations.	• Have reviewed design for P2 options and have made changes to reduce consumption of raw materials and reuse materials where possible.	• No response	• No response
#9	No response				
#10	This company is still in business, but the employee that we met with last year has left company and remainder of staff not aware of the CAMF & CRA project.				
#11	This company has gone out of business.				
#12	No response				