Socio-Economic Study to Assess the Canadian Metal Finishing Industry

Prepared for:

Environment Canada

Final Report

August 1994

Prepared by:

APOGEE RESEARCH

Apogee Ref.: 332 CEN

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International, Ltd.

August 23, 1994

Mike Barré
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351 St. Joseph Blvd.
Hull, Quebec
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Dear Mike:

RE: SOCIO-ECONOMIC STUDY TO ASSESS THE CANADIAN METAL FINISHING INDUSTRY

We are pleased to present three copies (two bound, one unbound) of our Final Report assessing the socio-economic characteristics of the Canadian metal finishing industry (Contract KA-168-3-7024).

The study presented considerable challenges, given the scarcity of socio-economic data on the MFI. The many metal finishers and suppliers that responded to our questionnaire and consented to be interviewed deserve special mention. Their help in filling the many gaps in traditional information sources was much appreciated.

Future analysis of strategic options will also be challenging. The MFI is unlike most other sectors being studied by Environment Canada. Any strategic options assessment will have to consider industry characteristics such as: the very large number of metal finishing operations; the small size of most operations; and the considerable diversity within the industry regarding markets, processes and financial performance. Innovative strategic options and analytical methods will undoubtedly be needed.

We wish you well and thank you for the opportunity to participate in this exciting work.

Sincerely,

Ken Watson
Director, Environment-Economy

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Executive Summary

Background

1. The Federal Green Plan identified for urgent action toxic Priority Substances released from the metal finishing industry (MFI). Releases from the MFI have been found to contain cadmium, nickel, chromium, lead and other substances.

2. This study provides background socio-economic information on the MFI that will be useful in evaluating strategic options to reduce toxic releases from the MFI and, if necessary, preparing a Regulatory Impact Analysis Statement.

3. This report summarizes information obtained from: interviews with 35 metal finishers and metal finishing suppliers; 85 responses to a questionnaire sent to 650 companies; and a review of existing pertinent studies.

Industry Overview

4. In this study, the metal finishing industry is defined as all plants that utilize the follow operations: mechanical deburring/sandblasting; hot dip galvanizing; electroplating; electroless plating; electrocleaning; anodizing; alkaline cleaning; acid pickling; acid bright dipping; stripping electrodeposits; etching; chemical conversion coating; electropolishing; and electronic-component operations. Plastic coating and painting are excluded from the study.

5. The Canadian MFI generates sales of approximately $800 million, representing about 0.2% of total manufacturing shipments.

6. About 600 Canadian firms are classed as metal finishing operations. About 60% of these firms are located in Ontario. Quebec, British Columbia and Alberta account for 15%, 11% and 8% of the remaining metal finishing firms.

7. About 75% of metal finishing operations are job shops -- that is, firms that do not own the products being finished but are contracted by other manufacturing firms to provide metal finishing services. The remaining 25% are captive shops -- metal finishing operations that are owned by and integrated into firms producing the products.

8. The ratio of job shops to captive shops has risen during the past 10 years. This trend is due to four factors: the relative operating costs of captive shops to job shops has increased; the quality of finishes available from job shops has increased; costs of complying with increasingly stringent environmental standards were unjustified for some captive shops; higher environmental liability risks associated with metal finishing operations have made firms reluctant to install captive metal finishing operations.

9. Half of the metal finishing operations employ less than 20 workers. Only 20% of metal finishing operations employ more than 49 people.

10. The MFI employs about 8,000 people, representing 0.5% of total employment in manufacturing industries.

11. Entry into the metal finishing industry can be difficult due to: creditors' reluctance to loan money to firms with high environmental risks; the need to meet higher quality standards; and the cost and time involved in obtaining certificates of approval from environmental authorities.

12. The most significant barrier to exit is the cost of cleaning contaminated sites.

13. Metal finishing technologies are relatively mature. Although refinements and automation are on-going, little change in basic processes and equipment has occurred in the last 10 years. The most significant change over the last 20 years has been the introduction of waste treatment systems.

14. The quality of finishing provided is a key characteristic that divides metal finishers. ISO 9000 is becoming increasingly important to obtain and maintain clients demanding high quality.

15. Almost all interaction between the MFI and governments have related to environmental concerns. Many technology demonstration/transfer projects and pollution prevention studies have been conducted with government assistance.

16. There are less than 25 metal finishing suppliers in Canada. These suppliers include: the largest mining companies selling metals; integrated metal finishing suppliers selling various equipment and commodity and proprietary chemicals; and small suppliers serving niche chemical or equipment markets.

17. Between 1988 and 1993, metal finishing suppliers report a decline in sales of 33% due to the recession and low demand from metal finishers. Declining demand has resulted in a significant consolidation of metal finishing suppliers.

Metal Finishing Markets

18. By far the most important factor affecting demand for metal finishing services is demand for the finished products. Trends away from metal finishing towards alternative finishes has a relatively small, long-term effect.

19. The major metal finishing markets are: automotive parts (25% of MFI sales); steel strip mills (11%); wire goods (10%); electrical appliances (9%); and hardware (8%). Metal finishing is also used in the furniture, engine and worn parts, electrical equipment, pole hardware and heavy steel, electronics, printed circuit boards, plumbing fixtures, military, aerospace, construction, hollowware and flatware, jewellery industries.

20. Although metal finishing markets are diverse, three industries are the main driving force behind well over half of the demand for metal finishing services. These industries are the auto, construction and housing sectors.

21. Different markets demand different levels of finish quality. Industries that demand particularly high quality include auto parts, military, aerospace and printed circuit boards. Industries that do not demand as high quality include furniture and wire goods.

22. Markets predominated by job shops are hardware (nuts, bolts and screws), plumbing (below sink), wire goods, furniture, engine and worn parts, and electrical equipment. Markets predominated by captive shops are: steel strip, electrical appliances, printed circuit boards, aerospace and hollowware and flatware.

23. Competition for jobs on the lower end of the quality scale is intense, resulting in low rates of return on sales for these jobs.

Financial Performance and Vulnerability

24. There is much uncertainty regarding financial performance in the MFI, since the MFI is predominately small, privately-owned companies.

25. "Best estimates" of average financial performance were developed, largely based on 25 responses to the questionnaire, financial databases and a previous Environment Canada report. Estimates are provided for large job plating shops (sales of over $5 million), medium-sized job plating shops (sales between $2 million and $5 million) and small job plating shops (sales under $2 million). Return on sales and return on assets are generally lower for smaller shops.

26. Metal finishers identify the following factors as being most important to their financial performance: the ability to meet quality control requirements; long-term decline in their customers' activities; wage rates and benefits; increasing material costs; the ability to raise investment capital; and environmental regulations.

27. Trade barriers, interest rates and labour problems pose few problems for the financial performance of most metal finishers.

28. Financial vulnerability varies among firms serving the same markets and/or in the same size range. However, as a general rule metal finishers serving low-quality/low-return markets and not generating high volumes of sales are most financially vulnerable.

29. Metal finishers are facing increasing difficulty obtaining credit due to the perceived environmental risks of loaning to metal finishers. Therefore, metal finishers that do not have access to other sources of financing (retained earnings and equity infusions) are financially vulnerable.

Trends in Metal Finishing Processes and Substances

30. Apart from the uncertain impact of non-metal coatings, zinc plating and electroless nickel are increasing significantly. Reductions in cyanide and cadmium use have occurred in the U.S., driven at least in part by environmental concerns.

Material Recovery and Recycling Practices

31. Evaporation, ion exchange and electrolytic recovery are the most common material recovery/recycling systems used. Respectively, these systems are used by 41%, 20% and 13% of the questionnaire respondents.

32. Two-thirds of metal finishers cite cost constraints as the most important barrier to further material recovery and recycling. Lack of markets for recoverable materials, space constraints in plants, lack of technical knowledge and government regulations are other important barriers. Regulatory barriers include the requirement that smaller metal finishers wishing to pool wastes before shipment to metal refiners must have their wastes collected by a registered hazardous waste receiver.

Foreign Environmental Regulations

33. Information on environmental regulations affecting metal finishing operations in the United States, Mexico, Hong Kong and Singapore are provided.

34. Comparisons of effluent limits across countries are difficult. Nonetheless, it appears that: the most stringent sewer use effluent limits in Canada are comparable to the most stringent limits in all the countries surveyed; the least stringent sewer effluent limits in Canada are often less stringent than limits in other countries; and Canada's Federal Metal Finishing Liquid Effluent Guidelines tend to fall between the most and least stringent sewer use effluent limits imposed by Canadian municipal governments.

1.0 Background and Purpose

Background

Canada's Green Plan identifies for urgent action toxic Priority Substances being released from several industries. The Plan calls for a Strategic Options Report to be released by 1994 for each identified industry. These Strategic Options Reports will assess the full spectrum of measures available to achieve reductions in toxic releases to the environment.

The metal finishing industry (MFI) is one of the sectors identified by the Green Plan for urgent action. Releases from the MFI have been found to contain cadmium, nickel, chromium, lead and other substances. If current research confirms the toxicity of these substances, strategic options to limit such releases from the MFI will be developed and implemented.

For any given environmental concern, Environment Canada is committed to identifying the most cost effective policies of achieving Canada's environmental goals. This process includes preparing background industry profile, using background profiles to assess the full range of strategic options available to achieve our goals, and consulting with stakeholders.

Purpose

The purpose of the proposed study is to prepare a Background Socio-Economic Study of the MFI. In conjunction with the Technological Background Report, the Background Socio-Economic Study will provide:

- an understanding of the state of the MFI;
- information that will be useful in preparing a Strategic Options Report that encompasses the full range of environmental protection approaches; and
- information that will be useful in preparing, if necessary, a Regulatory Impact Analysis Statement.

2.0 Methodology

Few sources of socio-economic information on the Canadian metal finishing industry exist. The industry has rarely been the subject of economic analysis. Furthermore, the metal finishing industry has many characteristics that hinder data/information collection:

- the metal finishing industry is dominated by small, private firms that are not covered well by public data sources;
- the range of firms of interest to this study are not well represented by any industrial classification used by Statistics Canada; and
- some end-product manufacturers have "captive" metal finishing operations within their plants that are difficult to identify.

These difficulties necessitated using a multiple research approach. Each section of the report opens with a description of the specific information sources used in completing the section. Here we describe the three most important information sources.

Company Interviews

Apogee Research conducted confidential interviews with a total of 35 companies associated with the metal finishing industry. Twenty-three of these companies were metal finishers from a cross-section of provinces and specializing in the full spectrum of markets for metal finishing services. Metal finishers were questioned on a wide range of topics, including:

- conditions and trends in their major market;
- factors affecting competitiveness;
- location of major foreign competitors;
- material recovery and recycling practices; and
- sales, employment, investment and financial performance.

Although metal finishers willingly discussed most topics, many companies refused to provide confidential information, particularly financial performance ratios.

An additional 12 metal finishing suppliers were interviewed regarding markets for metal finishing chemicals, metals and equipment. These companies account for the bulk of the Canadian market for metal finishing supplies. Each company was asked to describe various aspects or their business including: types of products sold to metal finishers; the size of their markets; portion of sales accounted for by the metal finishing industry; degree of competition in their markets; trade; factors affecting their competitiveness; profitability; relationships with metal finishers with respect to the determination of prices and passing on cost increases.

Questionnaire

Approximately 650 questionnaires were mailed to companies identified as being metal finishers. Company names and addresses were identified through a number of sources, including: Waste and Chemicals Division, Alberta Environment; Air Quality and Source Control Department, Greater Vancouver Regional District; the Montreal Urban Community; Environment Canada; and CH2M Hill (1994). The questionnaire and cover letter is provided in Appendix A.

Questionnaire responses are summarized in Exhibit 2.1. Seventy-eight of the questionnaires mailed did not reach metal finishers because companies had gone out of business or moved, mailing addresses were incorrect, of the companies did not perform metal finishing processes. The remaining 572 questionnaires yielded 93 responses, for a response rate of 16%.

Exhibit 2.1
Summary of Questionnaire Response

	Number of Questionnaires	Number of Questionnaires as a % of Questionnaires Mailed
Questionnaires Mailed	650	100%
Questionnaires Completed		
Returned By Mail	71	11%
Completed During Telephone	14	2%
Interviews	8	1%
Do Not Use Substances of Concern		
Total	93	14%
Questionnaires Returned Uncompleted		
Returned to Sender (unopened)	59	9%
Not Metal Finishers	14	2%
Blank	3	<1%
No Longer In Business	2	<1%
Total	78	12%

The major reasons for this low response rate are likely the following.

- As per the objectives of the study, the questionnaire requested economic and financial information that is usually confidential.

- The questionnaire was clearly linked to an environmental policy initiative. Rather than interpret the questionnaire as an opportunity to present their views, many metal finishers may have been reluctant to cooperate with a policy initiative that seems inevitable or "non-influenceable."

- The recession has hit metal finishers particularly hard. In such times, questionnaire response rates tend to suffer.

- Our questionnaire followed several other recent questionnaires of metal finishers. We may have exceeded the tolerance level of the industry.

Nonetheless, the responses received were helpful in assessing many of the socio-economic issues discussed in the report.

Other Information Sources

Although socio-economic information on the metal finishing industry is scarce, several studies provided useful information on other aspects of the industry. These are referenced throughout the study and listed in Appendix B. The most valuable studies included:

- CH2M Hill (1994) "Background Document on the Reduction of Potentially Toxic Discharges from the Canadian Metal Finishing Industry" Prepared for Environment Canada;
- Environment Canada (1987) *Overview of the Canadian Surface Finishing Industry: Status of the Industry and Measures for Pollution Control* Ottawa: Environment Canada, EPS 2/SF/1;
- Monenco (1992) "Waste Management Practices of the Alberta Chemical and Electrochemical Plating Industry" Prepared for Alberta Environment, Industrial Wastes Branch; and
- Proctor & Redfern (1991) *Metal Finishing Survey for Ontario* Toronto: Ontario Ministry of the Environment, Waste Management Branch.

3.0 Overview of the Metal Finishing Industry

Information Sources

The information presented in this section was obtained from the following major sources:

- existing studies, most importantly CH2M Hill (1994), Proctor & Redfern (1991), Monenco (1992) and Environment Canada (1987);
- published and unpublished data from Statistics Canada;
- industry associations, most importantly the Canadian Association of Metal Finishers, the Canadian Metal Finishing Suppliers Association and the Canadian Mining Association;
- responses to our questionnaire; and
- interviews with 35 metal finishers and metal finishing suppliers.

Sales of the Metal Finishing Industry

Total sales of the metal finishing industry are estimated to be approximately $800 million. This is based on an assumption that sales of $100,000 are generated for each worker.

Metal finishing sales represent about 0.2% of total shipments by the manufacturing sector.[1]

Number of Metal Finishing Firms

There are approximately 600 firms in Canada engaging in metal finishing processes. The number of firms has decreased over the past decade from an estimated 644 in 1983. Industry representatives indicate that few new metal finishing operations are currently being established. Industry representatives attribute this decline in the number of firms and lack of new entrants to five major factors.

(i) The recession which began in 1990 decreased the sales and profits that metal finishing firms were able to generate, resulting in some plant closures.

(ii) There has been an increase in the use of job shops (discussed in more detail below). There are now instances of one or two job shops contracted to do metal finishing work that was once completed in-house by several manufacturing companies.

1 Total manufacturing shipments in 1993 were just over $307 billion, as reported in Statistics Canada (1994) *Canadian Economic Observer* (March): Table 20. Publication No. 11-010.

(iii) Some small firms could not afford additional costs associated with complying with more stringent environmental regulations and were closed.

(iv) Lenders reluctance to extend credit to metal finishers due to environmental liability risks.

(v) After the Canada-U.S. Free Trade Agreement came into effect, some U.S. companies closed their captive metal finishing operations in Canada and relied on captive shops in their U.S. plants for their metal finishing needs.

Geographic Distribution of the Industry

Metal finishing firms typically locate very close to their markets. The distribution of metal finishing firms reflects the concentration of manufacturing industries in Canada.

Exhibit 3.1 presents estimates of the distribution of metal finishing firms by province. These figures show that Ontario and Quebec account for three-quarters of all metal finishers. British Columbia and Alberta contain approximately 20% of the remaining firms. A small number of firms are scattered in the other provinces.

Some of the apparent changes in distribution over time are a result of better data becoming available. For example, increased efforts to identify metal finishers in Quebec, Ontario and Manitoba likely account for part of their increased share of firms from 1973 to 1983/1984.

Exhibit 3.1
Regional Distribution of Canadian Metal Finishers

Province	1973[1]	1983/1984[2]	1992[3]
Newfoundland	0.0	0.0	0.0
Prince Edward Island	0.0	0.0	0.0
Nova Scotia	0.9	2.1	1.3
New Brunswick	0.3	1.4	0.8
Quebec	18.2	25.3	15.2
Ontario	63.6	51.8	60.3
Manitoba	3.2	6.2	2.3
Saskatchewan	0.6	0.2	0.8
Alberta	4.4	1.6	8.3
British Columbia	8.8	11.5	10.8
CANADA	100.0	100.0	100.0
TOTAL FIRMS	na	644	600

Sources: Environment Canada (1975), Environment Canada (1987) and CH2M Hill (1994).

Job Shops and Captive Shops

The metal finishing industry is typically broken down into job shops and captive shops, defined as:

- *Job Shops*: firms that do not own the products being finished but are contracted by other manufacturing firms to provide metal finishing services; and
- *Captive Shops*: metal finishing operations that are owned by and integrated into firms selling finished products.

While this distinction holds for most metal finishers, some firms fall somewhere between the two classifications. For example, some metal finishing operations are part of a larger manufacturing facility but also provide services on a contract basis.

About 75% of metal finishing shops are job shops. This marks a shift during the past 10 years from captive to job shops. For instance, in the early 1980s, job shops accounted for only about 40% of metal finishing firms.

The increase in the ratio of job shops to captive shops is mainly the result of three factors.

(i) For many manufacturing operations, the cost to operate a captive shop has become higher than the cost of contracting the work out to job shops. In some industries, there has also been a decline in the use of their captive shops because of changing product lines or increased demand for non-metal finished goods. In these cases, it becomes more economical to use a job shop than maintain a largely idle captive operation.

(ii) The quality of finishes now available in many job shops has increased. In the past, automotive and other industries requiring higher quality finishes were unable to rely on the quality of work done by job shops. Over the past decade, job shops have increased the quality of their finishing to meet the standards of the automotive and some of the aerospace industry.

(iii) Some companies with captive metal finishing operations have had to meet more stringent environmental standards. Closing their captive metal finishing shops and contracting metal finishing to job shops was one way of reducing the costs of complying with more stringent environmental standards.

(iv) Some companies may have been dissuaded from installing captive metal finishing operations by the potential environmental liabilities of such operations. Also to escape liability risks, companies may not report captive metal finishing operations.

The trend towards job shops has not occurred in all subsectors. Where metal finishing quality standards are still very high, such as jewellery, there is little movement to using job shops. In other subsectors, such as hardware and plumbing fixtures, cost savings from consolidation of metal finishing operations has provided less incentive to switch to job shops.

Firm Size

Exhibit 3.2 shows the breakdown of metal finishing companies by number of employees. Most metal finishing companies tend to be small to medium-sized. Nearly 30% of metal finishing firms employ between 20 and 49 workers. Firms with 10 to 19 employees account for a further 20% of the metal finishing industry. Only 20% of metal finishing companies employ more than 49 people.

Exhibit 3.2
Distribution of Firms by Number of Employees (SIC 3041)

Number of Employees	1975	1980	1985	1986	1987	1988	1989
1 - 4	13.4	19.6	17.3	20.8	18.1	18.7	15.9
5 - 9	15.6	17.9	20.5	17.3	17.7	18.1	15.6
10 - 19	24.0	29.6	22.6	22.2	21.5	17.8	19.7
20 - 49	33.0	20.8	24.4	23.9	24.0	26.9	27.6
50 - 99	10.6	11.3	10.2	11.3	12.2	13.3	15.8
100 - 199	3.4	0.4	2.8	3.2	5.2	3.9	4.1
200 - 499	-	0.4	1.8	1.4	1.0	1.0	1.0
500 - 999	-	-	0.4	-	0.3	0.3	0.3
1000 +	-	-	-	-	-	-	-

Columns may not add to 100 due to rounding.

Source: Statistics Canada (various years) *Manufacturing Industries of Canada: National and Provincial Areas* Cat. No. 31-203.

Exhibit 3.3 includes only those companies that are classified in <SIC 3041 - Custom Coating of Metal Products>. These companies are most likely to be job shops. Therefore, captive shops are not reflected in the above figures.

On average, captive shops tend to be smaller than job shops. For example, in 1983/1984, job shops employed on average 27.5 workers, whereas captive shops employed on average 12.5 workers (Environment Canada, 1987).

The questionnaire responses obtained for this study indicate that the average number of employees in job shops has increased to 37. Average employment in captive shops also appears to have increased. This is likely due to the fact that larger captive shops can compete against job shops better than smaller captive shops can compete against job shops.

Employment

Total Employees

It is estimated that metal finishing shops employ a total of about 8,000 workers. This estimate is derived as follows:

- Environment Canada (1987) found that in 1983 approximately 9,500 people were employed in 514 metal finishing shops (both captive and job);
- since Environment Canada (1987) estimated that there were 644 metal finishing shops in 1983, total 1983 employment was pro-rated to 11,900;
- approximately 20% of the firms included in Environment Canada (1987) are not included in the MFI under the definition used in this study;
- employment from 1983 to 1988 is assumed to have grown at an annual rate of 5%; and
- since 1988, employment is assumed to have fallen 33% in proportion to the decline in sales of metal finishing supplies (as reported by the CMFSA -- see below).[2]

The metal finishing industry accounts for about 0.5% of employment in Canadian manufacturing industries.[3]

2 Employment = 9,500 x (644/514) x (1 - 0.20) x $(1.05)^5$ x (1 - 0.33).

3 Total employment in Canadian manufacturing industries is taken from Statistics Canada (1994) *Canadian Economic Observer* Catalogue No. 11-010, March.

Employees by Gender

The breakdown of metal finishing workers by gender is shown in Exhibit 3.3. Although this breakdown covers only those firms classified in <SIC 3041 - Custom Coating of Metal Products>, the gender breakdown trends are probably very similar to those of all metal finishing firms.

Exhibit 3.3
Gender Breakdown of Employment in the Metal Finishing Industry (SIC 3041)

	1975	1980	1985	1986	1987	1988	1989	1991
Ratio of Female Employees to Total Employees (%)								
Production	16.9	17.9	19.9	16.6	na	21.2	19.9	16.8
Administration	31.8	35.5	32.7	33.6	na	39.6	38.8	na
Total	18.9	20.4	21.3	18.3	na	22.3	21.0	na

Sources: Statistics Canada (various years) *Manufacturing Industries of Canada: National and Provincial Areas* Cat. No. 31-203. Unpublished data for 1991 provided by Statistics Canada.

About 21% of employees in the metal finishing industry are women. Nearly 40% of administrative workers are women. These ratios have been fairly constant since 1975.

Wages and Salaries

Exhibit 3.4 present average weekly earnings for <SIC 304 - stamped, pressed and coated metals industry>, of which metal finishing is one part. These are believed to be representative of earnings in the metal finishing industry.

Exhibit 3.4
Average Weekly Earnings in the Metal Finishing Industry (SIC 3041)
(Current Dollars)

	1975	1980	1985	1988	1989	1990	1991	1992[2]	1993[3]
All Employees									
Incl. Overtime	221.2	348.5	483.8	531.1	546.6	579.6	575.1	632.9	588.4
Excl. Overtime	n.a.	n.a.	457.5	501.2	514.8	549.9	550.5	598.5	559.1
Salaried Employees (incl. overtime)	260.7	405.2	555.5	625.6	671.0	677.7	694.4	772.4	762.8
Employees Paid by the Hour (incl. overtime)	208.5	330.1	458.9	488.9	496.5	532.2	521.3	577.6	533.9

Notes:
1. Weekly earnings for July of each year.
2. Beginning in 1992, data are based on 1980 SICs. Data for other years are based on 1970 SICs.
3. Preliminary data.

Source: Statistics Canada (various years) *Employment, Earnings and Hours* Cat. No. 72-002.

Between 1985 and 1989, average weekly earnings by all metal finishing workers increased by about 3% per year. After an increase of 6% in 1989-1990, average weekly earnings have declined since then. Employees paid by the hour have borne most of the decline. Caution should be exercised in interpreting the figures since data for 1992 and 1993 are based on a more recent version of the Standard Industrial Classification system than previous years.

Job Classification

A typical metal finishing operation involves the tasks described below. In smaller shops, an individual employee may take on two or more roles. Employees of larger shops are usually more specialized.

- management;
- administrative/clerical support;
- placement (racking) of products to be plated;
- monitoring and dipping of products (hoist operators, monitors of computerized systems);
- lab operation (test baths and maintain chemical balance); and
- quality control (measure effluent concentrations).

Education and Training

The majority of training that Canadian metal finishing employees receive is on-the-job training although some metal finishers complete a course on metal finishing and receive a Certification of Electroplating Finishing. Forrestal (1987) found that the average education of equipment operators in the Canadian metal finishing industry is at a grade 10 to grade 12 level.

On-the-job training is required for supervisors and operators in addition to any formal education or certificates that they may have. Supervisors often require about one year's worth of on-site experience and operators are typically trained for 3 to 6 months. Further training may be conducted by equipment installers when new machinery is acquired. Some companies hire consultants to conduct on-site training programs with their employees.

The largest formal training program is the American Electroplaters and Surface Finishers Society (AESF) metal finishing training courses. This program consists of either a 4 day advanced course or a 2 day introductory course; both advanced and introductory courses are also offered through correspondence. The courses cover a number of topics related to metal finishing such as: chemistry, hard chrome plating, electroplating, nickel plating, decorative chromium plating, and gold plating. An additional 4 or 2 day course is offered in plating of electronic components. The course is available 6 or 7 times per year in different cities throughout the U.S. and also by correspondence via the headquarters in Orlando, Florida.

The AESF will also train workers on-site and customize their program to meet the requirements of any individual companies who wish to have their employees take the AESF course at their plant. An optional Certified Electroplater Finisher (CEF) exam is offered at the end of each course. Typically half the students taking the course obtain the CEF certificate. The AESF indicated that, on average, 350 to 400 people take the course each year, of which up to 30% are Canadians. The AESF estimates that 20% of all employees involved in metal finishing have completed one of their courses.

In Canada, the AESF course was taught at a secondary school in Toronto for over 40 years. In 1990, the program was terminated because the minimum number of students was raised from 15 to 18 and there were insufficient students to meet the new requirement. While the course was taught, there were an average of 15 graduates per year.

Several years ago, the Ontario government proposed requirements that all operators of wastewater treatment facilities must take a general course. A multi-stakeholder committee formed and eventually recommended that the government certify operators after passing courses specific to different types of wastewater treatment facilities. The Ontario government is currently considering this proposal.

Barriers to Entry

There are now five barriers that most strongly affect the entry of firms in the metal finishing industry:

- start-up costs;
- ability to raise investment capital;
- meeting quality standards and obtaining certification;
- obtaining permits from environmental authorities; and
- future risks of being held liable for site contamination.

New metal finishing firms are typically established by former employees of other metal finishing firms. New firms are usually very small and target niche markets. Start-up costs vary depending on the size of the operation, the quality requirements of the subsectors it will serve, and the type of shop. Very small job shops who are not serving subsectors that require high quality finishes have relatively low costs. Larger job shops, captive shops or shops that produce high quality finishes face considerably higher start-up costs since they require additional space, labour and/or more expensive equipment.

Metal finishing firms face substantial barriers to financing the costs of start-up or expansion.[4] Four major factors are causing financial institutions to become increasingly reluctant to extend loans to metal finishing firms.

(i) The recent recession has reduced revenues earned by the industry as a whole. Industry consensus indicates that metal finishing firms have been closing at the rate of about 1 per month for the last several years. This rate appears to be continuing.

(ii) The costs of complying with increasingly stringent environmental regulations are reducing the portion of revenues metal finishers can devote to loan repayment.[5]

(iii) Land and buildings are not attractive as collateral due to the associated risk of environmental liabilities. Financial institutions are extremely reluctant to accept land and buildings as collateral since, in the event of foreclosure, financial institutions could be held liable for high costs to remediate contaminated sites.[6]

(iv) Currently, there is a large supply of used equipment. Resale values are generally low, currently about 15% of original costs. Therefore, metal finishing equipment is not attractive as collateral.

These difficulties imply that entry into the metal finishing industry is largely restricted to individuals or firms that can self-finance the new operations or have personal assets with which to underwrite loans.

Prospective job shops that wish to serve the automotive or aerospace industry face an additional entry barrier associated with acquiring certification to meet the higher quality standards required. For many metal finishers meeting quality standards is crucial; 41% of respondents to our questionnaire said they considered the ability to meet quality control requirements very important to the competitiveness and financial stability of their firms.

Another potential barrier to entry is the permits required for air emissions and effluent discharges. Obtaining these permits may increase the costs of entry into the metal finishing industry. In most cases to receive a permit the firm must develop waste treatment procedures and discuss them with the permitting authority. Environmental regulations in general were considered to be a "most important" factor influencing the competitiveness and financial stability of 33% of firms responding to our questionnaire.

4 According to the survey conducted for this study, difficulty in raising investment capital for production was considered most important by 36% of firms. Difficulty in obtaining investment for pollution control equipment was ranked most important by 31% of responding firms.

5 Bankers call such risk "environmental credit risk" (Hanley, 1992).

6 Bankers call such risk "environmental liability risk" (Hanley, 1992).

Finally, contaminated site liability provisions are raising the risks associated with metal finishing operations. Building owners can be reluctant to let space for metal finishing operations. Metal finishers are discouraged from purchasing their own land and buildings by the risk of being held liable for site remediation costs in the future.

Barriers to Exit

Barriers to exit are factors that prevent or discourage the shut down, sale or transfer of a plant.

The major barrier to exit is environmental legislation and regulations stipulating site clean-up. Before agreeing to a buy-out, prospective buyers and financiers generally demand that an environmental audit be conducted of metal finishing sites. If a site is found to be contaminated, it is nearly impossible to sell it prior to remediation. Anecdotal evidence suggests that some contaminated sites have been abandoned.

Note that contaminated site liability provisions vary amongst provinces.[7] In some provinces, such as British Columbia and Manitoba, new legislation has been implemented. In other provinces, older provisions continue to hold. Although the Canadian Council of Ministers of the Environment has developed national guidelines for contaminated site liability policies, such policies continue to evolve. Confusion remains among some lenders and other private sector stakeholders regarding liability risks. This confusion in itself, regardless of the *actual* liability risks, tends to act as a barrier to exit.

A second barrier to exit is the currently low prices for used equipment. Low prices for used equipment decrease the economic attractiveness of closing metal finishing shops.

Technological Change

Major technological changes are described below. (See Section 5 for a detailed discussion of process trends.)

- Although little change in basic chemistry of processes and equipment has occurred in the last 10 years, refinements are on-going.

- The most significant change over the past twenty years has been the introduction of waste treatment equipment and procedures. In the past ten years, there have been few major changes made to waste treatment technologies. Most of the equipment does not change significantly. For example, tanks can be used that are over 20 years old.

  There has, however, been an increase in the use of polishing filters on final effluent from waste treatment plants. They are usually sand filters and can be back-washed. More sophisticated automatically reciprocating filters are available, but their use is limited by

7 See, for example, B.C. Environment (1991) and Manitoba Environment (1994).

high capital costs. Automatic sensing devices have been added by some finishers to detect when effluent concentrations are out of compliance with effluent limits. When such sensing devices detect violations, effluent are diverted to a holding tank and/or the water supply is shut off. Lack of sufficient training of waste treatment operators remains a problem.

- Over the past decade, there has also been an increased use of computers, meters and automation. Computer usage is widespread among medium and large firms but is not prevalent among small firms (fewer than 20 employees). Firms which are concerned about meeting quality standards use computerized systems to increase control and accuracy of solution mixtures. Computers monitor inventories and tank contents and automatically add chemicals to ensure the plating bath has the correct concentrations. Some very large, usually captive, firms have established computer systems to monitor every aspect of the process line from mixing chemicals to pump pressures and waste treatment efficiency. However, in most firms the use of computer technology is limited to programmable hoists for moving workpieces, monitoring plating bath solutions and administration.

Quality Requirements

The metal finishing industry has no industry-wide certification requirements. However, within some subsectors such as automotive parts, aerospace, military and printed circuit boards there are specific standards set for metal finishing operations. Job shops that are serving these subsectors must meet high quality standards to obtain and maintain contracts.

Within the automotive parts subsector, there are several quality specifications that must be met by parts suppliers. All of the North American automobile manufacturers use the Automobile Part Approval Process which requires that all parts are tested to meet all specifications; the parts suppliers must provide evidence from accredited laboratories. With respect to metal finishing these specifications include corrosion protection, adhesion, plating thickness and colour. For some specifications the automobile manufacturers have conducted tests of subcontractor facilities to produce a list of approved companies that parts suppliers must use. In most cases however, the metal finisher is contracted by the part supplier who develops their own system of ensuring and testing the quality of metal finishing necessary to meet the manufacturer's specifications. Therefore, the certification process within the automotive subsector is largely informal. However, companies are tested by the parts suppliers or the automobile manufacturers themselves. Companies which have met quality specifications and requirements in the past have a competitive advantage for future jobs.

In the future, ISO 9000 standards will likely become more important to the metal finishing industry in North America. ISO 9000 is an international framework of procedural standards that can be applied to almost any manufacturing or service industry. To be registered as ISO 9000 compliant, an ISO 9000 auditor must visit the firm and examine its quality assurance procedures. The major requirement for compliance is having a systematic, documented procedure in place for any operation or process (from manufacturing to contracting of suppliers) and a record keeping system which tracks any decision or problem-solving that occurred for that procedure. ISO 9000 standards for environmental protection are currently being developed and are expected to be in place in 2 years, by 1995. Currently, 22 companies of the 541 companies identified in CH2M Hill (1994) are registered as ISO 9000 compliant.

Relationship with Government

The federal and provincial governments have sponsored many studies of the metal finishing industry as part of environmental protection initiatives. Examples of these studies include CH2M Hill (1994), Monenco (1992), Proctor & Redfern (1991) and a current project of the Wastewater Technology Centre in Burlington, Ontario. This last study, funded by Environment Canada and the Ontario Ministry of the Environment and Energy, has two objectives:

(i) to identify the nature and size of the metal finishing industry, quantify toxics use and develop and test comprehensive audit and pollution prevention protocols; and

(ii) to evaluate, develop (as required) and demonstrate innovative, technically feasible and cost effective options for minimizing toxic discharges from metal finishing operations with particular emphasis on source reduction, instream recycling and recovery technologies.

Industry representatives are participating on the Steering Committee, in the testing of protocols and in providing information.

The economic performance or structure of the industry have not been studied in detail. For example, socio-economic statistics on the industry were not found in any government organization with the exception of Statistics Canada.

Many governments have sponsored incentive programs that may have benefitted some metal finishers. For example, the federal government's DRECT has paid for part of the cost of demonstration projects, including:

- an electrochemical reactor for recovering cadmium, copper and zinc from effluent;
- a system to recover and re-use chrome from effluent;
- purification and recovery of chromic acid in a chrome plating operation;
- a "Chemelec" process to recover toxic metals from dilute electroplating rinse waters;
- a recovery system for chrome VI in metal finishing wastewater;

- a precipitation flotation process to produce marketable concentrates of metal from metal finishing sludges; and
- a waste treatment and copper recovery system for wastewaters from a printed circuit board manufacturer.

The federal government also offers an accelerated capital cost allowance for equipment acquired primarily for the abatement of water or air pollution. Costs of purchasing eligible equipment are deductible at rates of 25%, 50% and 25% over three taxation years, provided the facility has been in place since 1974. This preferential tax treatment is due to be phased out at the end of 1998.[8]

Finally, some metal finishers have benefited from government-supported business financing initiatives, including the Federal Business Development Bank and the Ontario Development Corporation. However, industry representatives assert that such government affiliated financial institutions are becoming reluctant to extend credit to metal finishing firms for the same reasons that private financial institutions cite (see under "Barriers to Entry").

Metal Finishing Suppliers[9]

Sales

Metal finishing supplies can be broken down into four areas:

- equipment for both production and pollution control;
- commodity chemicals, such as sodium hydroxide;
- specialty (proprietary) chemicals; and
- metals, such as nickel and zinc.

For the past five years, total demand for metal finishing supplies has dropped considerably. Some suppliers estimate that demand has fallen off by 30-50% over the last five years.

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8 See Hon. Paul Martin *Tax Measures: Supplementary Information* Tabled in the House of Commons, February 22, 1994.

9 Information for this section was obtained from interviews with 12 metal finishing suppliers, the Canadian Metal Finishing Suppliers Association, the Canadian Mining Association, Natural Resources Canada and the U.S. Bureau of Mines.

Exhibit 3.5 presents an index of sales by 6 metal finishing suppliers in Canada. According to the Canadian Metal Finishing Suppliers Association, these firms account for 60-70% of the Canadian market for metal finishing supplies. The index shows 1993 sales being 33% lower than sales in 1988.

Exhibit 3.5
Index of Sales of Canadian Metal Finishing Suppliers

Year	Sales Index Value[1]	Annual Percent Change
1988	100	na
1989	105	5.0
1990	88	-16.2
1991	68	-22.7
1992	63.5	-0.7
1993[2]	66	2.5

Notes: 1. Based on quarterly data from 6 firms representing approximately 60-70% of total sales of metal finishing supplies.
2. Includes first two quarters only.

Source: Canadian Metal Finishing Suppliers Association.

Metal finishing suppliers cite several reasons for the decline in demand for their products. First, the recession has had a severe impact on major customers of metal finishing companies, including the automotive, hardware, plumbing and furniture industries. As these manufacturing industries contracted, their demand for metal finishing services also declined and therefore suppliers faced reduced demand for their products.

Suppliers also point to the Canada-U.S. Free Trade Agreement as a second factor that adversely affected the metal finishing suppliers. Two of the suppliers interviewed indicated that the free trade agreement was responsible for a loss of 30% of their business. These suppliers claimed that the agreement, in conjunction with the recession, led a number of U.S. subsidiaries, clients of the metal finishing companies and/or captive metal finishing shops, to close their Canadian operations.

Three suppliers indicated that environmental regulations have increased the production costs of metal finishers such that metal finishers have reduced orders of supplies or stopped operating entirely.

Three suppliers experienced decreased demand for their products as a result of increased use of non-metal coatings. The most commonly cited example was the automotive industry's use of plastic bumpers or paint coatings. However, increased demand from the printed circuit board and electronics industries have allowed some suppliers and finishers to generate revenue from these markets.

Market Structure

There are probably fewer than 25 companies supplying the Canadian metal finishing industry. Suppliers range from very small shops with fewer than 5 employees to large multinational mining companies that sell metals to the metal finishing and other industries. All the companies interviewed had Canadian headquarters in Ontario. The mining companies have offices throughout Canada.

There has been a significant consolidation of the suppliers in the past five years to benefit from economies of scale as the recession reduced demand for metal finishing and consequently for supplies. For example, two large multinational companies from the U.S. and Europe, ENTHONE-OMI and ATOTECH respectively, took over several of the small and medium-sized operations in Ontario. This consolidation has occurred as a result of decreases in demand and profitability discussed below.

Equipment and Chemical Suppliers

Smaller suppliers typically concentrate on market niches such as pollution control equipment, plating racks, or specialty chemicals. Larger suppliers provide a variety of chemicals and some small equipment.

We interviewed 4 firms who specialize in equipment for the metal finishing industry. Over 90% of their sales are equipment for metal finishing. These companies vary considerably in their annual sales depending on the type of equipment sold. Of the companies interviewed annual sales to the metal finishing industry ranged from $390,000 to $8 million. These firms sell a variety of metal finishing equipment including equipment for: plating; cleaning; mechanical finishing; polishing; buffing; and pollution control. Most of the companies dealing solely in equipment are Canadian-owned firms who buy or manufacture in Canada.

Commodity chemicals are sold by a large number of companies that serve many industries. Firms that concentrate on specialty chemicals tend to be subsidiaries of U.S. or European firms. These subsidiaries typically import 20% or more of their goods from their parent companies. There are a number of smaller firms that specialize in proprietary chemicals and a few larger firms who sell both specialty and commodity chemicals.

Metals[10]

Metals are sold by mining firms either directly to metal finishers or indirectly through other distribution channels. For example, nickel and zinc producers sell their metals:

- directly to the metal finishers (minimum order quantities generally apply);
- to recasters who produce anodes for sale to metal finishers; or
- to distributors.

The majority of sales by mining companies to the metal finishing industry are nickel and zinc anodes. The metal finishing industry accounts for approximately 9% of nickel sales worldwide and about 20% of nickel sales in Canada. Zinc sales to the metal finishing industry are more difficult to determine since sales figures include zinc sold to steel mills for purposes other than metal finishing. Including steel mill consumption, sales of zinc to metal finishers accounts for about 57% of total zinc consumption in Canada. Interviewed companies sold over $35 million worth of nickel and zinc to the Canadian metal finishing industry in 1992.

Chromium is not produced in Canada. Instead, chromium oxide (mostly CrO_3) is imported by chemical suppliers who sell it to metal finishers as is or use it to produce proprietary mixtures of chromium compounds consumed in hexavalent chromium conversion coating. Chromium product sales to the metal finishing industry are thought to be slightly under 30% of total chromium oxide imports, but this figure is based on U.S. trends.

Exhibit 3.6 summarizes the major suppliers, shipments to the metal finishing industry and pricing trends for the six substances of interest to this study.

Note that several metal mining companies will buy back nickel recovered from metal finishing wastes. In effect, a closed loop is established between the suppliers and metal finishers. About 12 metal finishers are currently selling recovered metals to metal suppliers.

Metal recovery and re-sale has three main advantages to the metal supplier:

- it can be profitable;
- it locks the metal finisher into buying their nickel; and
- the product contains only traces of sulphur.

10 Information in this section is derived from interviews with representatives of four Canadian metal producers, the Mining Association of Canada, Natural Resources Canada and the U.S. Bureau of Mines.

Exhibit 3.6
Indirect Suppliers of Metals to Canada's Metal Finishing Industry

Substance	Major Suppliers	Shipments to the Metal Finishing Industry	Pricing Trends
Nickel	- Inco currently accounts for 70-80% of sales to the Canadian MFI - Falconbridge accounts for 20-30% of sales - other suppliers account for smaller market shares - shares are sensitive to the terms set by the suppliers	- nickel anodes sold to MFI directly and through distributors - MFI accounts for about 20% of Canadian nickel consumption - nickel consumption by MFI expected to remain strong or increase	- prices based on London Metal Exchange - significant fluctuation in prices - prices in past 3 years ranged from $10/lb to $2/lb - prices expected to remain volatile
Zinc	- Hudson Bay Mining & Smelting (HBMS) - Noranda (does sales for its own mines and Falconbridge) - Cominco	- sold directly to MFI, through distributors or to remelters for manufacturing specialty products - steel mills, including steel strip mills, consume over 45% of zinc consumed in Canada - other hot dip galvanizing and electroplating account for an additional 11% of consumption - zinc consumption by MFI expected to remain strong or increase	- prices based on London Metal Exchange - currently low due to over-production by world producers
Chromium	- most imported from the U.S. as CrO_3 (original ore can come from abroad) - CrO_3 imported by many firms	- in U.S., the MFI consumes 27% of chromium oxide sold - consumption expected to follow production levels of MFI customers	- CrO_3 is a commodity chemical - conversion costs more significant than costs of ore
Copper	- Noranda (markets their own and Falconbridge copper) - Cominco	- MFI accounts for under 1% of total copper consumption	- prices based on London Metal Exchange

Continued on Next Page

Substance	Major Suppliers	Shipments to the Metal Finishing Industry	Pricing Trends
Lead	- Cominco - HBMS - Noranda	- MFI accounts for under 1% of total lead consumption - lead use by MFI expected to remain stagnant or decline	- prices based on London Metal Exchange - supply has been short in some regions, but stocks are climbing
Cadmium	- Noranda (markets their own and Falconbridge cadmium) - Cominco - HBMS	- MFI in Canada uses very little cadmium - consumption expected to remain at current (very low) levels	- not traded on London Metal Exchange - currently at five year low - modest increase in prices expected in the next few years
Sources:	Interviews with representatives of Canadian mining companies, the Mining Association of Canada and the U.S. Bureau of Mining.		

For the metal finisher, the advantages are:

- a substantial saving on the cost of disposal to a hazardous waste facility (if volumes are high enough, the metal finisher can dispose of the material at no net cost); and
- the material is being shipped to the smelter as a raw material and does not have to be classified as hazardous waste.

Metal suppliers place various restrictions (dryness, metal content, etc.) on the recovered metals they will accept.

Competition Among Suppliers

Equipment suppliers face moderate to intense competition for small equipment such as polishing equipment and buffers. There are usually three to five competitors for a given contract. However, larger contracts for plating equipment or pollution control equipment can usually be completed by only one or two Canadian suppliers. Although competition is most often restricted to firms in Canada, sometimes equipment suppliers located outside Canada will compete for Canadian contracts. Half of the equipment suppliers interviewed indicated that they faced direct U.S. competition in Canadian markets. Canadian suppliers generally serve only the domestic market, particularly if the suppliers are subsidiaries of U.S. companies. However, one equipment supplier was considering competing in the U.S.

Specialty and commodity chemical suppliers face more intense competition, although there is less direct competition from U.S. or other foreign firms. Companies would typically face 10 to 12 competitors for Canadian chemical supply contracts of which 4 or 5 would be large or medium-sized companies.

It is difficult to generalize about the competitive environment for mining companies in the metal finishing supply market since there is a mixture of direct sales and sales through distributors. Metal suppliers may compete with only one or two other large firms but in some markets (such as nickel) face very elastic demand curves where small price differences (cents per pound) can cause clients to change suppliers.

Profitability

Both equipment and chemical suppliers agree that their prices have remained stable or decreased over the past five years as demand fell. Chemical companies in particular have held prices constant even if costs increased in an attempt to maintain their customer base. Almost all equipment and chemical suppliers feel it is virtually impossible to pass on costs to metal finishers. Instead, firms buying metal finishing services, particularly large automotive companies, have been able to secure constant prices or price reductions from metal finishers. To meet such demands, metal finishers require price stability or reductions from suppliers.

There is general consensus among chemical and equipment suppliers that absorbing costs for the past few years has reduced their profit margins significantly. Sales of metal finishing supplies account for at least 75% of the revenues of most of these firms.

Canadian prices for metals are generally based on prices set at the London Metal Exchange. However, the metals sold to metal finishers are usually refined and, therefore, command a premium over the prices at the Exchange. Depending on the nature of the refining, these premiums can be substantial.

Metal finishing generally accounts for only a small percentage of the total demand for metals. Therefore, fluctuations in metal prices are usually caused by market forces unrelated to the metal finishing industry. For example, the market for stainless steel tends to drive prices for nickel.

Profit margins vary depending on the type of supplies and the degree of competition for the products. Companies were reluctant to comment on profit levels. The comments provided, however, included the following:

- one supplier indicated that specialty chemicals can have gross profit margins (prior to taxes and selling and administrative costs) of up to 35%, while commodity chemical margins are lower at 15-18% and anode supplies have the lowest margins at about 7%;
- a second supplier indicated that gross profit margins on commodity chemical are generally 10-15%; and
- a third supplier estimated average gross profit margins on specialty chemicals to be about 50% with a net return on sales between 8% and 10%.

4.0 Markets for Metal Finishing Services

Canadian metal finishers provide metal finishing services for a wide range of industries. Exhibit 4.1 disaggregates the total market for metal finishing services in Canada. Note that figures represent the *direct* sales to each market. For example, steel strip used for auto parts is included in the steel strip market, not the auto parts market.

Exhibit 4.1
Estimated Breakdown of Metal Finishing Sales

Market	% of Metal Finishing Sales
Automotive Parts	25
Steel Strip Mills	11
Wire Goods	10
Electrical Appliances	9
Hardware	8
Furniture	5
Engine and Worn Parts	5
Electrical Equipment	4
Pole Hardware and Heavy Steel	4
Electronics	3
Printed Circuit Boards	3
Plumbing Fixtures	3
Military	3
Aerospace	3
Construction	3
Hollowware and Flatware	0.5
Jewellery	0.5

Source: Adjustments made by Ken Coulter to Table 2, Environment Canada (1987).

4.0 Markets for Metal Finishing Services

On average, job shops serve 3 industries, though some may serve 7 or more. However, job shops that serve industries with high quality standards tend to specialize in those industries. This is particularly true for sectors that require quality certification, such as the auto parts, aerospace and military industries.

Captive shops, by definition, serve only the industry of their parent company. Captive shops tend to dominate in steel strip, plumbing fixtures ("above sink"), electrical appliances, printed circuit boards, aerospace and hollowware and flatware.

The remainder of this section provides detailed descriptions on metal finishing in each of the above industries. In particular, the section:

- describes the market, the metal finishers that serve the market, and the type of metal finishing processes the market relies upon;
- assesses trends in each market, including trends in demand for the finished products and trends in demand for metal finishing;
- presents the trade data that are available for each market; and
- the degree of competitiveness in the market between metal finishers.

Note that the data presented in this chapter -- for example, sales, exports and imports -- are aggregate figures for the industries served by the metal finishing industry. The data do *not* apply to the metal finishing inputs purchased by the client industries nor the portion of the client industries that purchases metal finishing services. Such data are not available.

4.1 Automotive Parts

The automotive parts industry produces a variety of original parts for use in the assembly of new vehicles and aftermarket parts for vehicle repair or alteration. Automotive parts are a significant portion of Canadian manufacturing output. In 1990, the original and aftermarket auto parts industry accounted for approximately $13 billion in shipments and employed over 85,000 people.[11] Original parts make up about 85% of total automotive parts output.

11 ISTC (1991) *Automotive Original Equipment Parts* Ottawa: Industry, Science and Technology Canada.
ISTC (1991) *Automotive Aftermarket Parts* Ottawa: Industry, Science and Technology Canada.

4.0 Markets for Metal Finishing Services

Approximately one half of original parts are produced by captive operations in which vehicle assemblers also produce the automotive components. Independent, foreign-owned parts producers constitute about a third of original parts. Several hundred, mainly small and medium-sized Canadian firms make up the remaining parts manufacturing. Investment by Japanese companies in the Canadian parts sector has been quite low compared to their investment in the U.S. industry. European companies have made substantial investments in production facilities in Canada.

The automotive parts industry has played an important role in the metal finishing industry for many years and, despite recent design trends (discussed below), continues to do so. Automotive parts plating firms use chromium, nickel, zinc and copper in several metal finishing processes, including electroplating, acid pickling and chemical conversion coating.

This market accounts for about 25% of metal finishing sales in Canada. Automotive parts plating firms are typically Canadian-owned job shops which are located in Ontario or Quebec. However, some parts firms, mainly in the aftermarket parts industry, are located in British Columbia and Alberta. Auto part job shops responding to our questionnaire have sales ranging from $500,000 to over $5 million and employ an average of 80 workers, of which 70 are full time production workers. The financial performance of these shops is assessed in the next chapter of the report.

Trends in Demand

There are a number of trends within the automotive parts industry that have had a large impact on metal finishing companies.

- Decorative electroplating for automobiles has decreased significantly in the past five to ten years as designers prefer other materials for parts that were traditionally electroplated with metals such as bumpers, grills, and door handles. In particular, the trend to plastic or painted bumper coatings has been the most damaging to decorative plating shops. Some recent evidence suggests increased truck and recreational vehicle sales have recovered some of the lost metal finishing business in decorative plating because these types of vehicles use more chrome.
- There is some increase in nickel-chrome plating on plastics, aluminum and zinc.
- Weight reduction requirements for cars are expected to increase demand for nickel-chrome plated aluminum wheels.
- The bumper recycling market was once a major component of the metal finishing industry, with a separate industry association (BRANA) and companies throughout Canada. However, this market has been in steady decline since the 1970s and will likely remain in decline. The cost of refinishing damaged bumpers relative to the costs of bumper replacements continues to increase. Indeed, one bumper recycling company commented that it was less expensive to buy a new bumper now than to have one

recycled. The trend towards alternative bumper coatings and the scrapping of older vehicles are slowly decreasing the number of chrome bumpers in existence.

- There is increased demand for functional finishes on locks, hinges, fasteners and fittings to reduce corrosion and extend the life of vehicle. The use of zinc plating, phosphate coatings, and conversion coatings used for functional finishes doubled between 1973 and 1987 (Environment Canada, 1987). Similarly, there is strong growth in the use of electrogalvanized steel which is then painted. However, most electrogalvanized steel is currently produced outside of Canada.

- The use of printed circuit boards in automobiles has grown significantly and it is estimated that the auto industry accounts for 25% of printed circuit board sales (CH2M Hill, 1994).

International Trade

There is a great deal of trade in the auto parts market as a result of the automobile manufacturers organizing their North American market as a single entity through the Canada-U.S. Auto Pact. Demand for original auto parts fluctuates with the demand for vehicles assembled in Canada and parts are typically imported for use in vehicles assembled here. As a result there is usually a trade deficit for auto parts in Canada. Exhibit 4.2 shows auto parts trade for the period from 1985 to 1989.

Exhibit 4.2
Trade in Automotive Parts
(millions of Canadian $)

	1985	1986	1987	1988	1989
Original Automotive Parts					
Exports	10766	10866	10756	10864	10810
Exports as a % of Canadian Shipments	96.6	99.6	98.0	88.6	86.3
Imports	18466	19000	17952	20590	19183
Imports as a % of Canadian Market	98.0	99.7	98.8	93.7	91.8
Aftermarket Parts					
Exports	1052.7	1129.0	1205.3	1233.9	1224.9
Exports as a % of Canadian Shipments	59.0	56.2	59.4	54.1	55.8
Imports	790.4	686.6	827.8	997.8	901.0
Imports as a % of Canadian Market	52.0	43.9	50.1	48.8	48.2

Sources: ISTC (1991) *Original Automotive Parts* Ottawa: Industry, Science and Technology Canada; and ISTC (1991) *Automotive Aftermarket Parts* Ottawa: Industry, Science and Technology Canada.

The U.S. is by far Canada's largest trading partner in the automotive parts industry. The U.S. accounts for about 96% of Canadian exports of original parts and nearly all Canadian exports of aftermarket parts. Over the period 1985-1989, the U.S. was the origin of 89.5% of Canada's total auto parts imports, with the balance originating in Japan and Mexico. The North American Free Trade Agreement on the Canadian auto parts sector could have a significant, but as yet unknown, impact on trade in auto parts.

Competition in the Market

The recent recession had a severe impact on the auto industry and caused metal finishers to face significantly decreased demand. In some cases, auto makers demanded price reductions or price stability for several years from suppliers and finishers. Metal finishers serving this market indicate that the most important factors affecting their competitiveness are:

- labour costs;
- quality standards; and
- and a long term decline in demand for their services.

Competition among auto parts finishers tends to be on the basis of price but companies that attain high level quality certifications from the manufacturers have a competitive advantage over those with lower quality certifications or no certification at all. Most parts contracts are for one year or less with no volume specified. However, some companies are able to establish somewhat longer term contracts for original parts.

Where auto components (such as headrests) have some parts manufactured in Canada and some manufactured in the U.S., there is direct competition for metal finishing contracts between Canadian and American metal finishing operations. In addition to the competition from American firms, auto parts makers have faced increased foreign competition especially from Asia which has also affected metal finishers.

Responses to our questionnaire indicate that auto parts platers rely heavily on a few customers for the majority of their volume of work. Over half of the respondents plating auto parts indicated that their 3 largest customers account for more than 60% of sales. This implies auto parts finishers are quite dependent on repeat business and the balance of power often lies with their customers.

4.2 Steel Strip Mills

Steel strip mills make up a fairly large portion of the metal finishing industry. It is estimated that they account for 11% of sales in the metal finishing sector. Most of this finishing is performed by the steel strip mills in captive shops.

The majority of steel strip is used by the automotive industry, although some steel strip is used in military, aerospace and packaging (tin-plated cans) products. There are only a few steel strip mills in Canada. These firms are Canadian-owned and located in Ontario.

The most common metal finishing process used by steel strip mills is zinc galvanizing of steel panel. Cold rolled steel is plated with zinc (or tin) while it is still in strip form. The finish provides added corrosion protection and/or coats interior surfaces otherwise impossible to plate.

Trends in Demand

The most important factor affecting the demand for finished steel strip is the demand for automotive vehicles. Demand has fallen off in recent years but currently looks more promising as demand for cars and trucks grows. There has been a major increase in the amount of zinc and steel coated strip used as corrosion protection standards have risen in the past decade.

International Trade

Canada exports approximately $122 million worth of finished iron or steel strip, and imports nearly $200 million of similar products. Exhibit 4.3 disaggregates this trade by type of finished strip.

The U.S. is by far the largest trading partner, accounting for most imports and exports of these products. Other significant export destinations include Hong Kong, Taiwan and Mexico. The increases in imports have resulted from increased trade with the U.S. but there also seems to be a small shift from European imports to more imports from Japan and Korea.

Competition in the Market

Canadian steel strip mills face significant competition from U.S. and off-shore mills. The major factors affecting the competitiveness of steel strip mills are: trade policies; labour costs; and environmental regulations. The high costs associated with establishing steel strip operations likely prevents any new facilities from opening in Canada.

4.3 Wire Goods

Wire goods are estimated to account for about 10% of the metal finishing industry's business. Wire goods include: shopping carts and baskets, display racks, and shelving. Typically surfaces are electroplated with nickel-chrome and then plated with nickel, brass, zinc or bronze or conversion coating is applied.

Plating of wire goods is usually performed by local job shops that serve many other industries. Most plating of wire goods is done in Ontario by small, Canadian-owned companies.

Trends in Demand

Demand in this sector is not expected to grow in the short-term. The recent high rate of retail closings has resulted in a surplus of used display racks and shelving. Since new grocery and retail stores are limited in number, demand for finished shopping carts and baskets is mainly driven by a low but constant need to refurbish or replace existing goods.

Exhibit 4.3
Trade in Plated or Coated Iron and Steel Products
(millions of Canadian $)

Flat Rolled Products of Iron/Non-Alloy Steel of width 600mm or more, clad, plated or coated	1988	1989	1990	1991	1992
EXPORTS					
Plated/Coated with Tin, thickness ≥0.5 mm	20.85	3.18	1.68	1.74	2.36
Plated/Coated with Tin, thickness <0.5 mm	54.79	72.87	65.10	54.58	68.75
Plated/Coated with Lead incl. terne-plate	0.10	0.00	0.00	0.14	0.85
Steel Electroplated/coated with Zinc, <3 mm (min. yield point 275) or ≥3 mm (myp 355)	10.23	4.45	0.45	1.16	0.96
Products Electroplated/Coated with Zinc	1.02	3.78	12.10	7.56	3.49
Products Plated/Coated with Chromium Oxides or Chromium and Chromium Oxides	8.41	21.32	20.65	31.35	41.49
Products Plated/Coated with Aluminum	0.00	0.39	1.24	1.01	1.33
Products Plated/Coated with Other Metals	4.34	22.89	6.04	3.33	3.41
Total Exports	99.74	128.88	107.26	100.87	122.64
IMPORTS					
Plated/Coated with Tin, thickness ≥0.5 mm	0.43	0.26	0.12	0.23	2.13
Plated/Coated with Tin, thickness <0.5 mm	4.12	4.36	7.32	19.39	34.92
Plated/Coated with Lead incl. terne-plate	11.38	10.42	12.39	9.99	10.27
Steel Electroplated/coated with Zinc, <3 mm (min. yield point 275) or ≥3 mm (myp 355)	4.42	1.31	6.24	6.25	7.83
Products Electroplated/Coated with Zinc	44.46	30.40	46.97	72.75	92.22
Products Plated/Coated with chromium oxides or chromium and chromium oxides	1.99	0.97	1.26	2.24	1.36
Products Plated/Coated with Aluminum	19.95	29.02	25.83	20.33	26.88
Products Plated/Coated with Nickel or Copper	15.58	7.73	12.17	14.12	18.18
Total Imports	102.33	84.47	112.30	145.30	193.79

Sources: Statistics Canada (various years) *Exports: Merchandise Trade* Cat. No.65-202; and Statistics Canada (various years) *Imports: Merchandise Trade* Cat. No. 65-203.

Zinc plating is displacing some of the demand for nickel-chrome plated wire goods due to price competitiveness. Powder paint coating is also slowly replacing nickel-chrome plating for display racks and shelving.

International Trade

Trade data for wire goods is presented in Exhibit 4.4. The data includes articles of iron or steel wire such as cages, refrigerator and stove racks, baskets, carriers and wire display racks and other wire items.

Exports of wire goods have declined sharply in the past few years. From 1989 to 1990 exports dropped by more than half and export levels have remained low since then. The 1992 figure shows some growth over 1991, but exports of $8.2 million is still only slightly more than half the 1988 level of $15.4 million. The decline in exports is likely due to declines in the U.S. market for wire goods, similar to the declines in the Canadian market described above.

Imports have grown somewhat in the past few years. However, since imports are only $20-25 million, these changes could be due to a very small number of sales contracts.

The majority of trade is with the United States. Over 90% of Canadian exports each year are destined for the U.S. Other significant destinations for exports include the United Kingdom, West Germany and Mexico. About 75-80% of Canadian imports originate in the U.S. Other importing countries are: Taiwan, the United Kingdom, Italy, Germany and South Korea.

Exhibit 4.4
Trade in Wire Goods
(Millions of Canadian $)

Articles of Wire (Iron or Steel)	1988	1989	1990	1991	1992
Exports to All Countries	15.4	14.6	7.5	6.7	8.2
Exports to the U.S.	14.5	13.2	7.0	6.4	7.9
Imports from All Countries	19.0	18.1	19.0	22.4	26.0
Imports from the U.S.	14.2	13.5	14.4	18.1	20.8

Sources: Statistics Canada (various years) *Exports: Merchandise Trade* Cat. No.65-202; and Statistics Canada (various years) *Imports: Merchandise Trade* Cat. No. 65-203.

Competition in the Market

Competition for wire goods jobs is based on price and is quite intense. In most cases, wire goods do not require high quality finishing. Since more metal finishers can meet these standards, competition for wire good jobs is intense. Competition is especially intense given the current depressed demand for metal finishing. When there is sufficient work elsewhere, metal finishers do not compete as readily for the wire goods jobs because such jobs are usually low price and low-volume and garner little customer loyalty. Wire goods metal finishing jobs rely largely on many small jobs in local markets. There is relatively little competition with foreign made products.

4.4 Electrical Appliances

Electrical appliances account for about 9% of total metal finishing sales. The largest appliance manufactures are foreign-owned and have captive metal finishing operations. However, a number of Canadian-owned firms are involved in forming, stamping and finishing input parts for electrical appliances. These parts manufacturers may have captive metal finishing shops or contract job shops to meet their metal finishing needs.

The major processes used in the metal finishing of electrical appliance components include plating, alkaline cleaning and acid pickling. The main substances of interest that are used are chromium, nickel and zinc.

Trends in Demand

There has been a trend away from use of plated steel components toward coloured plastics for small appliances such as kettles and toasters. Although plated plastics are replacing some metal parts on stoves and refrigerators, the demand for finished metal parts for larger appliances has been more stable.

Demand for major appliances is dependent on the replacement of existing appliances and growth in the housing industry. Since major appliances generally last 10 to 15 years, the replacement market is reasonably predictable. However, the new housing market is less stable and declined significantly during the recent recession.

Demand for small electrical appliances depends on more general economic conditions such as employment, and disposable income and to a lesser extent on the establishment of new households. As a result, demand for small appliances is more volatile and difficult to predict.[12] The Canadian market peaked at $1.1 billion in 1987. The recession reduced the Canadian market to $867 million in 1991.

12 Industry, Science and technology Canada (1993) *Small Portable Electrical Appliances* Ottawa: ISTC.

International Trade

As shown in Exhibit 4.5, trade in appliances is significant to Canadian manufacturers and metal finishers. The majority of trade occurs with the U.S. who accounted for 77% of exports and 67% of imports of major appliances in the years 1983 through 1991. For the same period, the U.S. made up 81% of exports and 55% of imports of small appliances.

Other trading partners include Hong Kong, Korea and Japan who have accounted for a small share of exports for both small and large appliances. Imports of large appliances from Asian countries have declined somewhat in favour of U.S. and European countries during the past four or five years. Imports of small appliances from the U.S. have declined but imports from Asian countries have increased by 10% in the past five years.

Exhibit 4.5
Trade in Electrical Appliances
(millions of Canadian $)

	1987	1988	1989	1990	1991
Major Appliances					
Exports	130.5	134.5	109.4	115.2	105.7
Exports as a % of Canadian Shipments	10.4	11.0	8.7	10.4	12.1
Imports	438.4	595.1	557.9	582.6	567.8
Imports as a % of Canadian Market	28.0	35.4	32.6	34.7	42.5
Small Appliances					
Exports	68	70	65	66	60
Exports as a % of Canadian Shipments	12.5	14.2	11.6	13.8	13.2
Imports	607	434	481	424	473
Imports as a % of Canadian Market	56.0	50.6	49.4	50.7	54.6

Source: ISTC (1991) *Major Appliances* Ottawa: Industry, Science and Technology Canada; and ISTC (1991) *Small, Portable Electrical Appliances* Ottawa: Industry Science and Technology Canada.

Competition in the Market

Finishers of electrical appliances tend to compete on the basis of price, although both service and quality are becoming more important. There is significant competition among job shops for small appliance jobs. Contracts with major appliance manufacturers tend to be long term. Competitiveness is affected by materials and labour costs, the ability to obtain investment capital for pollution control and production equipment, and environmental regulations. There have been problems for finishers as some American subsidiary appliance manufacturers moved back to the U.S. during the recession.

4.5 Hardware

Hardware includes items such as tools, locks, and fasteners used in homes and other buildings. These products account for an estimated 8% of the metal finishing industry.

Hardware metal finishing is most often done by U.S.-owned corporations with captive metal finishing shops. These hardware subsidiaries usually have sales of over $5 million annually. However, the nuts, bolts and screws segment of hardware manufacturing is an exception. These products tend to be plated in smaller, Canadian-owned job shops rather than in foreign-owned captive operations. Most hardware metal finishing operations are located in Ontario, Quebec and British Columbia.

Hardware finishing may involve a variety of processes including mechanical deburring or sandblasting, electroplating, electrocleaning, alkaline cleaning, acid bright dipping, stripping electrodeposits and chemical conversion coating. Chromium and nickel are the most common substances of interest that are used for hardware finishes.

Trends in Demand

This is a mature industry with no significant substitution of materials or technology changes expected. Demand for hardware, and consequently for metal finishing of hardware goods, is directly related to the construction/housing industry. The recent recession in construction and housing had negative impact on hardware metal finishers. Interviewed companies and questionnaire respondents in hardware metal finishing all indicate they expect no change in size of their markets in the next five years.

International Trade

Exhibit 4.6 shows hardware trade data for the years 1984 through 1988. The U.S. accounts for over 77% of exports and over 55% of imports. In recent years exports to the U.S. as a percentage of total exports has grown by almost 10%. Imports from the U.S. have declined as portion of total imports as imports from Europe and Asia have increased.

Exhibit 4.6
Trade in Hardware Goods
(millions of Canadian $)

	1984	1985	1986	1987	1988
Exports	146.2	160.0	168.9	200.1	312.0
Exports as a % of Canadian Shipments	36.9	36.2	32.4	33.9	48.9
Imports	447.3	500.7	551.8	615.5	582.3
Imports as a % of Canadian Market	64.1	64.0	61.0	61.2	63.8

Source: ISTC (1991) *Hardware* Ottawa: Industry, Science and Technology Canada.

Competition in the Market

The hardware industry faces significant and increasing competition from foreign competitors located in Taiwan, Thailand and Mexico. Competition is largely on the basis of price. Canadian firms face higher material and labour costs than their off-shore competitors and are attempting to compete by:

- adjusting the design, quality and selection of their product lines; and
- improving customer service.

4.6 Furniture

Furniture is presently a small market for metal finishers, accounting for about 5% of total industry sales. Much of this furniture is for offices and kitchens. Metal finishing is often contracted out by furniture producers to local Canadian-owned job shops who rarely specialize in furniture plating but serve a variety of industries. The majority of metal furniture manufacturing is located in Ontario and Quebec.

The most common metal finishing process used for furniture is electroplating. Steel furniture is usually plated with nickel and chrome, but nickel and brass, or brass only may also be used.

Trends in Demand

Trends in the demand for metal finishing services from the furniture market are highly dependent on designer preferences and may vary substantially from region to region. This makes it difficult to predict trends in demand. However, three factors limit the likelihood of growth in demand from the furniture industry for metal finishing:

- increased use of second hand office furniture;
- trend from nickel-chrome plating to painted finishes; and
- trend from brass plating to electro-lacquer finishes.

Exports, mainly to the U.S., have been consistent but are not expected to grow in the long term unless fashions change in favour of plated furniture.

International Trade

Exhibit 4.7 presents trade data for office furniture for the years 1985 through 1989. Exports of office furniture are significant in most years, accounting for over 30% of shipments. Imports remain a small portion of the Canadian market, although the share of imports has grown in recent years.

The majority, over 90% of exports are destined for the U.S., although there has been a slight increase in exports going to Europe (from 0% to 3% of exports) (ISTC, 1991). Imports are largely from the U.S., on average 74% originate in America. There has been an increase in imports from Europe and Asia in the past 4 or 5 years. European imports have increased from 15 to 24% of total imports and Asian imports have grown from 2% of total imports to 7%.

Exhibit 4.7
Trade in Office Furniture
(millions of Canadian $)

	1985	1986	1987	1988	1989
Exports	300.4	360.6	356.9	347.8	319.4
Exports as a % of Canadian Shipments	35.5	35.6	32.2	31.3	27.1
Imports	37.4	38.6	46.9	86.0	134.0
Imports as a % of Canadian Market	6.4	5.6	5.9	10.1	13.5

Source: ISTC (1991) *Office Furniture* Ottawa: Industry, Science and Technology Canada.

Competition in the Market

Since furniture items require lower quality finishes than many other goods, there is often intense competition for furniture plating jobs. The high degree of competition for jobs that require lower quality finishes keeps rates of return on these jobs very low. Intense competition for this segment of the market for metal finishing services, the recent recession and the growing portion of furniture sales accounted for by imports have helped drive some metal finishing operations out of business in recent years.

4.7 Engine and Worn Parts

Engine and worn parts account for about 5% of total metal finishing sales. Most metal finishing operations in this market are Canadian job shops located across the country to service the oil, pulp and paper, transportation and forestry industries. These industries need to refurbish pumps, diesel and gasoline engines, and paper mill rolls.

Chrome and nickel are the predominant substances used. Hard chrome plating is used to apply heavy deposits of chromium needed to restore original dimensions and to provide a durable surface coating. There is also some use of electroless nickel plating.

Trends in Demand

The recession has increased demand as companies restore and refurbish parts rather than buy new parts or equipment. Oil and gas exploration and sales particularly affect hard chrome platers in Alberta and off-shore drilling accounts for much of the Maritime refurbishing and restoring business. This market is expected to remain static or experience slight decline in the future.

International Trade

Trade data for this market are not available. However, industry representatives indicate that there is not significant trade in engine and worn parts.

Competition in the Market

Anecdotal evidence suggests that engine and worn parts may account for a greater portion of metal finishing sales in the western provinces. In other parts of the country, competition is believed to be relatively moderate.

4.8 Electrical Equipment

About 4% of metal finishing sales are to the electrical equipment industry. The largest equipment manufacturers are subsidiaries of foreign-owned multinational companies, but there are a few smaller Canadian-owned producers. Metal finishing services on electrical equipment are often contracted out to Canadian job shops.

Several electrical equipment products require metal finishing including: service boxes, conduit pipe and transformer parts. Electroplating and hot dip galvanizing are used to finish electrical equipment. These processes primarily involve zinc.

Trends in Demand

The most important factor influencing demand for metal finishing from the electrical equipment industry is the demand for electrical equipment. Domestic demand for electrical equipment in turn depends on the level of activity in the housing and construction sectors. Survey respondents indicate some growth is expected from upgrading of utilities. Also the market may experience moderate growth if government infrastructure programs are implemented.

As described below, economic development in countries such as China and Pakistan is expected to result in considerable growth in exports of electrical equipment.

International Trade

The industrial electrical equipment market generates considerable trade in Canada. Exhibit 4.8 shows that exports have grown considerably in proportion to domestic shipments over the past eight years. The main destination for exports is the U.S. which received an average of 82% of exports from 1987 to 1991. However, export markets in developing countries, such as China and Pakistan, are expected to grow considerably over the next decade.

Imports have been capturing an increasing share of the domestic market over the past five years. On average, 70% of imports originate in the U.S. Asian countries have steadily increased their share of the Canadian imports, moving from 8% in 1987 to 12% in 1991.

Exhibit 4.8
Trade in Industrial Electrical Equipment
(millions of Canadian $)

	1987	1988	1989	1990	1991
Exports	314	633	593	871	907
Exports as a % of Canadian Shipments	14.9	26.2	23.5	36.4	39.3
Imports	792	877	1037	951	959
Imports as a % of Canadian Market	30.6	33.0	35.9	38.5	40.1

Source: ISTC (1991) *Industrial Electrical Equipment* Ottawa: Industry, Science and Technology Canada.

Competition in the Market

Canadian manufacturers of electrical equipment have tended to specialize in niche markets which require custom engineering. In most cases, firms that comply with ISO 9000 standards have a competitive advantage as well. Since the implementation of the Canada-U.S. Free Trade Agreement there has been increased competition from American firms in the Canadian market and increased market penetration by Canadian firms into the U.S. market. The competitiveness of electrical equipment producers is also affected by their access to new technologies and capital.

4.9 Pole Hardware and Heavy Steel

Pole hardware and heavy steel are estimated to account for approximately 4% of total metal finishing sales. Much finishing of pole hardware and heavy steel is done in captive shops. Ontario hot dip galvanizers used to supply parts to all of Canada, but interprovincial barriers have been erected through provincial content requirements for construction projects. These requirements have reduced Ontario-based firms' share of the national market and resulted in more galvanizing plants in other provinces.

The majority of this market uses hot dip galvanizing with zinc to meet corrosion protection standards and because parts are too large to electroplate. Effective corrosion protection is essential since the products must withstand weather and outdoor conditions for long periods of time. Parts that are galvanized include: highway guard rails, transmission towers and some heavy steel structures used in construction.

Trends in Demand

Demand for metal finishing of pole hardware and heavy steel is most strongly linked to demand for the end products. The adverse impact of the recession on the construction industry has affected the demand for pole hardware and heavy steel finishing. However, this market may experience growth if government infrastructure plans are implemented.

There have been some attempts to replace hot dip galvanizing with other finishes such as mechanical plating. However, in markets where Canadian Standards Association approval is necessary, there has been little movement from hot dip galvanizing.

International Trade

Exhibit 4.9 summarizes Canadian trade in selected heavy steel products. Trade in heavy steel products is volatile because only a few orders can substantially alter export or import patterns.

For example, in the period 1988-1992, the destinations for Canada's exports of towers and lattice masts have fluctuated widely. In 1988, Columbia and India accounted for about 50% and 35% of Canadian exports respectively. Similarly diverse patters hold for imports. It is likely that such contracts are won on tender-specific characteristics, as well as general economic factors such as exchange rates.

Exhibit 4.9
Trade in Heavy Steel Products
(Millions of Canadian $)

	1988	1989	1990	1991	1992
Iron and Steel Towers and Lattice Masts (including Transmission Towers)					
Exports to All Destinations	10.9	8.1	1.1	0.6	1.2
Exports to U.S. as a % of All Exports	14.3	13.8	71.7	72.9	64.0
Imports from All Origins	3.5	3.5	2.7	9.0	4.4
Imports from U.S. as a % of All Imports	98.6	87.4	88.9	24.2	44.2
Other Iron and Steel Structures (includes highway guardrail)					
Exports to All Destinations	193.2	125.7	97.4	69.0	73.0
Exports to U.S. as a % of All Exports	84.6	79.4	64.4	63.3	63.9
Imports from All Origins	37.5	52.6	54.3	63.3	65.0
Imports from U.S. as a % of All Imports	77.7	76.9	90.1	80.4	86.1

Sources: Statistics Canada (various years) *Exports: Merchandise Trade* Cat. No.65-202; and Statistics Canada (various years) *Imports: Merchandise Trade* Cat. No. 65-203.

Competition in the Market

Pole hardware and heavy steel demand relatively high thickness metal finishing. As a result, there are fewer firms competing in this market than many of other markets for metal finishing. However, there is also competition from overseas finished goods, as well as direct competition from U.S. metal finishers bidding on large galvanizing contracts in Canada.

4.10 Electronics & Printed Circuit Boards

Electronics and printed circuit boards make up about 6% of total metal finishing industry sales. Metal finishing work for printed circuit boards is done by captive divisions of large, usually foreign-owned circuit board manufacturers or job shops who specialize in printed circuit work. Electronic components also tend to be finished in captive operations but job shops may be used in some cases.

Printed circuits are used in automotive vehicles, electronic machines such as telecommunications systems, computers and robots, and numerous other applications. Printed circuit boards require mainly copper plating but some use of gold, nickel, tin and tin-lead (solder) processes. The printed circuit technology has evolved from primitive wire boards to current micro-circuit boards and multi-layered boards.

Trends in Demand

There has been steadily increasing demand for printed circuits over the past decade. However, as the computer and telecommunications industries matured there has been increased competition and a levelling off of demand. Currently there is growth in demand for electronic products and printed circuits from the auto industry has offset some decreases, especially from military users. Further growth is expected in the auto and aerospace industries. Greater use of tin/lead plating is anticipated for electronic components in the future. However, it is possible that research into surface-mount technology in electronics may result in non-metal substances replacing molten tin-lead.

International Trade

As shown in Exhibit 4.10, trade in printed circuits is conducted primarily with the United States. Over the past 5 years the U.S. share of exports has grown from 87.6% to over 97% of total printed circuit exports. Similarly imports of printed circuits are almost exclusively from the America. The U.S. made up over 95% of imports over the period from 1988 to 1990 for all years but 1991 (when Germany accounted for an extraordinary 18.3% of total imports).

Canadian exports of printed circuit boards show few consistent trading patterns with countries other than the U.S. However, imports from Taiwan and Hong Kong have steadily increased their share of the Canadian printed circuit market over the past five years.

Exhibit 4.10
Trade in Printed Circuit Boards
(Millions of Canadian $)

	1988	1989	1990	1991	1992
Exports to All Destinations	355.3	302.8	1330.4	1208.4	571.5
Exports to U.S. as a % of All Exports	87.6	90.5	98.3	98.2	97.5
Imports from All Destinations	344.0	407.8	1434.8	1119.4	706.4
Imports from U.S. as a % of All Imports	96.2	97.0	99.1	76.4	96.2

Sources: Statistics Canada (various years) *Exports: Merchandise Trade* Cat. No.65-202; and Statistics Canada (various years) *Imports: Merchandise Trade* Cat. No. 65-203.

Trade in consumer electronics, quantified in Exhibit 4.11, is less dominated by the United States. Although the U.S. accounts for over 80% of exports, this share has been decreasing steadily over the 1980s from over 97% of total exports. There has been a rise in the percentage of exports destined for the European Community from just over 1% in 1984 to over 8% in 1990. Smaller increases in exports to Asia and other countries have occurred over the 1980s as well.

Imports of electronics have consistently accounted for about 79% of the Canadian market. The majority of imports originate in Asia, which makes up over 55% of all imports of consumer electronics. The U.S. share of imports has expanded through the latter half of the 1980s from 26% in 1985 to over 36% in 1990.

Exhibit 4.11
Trade in Electronics
(Millions of Canadian $)

	1988	1989	1990	1991	1992
Total Exports	207.0	244.0	142.0	n.a.	n.a.
U.S. Exports, % of Total	89.4	88.5	82.9	n.a.	n.a.
Asian Exports, % of Total	4.4	4.5	5.5	n.a.	n.a.
European Exports, % of Total	3.8	3.3	8.2	n.a.	n.a.
Other Exports, % of Total	2.4	3.7	3.4	n.a.	n.a.
Total Imports	1552.0	1715.0	1382.0	n.a.	n.a.
U.S. Imports, % of Total	37.9	33.1	36.7	n.a.	n.a.
Asian Imports, % of Total	58.4	60.3	55.8	n.a.	n.a.
European Imports, % of Total	1.4	1.3	1.6	n.a.	n.a.
Other Imports, % of Total	2.3	5.3	5.9	n.a.	n.a.

Sources: ISTC. (1991) *Consumer Electronics* and *Microelectronics* Ottawa: Industry Science and Technology Canada.

Competition in the Market

As mentioned above, competition has become intense as the printed circuit board industry has matured. There is now intense competition in the computer industry. Competitiveness is influenced by access to new technologies, materials costs and to some extent the application of environmental regulations. Interviewed companies indicated that they faced increasing competition especially from Asian firms supplying printed circuit boards and finished electronic goods.

4.11 Plumbing Fixtures

Plumbing fixtures represent about 3% of metal finishing sales. Both captive and job shops are involved with plumbing fixture plating jobs. Usually, fixtures that go above the sink are plated by captive operations of plumbing manufacturers. This ensures that the quality needed for visible fixtures is achieved. Plumbing products that are not usually visible are typically plated by job shops.

The large plumbing parts manufacturers tend to be foreign-owned subsidiaries. Small manufacturers and plating job shops are usually Canadian-owned. Plumbing products manufacturers (and the metal finishing job shops serving them) are located in all regions of Canada with the majority in Ontario and Quebec.

Metal finishing processes used for plumbing fixtures include: electroplating, alkaline cleaning, and stripping electrodeposits. Base metals are usually plated with nickel or chrome, but copper and zinc may also be used.

Trends in Demand

The most important factor affecting the demand for metal finishing from this sector is the demand for plumbing products. Demand for plumbing is highly dependent on the housing/construction industry which was adversely affected by the recent recession.

Two lessor factors are also affecting the demand for metal finishing in the plumbing products industry:

- a trend towards coloured plastics and plated plastics for plumbing fixtures; and
- increased use of acrylic fixtures.

Metal finishers serving this industry expect growth in demand of less than 10% in the next 5 years.

International Trade

Trade in plumbing products is relatively small. Of the plumbing products traded, metal fixtures make up probably less than 10%. Exhibit 4.12 shows trade data for all plumbing products for 1986 through 1990. The U.S. accounts for over 85% of exports and about three-quarters of imports.

Exhibit 4.12
Trade in Plumbing Products
(Millions of Canadian $)

	1986	1987	1988	1989	1990
Exports	45	53	44	47	44
Exports as a % of Canadian Shipments	9.4	9.6	8.2	8.2	8.2
Imports	126	170	105	107	101
Imports as a % of Canadian Market	22.4	25.5	17.6	16.9	17.0

Source: ISTC (1991) *Plumbing Products* Ottawa: Industry, Science and Technology Canada.

Competition in the Market

The plumbing fixture market is reasonably competitive within Canada. Imports of cheaper finished goods made in Taiwan, Thailand and Mexico are challenging Canadian producers. However, there is considerable flexibility among Canadian manufacturers, and several Canadian companies are developing more differentiated product niches, particularly in water conserving fixtures and decorative plumbing products.

4.12 Military and Aerospace

The military and aerospace industries are estimated to account for about 6% of total metal finishing sales. These industries are characterized by large firms most of which are foreign-owned subsidiaries. However, there are some Canadian facilities located in Quebec and Ontario that manufacture military and aerospace goods.

Most military and aerospace parts manufacturers do their own metal finishing. The prevalence of captive shops is largely due to the high quality standards for metal finishing in these industries. However, there are a few military and aerospace manufacturers who contract out metal finishing to job shops.

Job shops serving these industries must obtain certification which states the job shop can meet metal finishing quality specifications (primarily for coating thickness and corrosion protection). To be certified, job shops must have their equipment and processes inspected by the manufacturers and, for military equipment, Defense Department officials. If the facilities at the job shop pass the inspection the job shop is placed on an approved suppliers list. Both captive and job shops serving the military and aerospace subsector must certify that they have used approved processes and materials from approved suppliers for all parts.

The most common processes used in metal finishing for military and aerospace applications are electroplating, anodizing, conversion coating and some galvanizing. Chromium, cadmium and zinc are the most common substances used in this subsector.

Trends in Demand

A 1993 survey of the aerospace and defense related industries shows sales of aerospace and defense subsector goods declined by 2.5% between 1991 and 1992[13]. This decrease in demand was largely due to the slump in military sales, which fell by 4.2%. Civil aerospace sales actually increased by 1.1% from 1991 to 1992.

It is expected that there will be continued decline in demand for military goods through 1994 and after that very limited growth from 1995 to 1997.

Civil aerospace sales are expected to have increased growth through 1993 and to make a strong recovery over the next few years. The industry forecasts growth of 13 to 18% per year for the period 1994 to 1996. Of the companies responding to Apogee's survey, 3 of 4 serving the aerospace industry indicated that they expect their markets to grow by more than 10% over the next five years.

13 ISC. (1993). *Aerospace and Defense-Related Industries: Statistical Survey Report 1993.*

The future growth of the aerospace industry is expected to come mainly from increased sales of aircraft, particularly to foreign governments other than the U.S. government. The U.S. is expected to account for somewhat fewer sales of exported goods over the period from 1994 through 1997, while market share in other countries is expected to grow. There is little growth anticipated for the domestic market over the period from 1994 through 1997.

International Trade

As shown in Exhibit 4.13, the majority of trade in military and aerospace equipment is with U.S. firms. In 1991 and 1992 exports to the U.S. accounted for 44% of sales each year and 61% of total exports. However, Canadian military and aerospace manufacturers expect the U.S. share of exports to decrease over the next few years to about 54% of all exports. This decline reflects the expectations of very limited growth in U.S. defense spending and the anticipated increases in sales to other governments particularly aircraft sales.

Imports accounted for just under 30% of net sales in Canada during 1991 and 1992. The U.S. accounts for a large share of Canadian imports; U.S. imports constituted about 83% of total imports in 1991 and 84% in 1992. In the years from 1994 through 1996 all imports are expected to grow by over 10% per year. Shares of the Canadian imports market are not forecasted to change significantly. The U.S. is forecast to continue to make up over 80% of total imports over that period while all other countries account for under 20%.

Exhibit 4.13
Trade in Military and Aerospace Products
(Millions of Canadian Dollars)

	1991	1992	1993(F)	1994(F)
Exports	6084	6085	6140	7090
% of Exports Destined for the U.S.	61.2	60.9	55.7	52.7
Imports	2431	2400	2389	2819
% of Imports Originating in the U.S.	83.0	84.0	79.5	81.5

(F) denotes forecasted values.

Source: ISC (1993) *Aerospace and Defense-Related Industries: Statistical Survey Report, 1993* Ottawa: Industry and Science Canada.

Competition in the Market

There is significant competition among parts manufacturers including a large number of foreign firms, for military and aerospace contracts. To remain competitive Canadian-based manufacturers tend to specialize in the production of customized parts.

Since the metal finishing quality requirements are very high, and meeting the requirements can be an expensive and time-consuming process, there are a very limited number of job shops serving the military and aerospace industries. A representative from one of the jobs shops interviewed estimated that there are about 20 Canadian job shops in this subsector of which only 2 or 3 firms would compete on a given military or aerospace metal finishing contract.

In the future it is expected that ISO 9000 certification will be required for captive and job shops in this subsector in addition to the existing quality specifications that they must meet. This additional certification will probably further limit the number of job shops that will operate in the military aerospace subsector.

4.13 Construction

Metal finishing of construction materials is estimated to make up 3% of the total metal finishing market. Construction materials such as steel beams, bridge components, railings, window and door frames may be metal finished. Steel materials are often galvanized to provide additional corrosion protection and aluminum parts are anodized and coated using chemical conversion coating.

Both captive and job shops are involved in metal finishing of construction materials. Aluminum anodizing and galvanizing of large materials that are difficult to transport are usually done by captive shops. Smaller materials such as window and door frames or railings are frequently contracted out to job shops for chemical conversion coating or galvanizing. It appears there are only a few metal finishing firms in the construction subsector but these firms tend to be located in all regions of Canada.

Trends in Demand

Demand for construction materials that are metal finished is dependent on the demand for new houses and offices, and to some extent on industrial construction and infrastructure. The construction industry is very cyclical and often lags other sectors in recovery from recession. One company located in Quebec indicated that the political instability in that province was expected to reduce demand for construction materials and metal finishing of those materials.

The recent recession severely contracted the construction industry, particularly in the Atlantic provinces, Quebec and Ontario. There are some indications that there will be growth in this subsector in the upcoming year, particularly if infrastructure programs such as the fixed link to Prince Edward Island, and federal-provincial programs promised during the recent election campaign, are implemented.

Some of the respondents to our survey indicated they have noticed a trend toward increased galvanizing in place or in conjunction with paint surfaces to increase corrosion protection and reduce maintenance costs.

International Trade

Exhibit 4.14 shows trade figures for steel and aluminum construction materials from 1988 to 1992. From 1988 to 1991 exports decreased by more than half while imports increased by more than 65% over the same period. The 1992 figures seem more optimistic as exports show an increase by 12% from the previous year and imports declined by almost 7% from 1991.

The most significant trading partner for these construction materials is the U.S. which typically accounts for over half of exports and more than 75% of imports. Other major partners include the United Kingdom, Hong Kong and the Philippines for exports and the United Kingdom, Germany, Sweden and Hong Kong for imports.

Exhibit 4.14
Trade in Steel and Aluminum Construction Materials
(Millions of Canadian $)

	1988	1989	1990	1991	1992
Steel Components for Structures or Their Parts (incl. bridge parts, doors, windows, frames, scaffolding equipment)					
Exports	239.0	166.1	127.8	91.7	102.9
Imports	79.5	102.5	118.3	134.9	125.5
Aluminum Components for Structures or Their Parts (incl. doors, windows, frames, plate, rods)					
Exports	40.2	28.9	53.0	45.9	50.1
Imports	38.7	50.3	45.7	38.3	46.7

Source: Statistics Canada (various years) *Exports: Merchandise Trade* Cat. No. 65-202; and Statistics Canada (various years) *Imports: Merchandise Trade* Cat. No. 65-203.

Competition in the Market

Because there are a fairly small number of firms which finish construction materials and they are located throughout Canada, there is limited competition among metal finishing firms in this subsector. In many regions there are only two or three firms that would be competing on a given job. However, some firms indicated that the recession has brought about strong price-based competition. The increase in imports over the past five years has also decreased the market share of Canadian firms in this subsector since they are in effect competing with finished imports. The price of materials is an important factor which affects the competitiveness of metal finishing firms in this subsector. In particular, zinc (used in galvanizing) fluctuates in price considerably and may reduce profitability of large, longer term contracts.

4.14 Holloware and Flatware

This industry constitutes less than 1% of total metal finishing sales. Most production occurs in small Canadian-owned firms with captive metal finishing operations. These firms are usually located in Ontario or Quebec.

Hollowware includes coffee pots, tea pots, bowls, cream and sugar containers and flower holders. Hollowware items are often electroplated with silver using silver cyanide plating bath. Additionally a small amount of nickel could be used for hollowware. Flatware includes tableware such as knives, forks and spoons. Flatware is made from stainless steel or cold-rolled steel plated in silver cyanide solution.

Trends in Demand

In the 1980s, competition from Germany and Japan significantly reduced Canadian production of both hollowware and flatware products. Demand for these products depends on population growth and formation of new households. There is some movement away from electroplated hollowware to other finishes. However, this small market is a relatively stable portion of metal finishing market with no significant changes in demand expected.

International Trade

Trade figures for knives and tableware are shown below in Exhibit 4.15. Sufficiently aggregated data for hollowware was not available however, it is likely that hollowware accounts for similarly small volumes of trade. The table shows the small volume of exports Canada generates in knives and tableware: a total of only $6.2 million worth of knives and $7.1 million in tableware over the period from 1988 to 1992. The majority of exports, usually over 75%, go to the U.S. Other export receiving countries include the United Kingdom, Germany, Sweden, and several Caribbean countries.

Imports of knives and tableware are more significant; imports of knives averaged $40 million per year and tableware imports were worth an average of $28 million per year over the five year period from 1988 through 1992. Most knife imports originate in Asia (especially China and Japan), and the U.S. Tableware is also most often from Asia in particular, South Korea, China, Taiwan and Thailand.

Exhibit 4.15
Trade in Knives and Tableware
(Millions of Canadian $)

	1988	1989	1990	1991	1992
Knives (including sets, table, butcher, hunting, pocket knives and blades for knives)					
Exports	1.3	2.2	0.7	1.5	0.5
Imports	37.2	41.1	37.0	34.2	45.3
Tableware Articles (including sets coated or not coated with precious metal and individual articles coated or not coated with precious metal)					
Exports	1.4	1.5	0.5	1.8	1.9
Imports	26.1	28.2	25.5	26.0	32.7

Source: Statistics Canada (various years) *Exports: Merchandise Trade* Cat. No. 65-202; and Statistics Canada (various years) *Imports: Merchandise Trade* Cat. No. 65-203.

Competition in the Market

The major factor affecting competitiveness in recent years has been the increased competition from imported goods, especially holloware. However, as mentioned above, this market is relatively stable and competition is not intense. Most holloware firms are small companies that rely on specialized products to retain market share.

4.15 Jewellery

Jewellery is also a very small market for metal finishing. It makes up less than 1% of total sales. Small, Canadian-owned captive operations do the majority of jewellery finishing. Only costume jewellery is plated. Costume jewellery is typically finished with a flash coating of a precious metal such as gold, rhodium on a nickel base.

Trends in Demand

It is unlikely this market will experience any significant growth or decline in the next few years. The most important trend in this market is the expected requirements for nickel-free costume jewellery.

International Trade

Exhibit 4.16 presents trade statistics for jewellery for the past 5 years. Currently, the U.S. accounts for most trade in jewellery items. Typically, two thirds of jewellery exports go to the U.S. with the remainder going to many countries especially the United Kingdom, Hong Kong and the Caribbean. The majority of imports come from Italy but imports from the U.S. have increased significantly since 1988. The U.S. imports slightly less than Italy but these two countries make up about two thirds or all imports. Other significant importing countries are Thailand and Hong Kong.

Exhibit 4.16
Trade in Jewellery of Precious Metal or Clad with Precious Metal
(millions of Canadian $)

	1988	1989	1990	1991	1992
EXPORTS					
Of Silver whether or not plated/clad with other precious metal	2.77	3.48	3.74	7.10	4.47
Of Precious Metal whether or not plated/clad with precious metal	10.89	9.85	26.10	34.45	40.69
Of Base Metal clad with precious metal	2.04	0.74	0.22	0.29	0.51
Total	15.70	14.07	30.06	41.84	45.67
IMPORTS					
Of Silver whether or not plated/clad with other precious metal	11.07	11.86	11.59	11.58	14.94
Of Precious Metal whether or not plated/clad with precious metal	46.64	61.27	51.58	63.36	69.22
Of Base Metal clad with precious metal	5.20	6.58	6.36	7.47	8.16
Total	62.91	79.71	69.53	82.41	92.32

Source: Statistics Canada (various years) *Exports: Merchandise Trade* Cat. No. 65-202; and Statistics Canada (various years) *Imports: Merchandise Trade* Cat. No. 65-203.

Competition in the Market

For low quality finishes, competition tends to be based on price. Material and labour costs are especially important. Increasing competition from East Asian countries is expected.

For higher quality jewellery, non-price features, including quality and distribution channels, allow Canadian manufacturers to remain competitive.

4.16 Summary of Findings

- The Canadian metal finishing industry provides services for many, diverse industries. With the exception of the auto parts market, most markets account for 10% or less of metal finishing sales.

- By far the most important factor affecting the demand for metal finishing services is demand for the finished products. Trends away from metal finishing towards alternative finishes has a relatively small effect.

- As illustrated below, three industries "drive" over half of the demand for metal finishing services. The *auto industry* is a major buyer of outputs from three metal finishing markets: auto parts; steel strip and printed circuit boards. The *construction industry* is not only a market for metal finishing services in its own right, but also absorbs goods from two other markets for metal finishing services: pole hardware/heavy steel; and hardware. Finally, the *housing industry* is a major driver of three markets for metal finishing: electrical appliances; plumbing; and hardware.

Industries that Buy Finished Metal Products		Industries that Purchase Metal Finishing Services (% of MFI Sales)
Auto	=>	auto parts (25%), steel strip (11%), printed circuit boards (3%)
Construction	=>	pole hardware/heavy steel (4%), hardware (8%), construction (3%)
Housing	=>	electrical appliances (9%), plumbing (3%), hardware (8%)

- Many of the firms served by metal finishers face significant competition from foreign manufacturers of finished products. These firms include those producing: auto parts, plumbing, steel strip, hardware, electrical appliances and electrical equipment.

4.0 Markets for Metal Finishing Services

- The recession has significantly reduced many of the markets for metal finishing services.

- Different industries demand different levels of finish quality. Industries that demand particularly high quality include auto parts, military, aerospace and printed circuit boards. Industries that do not demand as high quality include furniture and wire goods.

- Although some markets are served by both captive shops and job shops (auto, military), many other markets are served predominantly by one type of shop. The following exhibit lists these markets.

Markets Predominated By Captive Shops	Markets Predominated by Job Shops
Hardware Plumbing ("above sink") Steel strip Electrical appliances Printed circuit boards Aerospace Hollowware and flatware	Hardware (nuts, bolts and screws) Plumbing ("below sink") Wire goods Furniture Engine and worn parts Electrical equipment

- As a general rule, captive shops are more likely to serve industries that demand high quality or specialized finishes.

- Competition for jobs on the lower end of the quality scale is intense, resulting in low rates of return on sales for these jobs.

5.0 Assessment of Financial Performance and Vulnerability

5.1 Financial Performance

Assessing financial performance in the metal finishing industry is inhibited by several significant factors:

- Canadian financial databases have very poor coverage of small, privately-owned companies and do not define the MFI in ways suitable for this study;
- given the diversity of the industry and the large number of companies, it is difficult for industry experts to know with accuracy current financial performance; and
- small, privately-owned businesses operating in a competitive industry, such as the metal finishing industry, are generally reluctant to reveal their financial performance.

To overcome these difficulties, a four-step procedure was used to develop best estimates of average financial performance in the Canadian metal finishing industry.

(i) Financial performance ratios were provided by about 25 Canadian metal finishers in response to this study's questionnaire. Average financial performance ratios were calculated from this sample.

(ii) The average financial ratios from the questionnaire responses were compared to financial ratios contained in: Dun & Bradstreet's *Industry Norms and Key Business Ratios*; and L. Buffa and K. Coulter (1978) *An Assessment of the Financial Impact of Federal Guidelines on the Canadian Metal Finishing Industry*.

(iii) With the assistance of Mr. Ken Coulter, the above information was taken into account to develop draft best estimates of four financial ratios:

Return on Sales	After Tax Earnings ÷ Sales
Cash Flow/Total Debt	(After Tax Earnings + Depreciation) ÷ Total Debt
Return on Assets	After Tax Earnings ÷ Assets
Total Debt/Total Assets	Total Debt ÷ Total Assets

(iv) The draft best estimates were reviewed in a meeting with a representative of the Canadian Association of Metal Finishers and then mailed to 60 metal finishers. These metal finishers had responded to the questionnaire and indicated that they would be willing to participate in future research efforts. A cover letter asked these metal finishers to provide their opinions on the accuracy of the best estimates.

This last step provided little feedback. Several metal finishers indicated that they had no knowledge of financial performance in the industry as a whole and, therefore, could not venture an opinion as to the accuracy of the estimates.

Exhibit 5.1 presents the best estimates of average financial performance developed through the process described above. Estimates are presented for three types of job shops: small job shops (sales under $2 million); medium-sized job shops (sales between $2 million and $5 million); and large job shops (sales over $5 million).

It is important to realize that there is much uncertainty regarding these estimates. Furthermore, financial performance within any group of companies can vary significantly.

Formal financial performance ratios are, of course, not available for captive shops. In recent years, captive shops have had to become more competitive relative to job shops and, to this extent, have had to match the performance of job shops. The result has been a significant decline in the number of captive shops, as described in Section 3 of this report.

However, some captive operations are maintained for reasons of increased quality control, reduced transportation costs and timing convenience. For these shops, financial performance is of less concern.

5.2 Factors Affecting Financial Performance

Exhibit 5.2 presents questionnaire responses to questions regarding the factors affecting the financial performance of metal finishing companies. Specifically, metal finishers were asked to rank various factors as "most important," "important," "not very important" and "not at all important." The number of responses for each factor are shown in the exhibit.

Metal finishers indicated that the most important factors affecting their financial performance are:

- their ability to meet quality control requirements;
- long-term decline in their customers' activity;
- wage rates and benefits;
- increasing material costs;
- their ability to raise investment capital for production equipment; and
- existing environmental regulations.

Exhibit 5.1
Best Estimates of Average Financial Performance Ratios
(1988-1992)

Financial Ratio	Small Job Plating Shop Sales Under $2 million Less than 20 Employees	Medium-Sized Job Plating Shop Sales Between $2 million and $5 million Between 20 and 50 Employees	Large Job Plating Shop Sales Over $5 million Over 50 Employees
Return on Sales	3%	6%	8%
Cash Flow/Total Debt	33%	33%	33%
Return on Assets	10%	19%	20%
Total Debt/Total Assets	32%	32%	32%

Exhibit 5.2
Factors Affecting the Financial Performance of Metal Finishers
(number of respondents from 85 completed questionnaires)

Factor	Most Important	Important	Not Very Important	Not At All Important
Ability to Meet Quality Control Requirements	31	30	7	0
Long-Term Decline in Customers' Activity	31	25	9	1
Wage Rates and Benefits	25	34	12	3
Increasing Cost of Materials	24	39	8	1
Ability to Raise Investment Capital for Production Equipment	24	21	15	8
Existing Environment Regulations	24	44	5	0
Ability to Raise Investment Capital for Pollution Control Equipment	20	27	15	4
Federal Tax Structure	19	30	8	7
Provincial Tax Structure	16	33	8	7
Short-Term Decline in Customers' Activity	16	30	14	3
Exchange Rates	12	31	14	7
Access to New Technology	10	47	10	3
Ability to Obtain Operating Credit	10	25	19	10
Access to Federal Subsidies	10	16	22	11
Other (non-environmental) Government Regulations	10	38	10	0
Location of Customers	10	25	19	10
Access to Provincial Subsidies	9	14	24	10
International Trade Barriers	7	22	21	14
Ability to Achieve Economies of Scale	6	39	14	4
Pressure from Environmental Lobby Groups	6	29	21	6
Interest Rates	5	26	22	7
Pressure from Organized Labour	5	17	29	11
Scarcity of Qualified Labour	3	20	36	9
Interprovincial Trade Barriers	3	6	33	21
Other	3	3	0	0

A small number of respondents indicated "other factors" as being most important or important to their financial performance. These other factors include:

- obtaining ISO 9000 approval;
- increased overhead costs;
- keeping up-to-date with legislative changes; and
- the Goods and Services Tax.

Trade barriers, interest rates and labour problems pose few significant problems to the metal finishing industry.

The questionnaire responses indicated that the factors most important to financial performance are similar for different sizes of firms and firms that serve different markets. Two major exceptions to this rule are:

- the ability to meet quality control requirements is of most concern to metal finishers serving the auto parts, military, aerospace and printed circuit board industries; and
- smaller firms tend to rank the ability to raise investment capital for pollution control equipment as a more important factor than larger firms.

5.3 Financial Vulnerability

Financial vulnerability refers to the potential for a metal finishing operation to close as a result of changes to the factors that influence financial performance.

In this study, we are most concerned with assessing the potential for operation closures if more stringent environmental standards are implemented. Higher environmental standards would require metal finishers to invest in waste treatment or material recovery systems. Such investments could be financed through retained earnings, credit and/or equity infusions (that is, further investment in the company by owners).

The likelihood that metal finishers have access to the three financing sources depends on the following factors:

- *Retained Earnings*:
  - firms with poor financial performance in recent years will likely have very low levels of retained earnings
  - decisions to retain earnings are made by individual owners and, therefore, access to retained earnings is firm-specific

- *Credit*:
  - firms with poor financial performance have less likelihood of obtaining credit
  - even firms with strong financial performance can be denied credit due to creditors' perceived environmental risks

- *Equity Infusion*:
  - being small, privately-owned businesses with environmental risks, metal finishing companies must rely largely on current owners for equity infusions
  - the ability of current owners to increase their investment depends partly on the firm's past financial performance and partly on the owners' personal resources

Given these factors, financial vulnerability clearly differs across metal finishing operations. It would, therefore, be useful to identify different groups of metal finishers (industry "sub-sectors") that share a common level of financial vulnerability.

In various parts of this report, the industry has been divided according to:

- ownership (job vs. captive);
- the markets served; and
- the size of firm.

Unfortunately, none of these divisions of the industry yield sub-sectors that are sufficiently homogeneous to draw conclusions regarding financial vulnerability. An example is useful to illustrate the inadequacy of defining sub-sectors according to markets and/or firm size:

> Low rates of return prevail in some markets. Since rates of return earned are a key component of financial performance, it might seem logical to assess financial vulnerability according to the markets served by a firm.
>
> Some firms serving low-return markets, however, are able to earn sufficiently high profits by finishing high volumes of products. Therefore, a division by market served fails to capture the diversity of the industry.
>
> High-volume (large) firms should be less financially vulnerable than smaller firms since they are better able to finance needed investments through retained earnings. Therefore, it might seem logical to assess financial vulnerability according to size of firm.

> However, firms have different financial commitments and capacity. Even large firms may be financially vulnerable if there are over-riding constraints on the firms ability to raise capital. A large firm with a high debt load may need to borrow to meet more stringent environmental standards. As discussed in Section 3, even metal finishers with strong financial performances are having difficulties borrowing funds due to creditors' wariness of the environmental risks associated with accepting metal finisher's land or building as collateral.

Rather than imposing arbitrary divisions on a non-homogeneous industry, the metal finishing industry should be viewed as a continuum of diverse firms.

There are, however, some broad conclusions regarding financial vulnerability that can be made.

- Financial performance, and therefore financial vulnerability, fluctuates widely with the demand for metal finishing services. This implies that the impacts of environmental policies will be more severe during periods of recession than in periods of increasing demand.
- The financial performance of many metal finishers declined significantly during the recent recession. Retained earnings, for the industry as a whole, are likely low.
- Rates of return tend to be lower in lower-quality markets such as wire goods, below-sink plumbing and some hardware. Metal finishers serving these markets are likely to be more financially vulnerable.
- Rates of return tend to be higher in markets that demand higher quality, including aerospace and military. Firms serving these markets are likely to be less financially vulnerable. Some metal finishers indicate that ISO 9000 certification can result in improved financial performance and consequently lower financial vulnerability.
- For any given rate of return, smaller firms will generate less total profits, thereby having less access to retained earnings, credit and equity infusions. Smaller firms, therefore, are likely to more financially vulnerable.
- Anecdotal evidence indicates that metal finishers' ability to raise investment capital does not always depend on financial performance. Creditors' perception of environmental risks is an increasingly important barrier to financing investments. Therefore, financial vulnerability can vary significantly among firms with the same markets and size.
- If some shops close, the market share of at least some of the remaining shops will increase. Therefore, the closure of some shops may decrease the financial vulnerability of the remaining shops.

6.0 Trends in Metal Finishing Processes and Substances

This section provides an assessment of trends in processes used by metal finishing operations. The assessment was conducted in two parts. First, the most important process trends were identified and assessed. These trends are believed to account for most of the changes taking place in the industry. Second, changes taking place in the use of other substances of interest to this study were assessed.

Major Trends in Metal Finishing Processes[14]

Four major topics were identified where the most significant trends are occurring with respect to process replacement, the development of new processes, and substitutes for toxic inputs. These four topics are:

(i) chlorinated solvent cleaning;

(ii) chromium use;

(iii) cyanide use; and

(iv) cadmium use.

Sometimes referred to as the Four Cs, these materials have been identified by EPA as key targets for control within the metal finishing industry (U.S. EPA, 1992a and 1992b). As a result of existing and anticipated environmental controls, I would estimate that 90% or more of the material substitution efforts by the U.S. metal finishing industry have focused on these material. This estimate is supported by a recent (and soon to be published) survey conducted for the National Centre for Manufacturing Sciences (NCMS)[15]. This study, which is entitled *Assessment of Pollution Prevention and Control Technology for Plating Operations*, asked plating shop personnel to list environmental technology needs that are most important to their company. Of the ten most frequently listed topics, six were related to process input changes(e.g., alternatives to chlorinated solvent cleaning/degreasing), with the Four Cs making up over 90% of these responses.

Before beginning this discussion, two points that relate to input material substitution are worth noting. First, not all substitutions are environmentally sound, including many cases where a less toxic material is used. The truth is that most substitution studies fail to consider the life cycle costs associated with the substitution. Also, they fail to consider engineering solutions that can make a hazardous process safe. For example, there are many input material alternatives to hard chromium plating. However, none of

14 This section is based on research by Mr. George Cushnie of Science Application International Corporation (SAIC).

15 The NCMS study results are presently under review and are expected to be released by January, 1994.

these alternatives can be operated as an essentially closed-loop process like chromium plating. With proper engineering, chromium can be recovered from air emissions and water and the process solutions can be maintained in useful condition indefinitely. All of the alternatives generate residuals in the form of wastewater, spent baths, etc.

Second, one should not completely accept the information contained in the literature with regard to the success or material input substitution. Too often, articles portray products as state-of-the-art when they are actually in the development stage or have limited applicability.

Chlorinated Solvents[16]

Chlorinate solvents have been used extensively in the metal working and metal finishing industry for degreasing and cleaning. The most commonly used degreasing solvents include: 1,1,1 trichloroethane (or TCA), trichloroethylene (or TCE), perchloroethylene (or PERC), chlorofluorocarbons, (or solvent 113) and methylene chloride. These solvents are used in a variety of methods, but most frequently in vapour degreasers, immersion or spray operations, and had wiping. Solvent use has declined during recent years and especially since 1990, due to regulations restricting the use of ozone-depleting substances, voluntary actions by industry under EPA's 33/50 Program (Industrial Toxics Project) (Graves, 1992), rising costs for the purchase of solvents and the disposal of solvent wastes, and concerns over the health effects of solvents. However, as late as 1989, an estimated 84,000 U.S. firms still used vapour degreasing with TCA (Werner and Mertens, 1991).

Data from the recent NCMS study show that approximately one quarter of the plating shops that used chlorinated solvents in 1980 (approximately one half of the shops used chlorinated solvent in 1980) have eliminated use of this material. The study also shows that newer plating shops (i.e., those established since 1980) are even less likely to use chlorinated solvent. Further, the study showed that the average quantity of solvent used by shops has declined significantly since 1980.

Various alternatives are being substituted for chlorinated solvents. The alternatives include a combination of equipment and material input changes. Usually, both an equipment and a material change is necessary since the equipment is designed to the characteristics of a given material.

From an equipment standpoint, vapour degreasers are being replaced mostly by tanks containing non-chlorinated materials. The tanks are used like other metal finishing process tanks. Parts contained in baskets, barrels or on racks are lowered into the tanks, some form of agitation is applied (i.e. mechanical and/or sonics), and after a period of time the parts are removed and rinsed. Other types of equipment are also being used, but less frequently than the tank. One of the more common alternatives is automatic parts washers. These units operate like washing machines; parts are loaded into the unit and a cleaning/rinsing cycle occurs.

16 Other Environment Canada initiatives are addressing chlorinated solvent use in the MFI. However, since the MFI's use of these substances is changing, a brief discussion of these trends is included in this report.

6.0 Trends in Metal Finishing Processes and Substances

Input material changes mostly focus on aqueous and semi-aqueous cleaning substances. Aqueous cleaners have been used in the metal finishing industry since its inception. However, solvents were typically used prior to aqueous cleaning to remove the bulk of the soils (referred to as precleaning and/or degreasing). As the role of the aqueous cleaner has changed, so has its formulation. The newer cleaners are more sophisticated. Rather than simply removing and permanently holding soils, the new cleaner permit light oils to float and heavy soils to sink. This prevents the cleaner from becoming overly saturated with soils and therefore extends the life of the cleaner. Associated with the use of these cleaners are equipment such as skimmers and filters that separate the soils from the cleaning bath. Semi-aqueous cleaners have better solvency properties than aqueous cleaners. However, there are some drawbacks with their use, including: oily films lift on parts, air emissions, and disposal problems. As a result, the general preference is to use aqueous products (e.g., buffing compounds) and the semi-aqueous chemistry is needed.

There are numerous other input material and equipment substitutions being used or investigated by the metal finishing industry. However, these are most often directed at specific degreasing/cleaning operations and generally have less applicability than aqueous and semi-aqueous cleaning. Some examples include: (1) non-ozone depleting solvents that are used as drop in replacements in conventional chlorinated solvent equipment (includes hydrochlorofluorocarbons (HCFCs); (2) perfluorocarbons (PFCs) which are used in new vapour degreasing tanks for cleaning heavily soiled parts requiring a higher quality cleaning process (Wang and Merchant, 1993); (3) supercritical fluids (e.g., CO_2) which is an emerging technology with very limited application; and (4) molten salt baths which are in fairly wide use, but have limited application.

Cost differences between conventional chlorinated solvent cleaning and the alternative methods varies widely depending on the specific application. Also, chlorinated solvent cleaning costs are rapidly changing due to decreases in material production and increases in disposal costs. Prior to recent changes in environmental laws governing chlorinated solvents, the cost of using these materials was relatively low.

Chromium

Chromium is one of the more common input material used in the metal finishing industry; with the most significant uses involving decorative and hard chromium electroplating, conversion coating for cadmium and zinc plated parts, bright dipping of copper and copper alloys, and aluminum finishing (includes chromic acid anodizing, deoxidizing/desmutting, sealing and aluminum conversion coating). Due mostly to health concerns, environmental regulations and efforts to reduce operating costs (including treatment and disposal costs), the metal finishing industry has sought alternatives to the use of chromium. Also, there has been some change involving the substitution of trivalent chromium in processes where hexavalent chromium has been traditionally used (trivalent chromium is generally considered to be less hazardous and less costly to treat).

The greatest use of chromium is with decorative chromium plating. This process is traditionally performed with a hexavalent chromium bath, but trivalent chromium plating has increased in use, especially during the past ten years. With either process, an undercoat of nickel/copper or nickel is usually applied. Chromium plating has been replaced on some products by replacing steel parts with noncorrosive materials, such as stainless steel and by organic coatings (paint). An example of chromium plating displacement is automobile bumpers. Although some chromium plating has been replaced, it remains as one of the most frequently applied electroplates.

Trivalent chromium plating is an economically attractive alternative to hexavalent plating for some applications. However, its use has been limited due to a difference in appearance from the standard hexavalent bath. The trivalent bath chemistry is more expensive to purchase than the hexavalent bath. The cost savings is a result of reduced metal loadings on the treatment system (the trivalent bath contains less total chromium) and the avoidance of the hexavalent chromium reduction step during treatment. One source estimates that, considering treatment costs, the cost of trivalent chromium plating is about one-third of the costs for hexavalent solution (Spearot and Peck, 1985).

Hard chromium plating is applied to tools, hydraulic cylinders and other metal surfaces that require wear resistance. The major difference between the decorative and hard chromium deposits is their thickness. The hard chromium deposit is typically hundreds of times thicker than decorative ones. Although research efforts have sought a trivalent chromium substitute for hard chromium plating, no solutions are commercially available. Input material changes for hard chromium have focused on alternative deposits. Also, alternative processes have been used. The alternative input material that has been most successful is electroless nickel (Jeanmenne, 1990). Other alternative input materials under current consideration are electroplated nickel alloys (e.g., Amplate), and nickel alloy composites (e.g., Boeing Ni-W SiC). Alternative processes to hard chromium plating include brush plating and metal sprays. SAIC has worked with the Air Force during the past several years investigating alterative input materials and process for hard chromium. It is my opinion that substitutions can be made, but that they will be done on a case by case basis. There will not be a universal substitute for hard chromium plating during the next 10 to 20 years. In fact, many users switching to non-chromium input materials and processes, may find that they have complicated their treatment processes and increased their overall costs by switching away from hard chromium plating and they may return to hard chromium plating in the future.

Chromium use with aluminum finishing is perhaps most common in the aerospace industry. Chromium combines with aluminum on the surface of parts to provide corrosion and wear resistance and a chemically active surface for painting of colouring. The two most common processes are chromic acid anodizing and chromate conversion coating. These are not competing processes, but rather each has a specific role. Both processes are performed in hexavalent chromium baths. The anodizing process is electrolytically performed and the conversion coating process involves simple immersion. Significant research efforts have been expended during the past ten years to find alternatives to these processes. For many applications, alternatives have been identified and implemented. For example, chromic acid anodizing has been partially replaced by common sulphuric acid anodizing and sulphuric/boric acid anodizing and non-chromium conversion coatings (e.g., permanganate, rare earth metals and zirconium oxide) (Hinton, 1991) have to a lesser extent replaced the chromium baths. Another use of chromium during aluminium finishing is for deoxidizing/desmutting. Deoxidizing and desmutting (sometimes a combined single step) remove oxides and other inorganics that would interfere with aluminum processing (e.g., anodizing).

Alternatives to the chromium-based products include iron and ammonium salts or amines mixed with various oxidizers and/or etchants. Owing to the extent of research for non-chromium aluminum finishing and the success rate of these efforts, it is feasible that chromium use will eventually be eliminated from the aluminum finishing area. One would expect to see large scale substitutions during the next ten tears. However, total elimination will take considerable longer due to small residual uses of chromium for which no satisfactory substitute exists and due to the complexity of the military and aerospace specifications that presently require the use of chromium.[17]

Cadmium

Cadmium is electroplated, primarily on steel, to provide corrosion resistance, It is especially useful for marine environments, where zinc plating (the primary alternative to cadmium plating) is less effective. Cadmium plating presents even greater concerns that chromium plating. First, cadmium is usually deposited from a cyanide based bath (non-cyanide baths are also employed, but to a much lessor extent due to their inferior plating characteristics), which provides additional incentive for its replacement. Second, unlike chromium plated deposits (which are often applied to surfaces intended to contact humans, including surgical instruments), cadmium deposits pose a potential health hazard. As a result, the use of cadmium may be restricted on some parts/applications in the future (Ko, 1991). Therefore, cadmium plating poses a threat as a process and as a product.

Many alternatives to cadmium plating exist, with no single universal substitute available. Some of the cadmium plating alternatives include: zinc plating, tin or tin alloy plating, cobalt-zinc plating, nickel-zinc plating, zinc-iron plating, zinc-flake dispersion coating, metallic ceramic coating, and ion vapour deposition of aluminum (Mandich and Krulik, 1992; Holmes et al., 1989; Wood, 1990). Generally, for alternatives to be successful, they must provide sufficient corrosion resistance as measured by standard tests (e.g., salt fog test). Also, for certain military and aerospace applications the alternative deposits must provide other desired characteristics such as lubricity.

Many electroplating job shops have eliminated cadmium plating due to a reduced market and to the enforcement of local discharge standards that are often much more restrictive than the federal limitations. Also, many captive shops and military shops have reduced or eliminated the use of cadmium plating.

It is conceivable, owing to the toxicity of the cadmium deposit, that cadmium plating will be eliminated within ten to twenty years, except for some special applications (e.g., aerospace).

Cyanide

Cyanide, in the form of either sodium of potassium cyanide, has been a key component of plating solutions for many years. Some of the metals commonly plated from cyanide baths includes: cadmium, zinc, copper, brass, and precious metals. Cyanide is also present in some cleaning baths, some stripping solution (e.g., nickel strips) and in many chromate conversion coatings (as ferrocyanide). The most

17 One Canadian metal finisher also noted that chromium is used as a passivate for zinc plated articles. The chromium from this source cannot be readily recycled or recovered as it can from chromium plating operations. There are apparently no readily available alternatives to these chromium based passivates.

extensive use of cyanide is in plating baths. When used in a plating bath formulation, cyanide forms a moderately stable complex with metal ions that permits the deposition of the metal under the influence of a suitable electrical potential.

Although cyanide-containing baths are eminently satisfactory as far as plating results go, pollution control poses a problem in terms of both compliance and economics (Lowenheim, 1978). Cyanide effluent limitation are often set locally at concentrations far below the federal standards (probably more for emotional reasons than for scientific reasons).[18] The conventional cyanide treatment methods are able to destroy cyanide to low levels as long as the cyanide is not present as a strong complex (e.g., cyanide and iron form a complex that is not usually destroyed by conventional treatment). If an untreatable complex is present, then compliance is difficult, especially if the local standards are more stringent than the Federal standards. In either case, cyanide destruction requires the use of expensive treatment reagents. As a result, there has been a significant effort to find and implement cyanide-free plating processes since approximately 1975. The earliest and most complete cyanide substitution that has taken place in the plating industry is the switch from zinc cyanide plating to zinc chloride and zinc alkaline (non-cyanide) baths to replace the single cyanide bath. On a positive note, in addition to cyanide use reduction, some platers enjoy production benefits from the substitution, including better and brighter plating.

The second most complete non-cyanide plating substitution is the switch from cyanide copper plating to alkaline non-cyanide and acid copper baths. Like with zinc plating, platers switching to non-cyanide copper must often implement two processes. For example, acid copper cannot be applied directly to steel or zinc-ally die castings, whereas copper cyanide can. When these types of parts are to be plated in an acid copper bath, they must first be coated with a copper cyanide or nickel strike (thin deposit).

Cadmium, silver and gold are almost exclusively plated from cyanide baths, although non-cyanide substitutes are available for all three metals. In each case, the substitutes have very limited application or are significantly inferior in terms of deposit quality. For example, non-cyanide cadmium solutions have been available for more than 15 years (e.g., ammonium chloride/ammonium sulphate, ammonium fluoborate/boric acid and sulphuric acid types). However, they have poor throwing power (cannot plate into recesses) and therefore limited application.

Cyanide was previously a common ingredient in electrolyzed cleaning baths such as those used for alkaline descaling. Owing mostly to environmental regulations, cyanide cleaning formulations have been mostly abandoned. Approximately less than 5% of plating shops use cyanide-bearing cleaning solutions today.

18 There is an emotional factor involved with cyanide because it is widely been regarded as a deadly poison. Because of its notoriety, cyanide is probably feared more by the general public than many compounds that pose significantly greater environmental and health risks.

In summary, much of the plating workload that was once processed in cyanide baths is now being processed in non-cyanide baths. Overall, cyanide usage has probably decreased by 50% or more since 1980. The complete elimination of cyanide use has been accomplished by may plating shops. However, because most non-cyanide substitutes do not cover the range of applications of their cyanide counterparts, the majority of these shops have had to reduce their customer base in order to eliminate cyanide use. One would expect continued improvements in non-cyanide metal finishing solutions with nearly complete substitution during the next ten to twenty years.

Trends in Metal Finishing Processes Involving Other Substances of Interest[19]

Copper

Copper is used most frequently as a coating between a substrate such as zinc diecastings, plastics, aluminum and steel and the subsequent application of nickel and chromium. It is also used in the manufacture of printed circuit boards and, either as the metal itself or alloyed with zinc or tin, in the plating of brass or bronze decorative finishes.

There are four basic copper processes.

▶ *Acid Copper Using Copper Sulphate as the Electrolyte*

Acid copper is most frequently used to apply heavier coatings of copper and to smooth out the polishing marks and other minor surface imperfections. It also contributes to the corrosion resistance and is usually specified by the automotive companies for exterior applications.

There was some substitution away from acid copper in auto parts during the 1980s. However, this trend is largely completed and no additional substitution is predicted.

▶ *Cyanide Using Copper Cyanide*

Copper cyanide baths are used to give a protective layer of copper on zinc diecastings, rolled zinc and zincated aluminum to provide protection against the aggressive acid action of subsequent electroplating operations.

Attempts have been made to develop an alkaline copper process to replace cyanide but it has not worked well in production on zinc diecastings and zincated aluminum. It is more difficult to control and more expensive to operate.

19 This section is based on research by Mr. Ken Coulter.

- *Pyrophosphate Using Copper Pyrophosphate*

  Copper pyrophosphate is used in electroplating of printed circuit boards and other applications where its ability to plate through holes is required. No substitutes are expected.

- *Electroless Copper*

  Electroless copper uses catalytic deposition of copper in an aqueous solution containing copper ions with reducing agents, complexing agents and stabilizers. The process is primarily used in printed circuit board manufacture where its ability to plate evenly and through holes is significant. This application of copper is increasing.

With the lack of alternatives on the horizon, the use of copper in metal finishing is expected to be proportional to demand trends in the auto parts and printed circuit board industries. Additional use for decorating furniture will depend on trends in furniture design.

Nickel

Nickel electroplating is a key process in obtaining attractive, corrosion resistant coatings. It is an intermediate step immediately prior to the application of chromium or a precious metal. It provides major protection against corrosion in the sequence of plating layers and produces a bright finish when desired. There is no substitute on the horizon for nickel plating except in painted or powdered coated applications.

The process baths are made up primarily of nickel sulphate and nickel chloride with agents added to control grain structure and other process control chemicals. It is also applied by catalytic precipitation on plastic and ceramic pieces as a step before plating with copper-nickel-chromium.

Electroless nickel is sometimes used as a substitute for hard chromium plating. This process has significant potential for growth for several reasons:

- electroless nickel is used as an undercoating prior to plastic coating of some auto parts;
- it is used in the manufacturing of some printed circuit boards, a growing metal finishing activity; and
- it is replacing some hard chromium plating in the rebuilding of worn parts.

Zinc

Zinc is the most widely used metal in the metal finishing industry. Its applications are increasing rapidly as the demand for greater corrosion protection is made by the automotive, agriculture and construction industries.

Zinc is applied mechanically as in hot dip galvanizing and electrolytically. Small parts, such as fasteners, are plated in barrels, while larger parts are fastened to racks and carried through the plating process.

Plating baths may be acid with the electrolyte primarily zinc sulphate or zinc chloride, or they may by alkaline or cyanide based. The choice of which bath to be used is determined by the customers specifications, the quality required, the economics, including waste treatment and the equipment in place for processing.

Its applications would apply across all but two or three of the sectors of the industry under discussion. It is also used in the zincate process for chromium plating aluminum.

Lead

There is very little application of lead in Canada, if there is any at all. It is, however, used extensively when plated as a tin/lead alloy (usually 60%/40%) in the manufacture of printed circuit boards. Its function there is to provide a solder to facilitate the manufacture of the boards. Some processors have found alternatives to its use such as tin plate plus a stearic acid immersion. Development of alternatives is on-going.

Non-soluble lead nodes are used in chromium plating. However, some slight dissolution of the lead does occur. Therefore, lead is found in the running rinses from such chromium plating processes.

Finally, the tin/lead plating process uses lead fluoborate in the electrolyte.

7.0 Material Recovery and Recycling Practices

Reductions of potentially toxic materials from metal finishing waste streams can be achieved through material recovery and recycling practices. For example, recovery of materials for reuse at the source, before they become part of the waste stream, reduces the amount of waste requiring treatment and disposal. Material recovery measures can be applied to rinse water, drag-out, plating bath solutions and air emissions. Such measures can reduce waste water and plating chemical costs as well as reducing the capacity requirements for downstream recovery and treatment facilities.

Environmental policies are designed to reduce the environmental impact of industrial operations on the environment. One way of doing this is to encourage metal finishers to adopt material recovery and recycling practices. Therefore, it is important to understand the current state of material recovery and recycling in the industry and the potential to increase such practices.

This section of the report addresses these issues by answering the following questions:

- What material recovery and recycling practices are available?
- How widely are these practices currently in use?
- What are the major barriers preventing metal finishers from increasing material recovery and recycling?

Information on recovery and recycling techniques was assembled from 4 major sources:

- CH2M Hill (1994);
- Environment Canada (1987);
- Forrestal (1987); and
- the questionnaire and interview program conducted by Apogee Research.

7.1 Rinse Water Reduction and Reuse

Rinse water is used to remove residual drag-out from racks and plated parts. Rinse water reduction or reuse techniques decrease the amount of effluent that needs to be treated and lowers treatment costs. However if rinse water becomes too concentrated treatment may be impaired. Conventional processes employ a continuous flow tank but the amount of rinse water used and treated can be reduced significantly from applying any of the following techniques: counterflow rinsing, spray rinsing, still (or "dead") rinsing, cascade rinsing, improved mixing, flow control, conductivity control, drip trays, air jets and timers. These methods will be discussed in detail below.

7.0 Material Recovery and Recycling Practices

A majority of the responses from metal finishers indicate that they use some method of reusing rinse water; of the 88 respondents (including interviewed companies), 59 reuse rinse water. Interviewed companies most frequently referred to counterflow rinsing and closed loop rinse water systems to recover rinse waters.

Counterflow Rinsing

Counterflow rinsing involves immersing plated parts in a series of rinse tanks (usually 3) to remove residual plating metals and chemicals. The parts move in the opposite direction to the flow of water.

There are a number of advantages associated with counterflow rinsing:

- Counterflow rinsing may reduce rinse water waste flows by up to 95% over conventional method.
- It reduces wastewater treatment costs.
- It is a simple technique which requires very little maintenance after installation.

The major disadvantages to counterflow rinsing are:

- Series of counterflow rinsing tanks require additional space in the plant.
- Additional rinsing increases production time.
- May not be cost effective if treatment cost savings do not offset costs of additional tanks, space requirements and longer production time.
- Aeration may be required to ensure adequate mixing of rinse water.

Counterflow rinsing was specifically indicated by a number of companies in our survey as their major means of rinse water reduction. Other studies indicate that it is usually the most common form of rinse water recycling practice used by the metal finishing industry. Environment Canada (1987) found that 27% of metal finishers in Canada used this technique. Two recent studies of Ontario and Alberta, Proctor & Redfern (1991) and Monenco (1992) respectively, found that about 46% of respondents use counterflow rinsing.

Spray Rinsing

Residual drag-out is sprayed off over the plating tanks which allows rinse water to drain directly back into plating baths to make up for evaporative losses.

Spray rinsing has several advantages:

- This method uses less water than rinse water baths.
- Spray rinsing can recover 75% of the residual dragout materials.
- It requires less space than other methods of rinse water recovery, most notably counterflow rinsing.
- This method can be applied to plating baths which are operated at higher temperatures since addition of rinse water into the tank makes up for evaporation losses.

The method has two important drawbacks:

- Although spray rinsing is particularly well-suited to flat items such as printed circuit boards, it is not as effective for parts with more complicated designs.
- Although this method is compatible with counterflow rinsing, it precludes other waste reduction methods such as cascade rinsing.

Despite these drawbacks, spray rinsing is one of the most common rinse water recycling practice used by metal finishers. Environment Canada (1987) found that 144 firms, or 26% of respondents used spray rinses. In particular, the majority of hard chrome operations use spray rinsing over plating tanks. Ontario metal finishers indicated that this method was the second most common wastewater reduction method with approximately 35% of respondents using spray rinsing (Proctor & Redfern, 1991).

Still Rinsing

Also called "dead" rinsing, this method uses a rinse water tank that is not continually overflowing and being replenished.

The advantages of still rinsing include:

- Dead rinse waters can be returned to the plating tank to make up for losses due to evaporation.
- Where there are a series of plating tanks, a dead rinse tank can be placed before a plating tank to drag in small amounts of plating solution to make up for the drag out lost as the part is removed from the plating bath.

There are two notable disadvantages of still rinsing:

- Still rinsewater tanks must be used in conjunction with other rinse tanks and therefore require additional space.
- Without additional water flowing into the tank, rinsewater may not be mixed enough to allow for full usage of the entire volume of the tank.

Still rinsing was one of the first methods used by the industry to recover plating solution and is still very common; almost every plant has at least one still rinse tank.

Cascade Rinsing

Also known as "reactive" rinsing, this practice involves using rinse water effluent from one operation as a rinse water supply for a compatible operation. For example, effluent from an acid rinse water bath may be used as the rinse water supply for an alkaline cleaning process that precedes the acid bath. The acid in the effluent helps neutralize some of the dragged-in alkaline in the acid bath, thereby extending the life of the acid bath.

Desirable features of cascade rinsing include:

- Cascade rinsing prolongs the life of plating and cleaning solution baths.
- It can be used in conjunction with other waste minimization techniques such as counterflow rinsing.

Cascade rinsing has two significant disadvantages:

- It can only be used when chemicals used in various baths are compatible such as an acid and an alkaline solution.
- This method requires linking operations which may result in production scheduling changes or extended production time.

Cascade rinsing is less commonly used than other rinsing practices. Nineteen percent of companies in Alberta use cascade rinsing (Monenco, 1992).

Improved Mixing

Improved mixing refers to the use of agitation techniques to mix tank contents and help remove excess plating solution from parts. Mixing techniques include: placing inflow pipe at bottom of the tank, air or mechanical agitation, hydraulic or ultrasonic devices.

There are three advantages to improved mixing of tank contents:

- Properly mixed rinse water tanks improve efficiency by ensuring the entire tank is used.
- Mixing of rinse tank contents with air or mechanical devices requires that lower rinse water inflow rates, thereby reducing the amount of water used.
- Agitation of rinsewater is effective in removing excess plating bath solution from plated parts.

The only potential drawback to improved mixing is the need for additional equipment such as water lines, or mixing machinery to be placed in the tank to agitate the rinsewater. Additional mixing machinery for instance, could require extra space.

Improved mixing techniques are employed by most metal finishers, since it is a simple means to increase the efficiency of rinsewater tanks. The Alberta study found that 50% of firms responding used rinse water agitation (Monenco, 1992). Although there are no figures specifically on the improved mixing techniques in other areas of Canada it is likely that approximately the same percentage use improved mixing.

Flow Control

Flow control refers to the use of valves to regulate the amount of water inflow into rinsing tanks.

The advantages of flow control systems include:

- Water supply valves can be used to keep effluent flow rates to rinsing tanks at a minimum and therefore reduce water usage.
- Flow control ensures constant flowrates and constant quality of rinsing despite variations in water line pressure.

There is one major drawback to flow controls:

- The effectiveness of the flow control may be limited where high flow rates are required to provide adequate mixing in rinse water tanks.

The Ontario study found 76 firms, 29% of respondents used rinse water flow controls while the Alberta study shows 50% of the 80 responding companies employed flow controls.

Conductivity Control

Conductivity meters can be placed in rinse tanks to measure the conductance of the solution and infer the contamination of a rinse tank. As the rinse water becomes contaminated, the ionic strength increases and the conductance measure increases. When the conductance reading reaches a set point, the controller allows additional water to enter the rinse water tank.

The advantage of the conductivity control system is that it minimizes the amount of fresh water added to the rinse tank while ensuring that the parts are properly rinsed.

The disadvantages to conductivity control meters are:

- They must be regularly maintained to perform well and do not withstand rugged conditions.
- It is often difficult to establish optimum set points.

Since they are relatively inexpensive, conductivity controllers were once widely used, however as their disadvantages became known they became less prevalent. The Environment Canada 1987 study found 45 companies, only 8% of respondents used conductivity meters and the provincial studies also found 8% of plants indicated that they used conductivity controllers.

Timers

Timers are also employed to ensure mixing occurs at appropriate times and that flow is adequate. They are used to reduce rinse water flow by providing inflow only when rinsing is taking place. Timers have similar advantages and disadvantages as conductivity cells.

7.2 Drag-Out Minimization and Recovery

As workpieces are removed from plating solution baths, some residual plating solutions remains on the part, the residual solution is drag-out. Drag-out is rinsed off of plated parts with rinse water baths or sprays. Recovery and minimization of drag-out can be achieved using a variety of methods including:

- longer withdrawal/drainage times
- minimize concentration of plating baths
- reduction of bath viscosity
- rotation of plating barrel over process tank
- low pressure air jets over process tank
- agitate plating bath contents
- use de-ionized water
- use of tanks to catch splashes or spills
- surface tension reduction
- improved racking orientation
- drip bars over process tanks
- maximize holes in plating barrel
- increase plating bath temperature
- use drain boards between tanks
- rock parts to maximize drainage
- segregation of effluents

Drag-out minimization and recovery has several significant advantages:

- Recovery of drag-out is a relatively inexpensive material recovery procedure.
- Minimizing or using drag-out will reduce the total amount of rinse water required and the amount of rinse water that must be treated.
- Carry-over from one process bath to the next is reduced so there is less cross-contamination between process tanks.
- Drag-out minimization and recovery methods often involve simple, operational or process changes.
- Recovery and minimization techniques can easily be used in conjunction with other material recovery methods.

There is one notable disadvantages associated with drag-out recovery:

- Additional time required to drain off drag-out increases total production time.

Our survey results indicate that half of responding firms, 44 of 88, practice some form of drag-out recovery. In particular, longer withdrawal time was used by 28 of 88, or 32% of respondents. Existing studies show similar trends. Environment Canada (1987) reports that: 32% of firms used delays to reduce dragout; 32% of firms had tanks to catch spills; and 18.5% of firms practised effluent segregation.

More recent findings indicate that in Ontario 37% of operations use longer withdrawal/drainage time and 16% use wetting agents to reduce surface tension or viscosity in plating baths. Monenco (1992) reports somewhat higher rates in Alberta study. There were 78% of firms using longer drainage over plating tanks and 35% using drip collection between tanks.

7.3 Evaporation

Evaporation of rinse waters is used to increase the concentration of metals contained in the rinsewater baths. The concentrated solution can then be purified and reused in plating baths. This method can be used for many metal finishing processes including: chromium, nickel, copper, cadmium, brass, zinc, silver, gold, alkalis and acids.

There are two types of evaporators, atmospheric and vacuum. Atmospheric evaporators evaporate 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 take advantage of the lower boiling point of the liquids in low pressure conditions. Energy requirements are lower for vacuum evaporation as is the potential for decomposition of the recovered materials.

Evaporation has several advantages as a recovery procedure:

- Evaporators are readily available on the commercial market with sufficient selection for both small and large metal finishing operations.
- May be used with other recovery systems such as ion exchange to form a closed loop system which reuses all rinse waters.
- Large plants may find recovery of chromium, nickel and cyanide may have a favourable pay-back period with considerable savings if conventional rinse water treatment is avoided.
- Atmospheric evaporation is a relatively simple technology and is therefore easier to install, operate and maintain than some other recovery methods.

There are some significant disadvantages to using evaporation:

- Evaporation is relatively costly as a result of higher capital costs and energy required to generate steam.
- Not suitable for highly diluted solutions due to high energy consumption.
- 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.
- Evaporation, in particular vacuum evaporation, requires significant expertise to operate efficiently.

Evaporation is one of the most frequently used recovery technologies. Our questionnaire found 41% of respondents use evaporation recovery. This is considerably higher than other studies. Environment Canada (1987) found evaporation techniques in less than 4% of metal finishing operations. Proctor & Redfern (1991) indicates that 9% of Ontario metal finishers use this method. The Alberta study did not identify evaporation as prevalent in waste minimization practices (Monenco, 1992).

7.4 Ion Exchange

Ion exchange involves passing wastewater through a resin bed which contains negatively and positively charged ions. Harmless ions held by electrostatic forces in the resin are exchanged for targeted ions in the solution, such as metals. When the exchange sites on the resin are saturated, the resin is regenerated using an acid or a base.

Ion exchange can be used for chemical recovery, water recycling or effluent polishing. Commercial applications include acid-copper, acid-zinc, nickel, tin, cobalt, 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.

The advantages of using ion exchange include:

- Ion exchange is an 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.
- Ion exchange may be cost-effective when drag-out rates are relatively high and costs of waste treatment is prohibitive.

However, ion exchange has the following major disadvantages:

- The upper concentration limit is generally $\leq$ 2500 mg/L for efficient operation.
- Relatively high capital expenditures are needed to set up this type of system.
- Regenerating resin on-site requires either a shut-down period or multiple ion exchangers.
- Regeneration agents contain metals and other targeted materials and may be recoverable but often need to be treated before disposal.
- Ion exchange is a relatively complex technology and has significant installation, operation and maintenance requirements.

Ion exchange is not as common as some of the other materials recovery practices for some of the reasons given above. Our survey found that about 20% of responding plants use this system. Environment Canada (1987) indicates less than 5% of metal finishers use ion exchange. Only 4% of Ontario plants and 1% of metal finishers in Alberta are reported to use ion exchange (Proctor & Redfern, 1991; Monenco, 1992).

7.5 Reverse Osmosis

Reverse osmosis separates solute from a solution by forcing the solvent through a semipermeable membrane by applying a pressure usually 2750-5500 kPa. The membrane permeate can be used as rinse water and the remaining concentrate may be returned to the plating bath. This procedure can be applied to recover nickel, copper, cadmium, zinc and other solutions.

The advantages of reverse osmosis include:

- This process is relatively inexpensive and requires little floor space to operate.
- Reverse osmosis may be applied to any dilute waste stream where ionic species removal is desired.
- Power requirements for this system are low.
- Pure water is produced as a byproduct which can be used as rinse water.
- Pay-back periods of about three years have been realized by industry.

Disadvantages include the following:

- There is a narrow operating temperature, and pH range at which this process is effective.
- The membrane is susceptible to strong acids, bases and particulate matter and can be expected to last only 1 - 4 years.
- Replacement costs for membranes, high pressure pumps and accessories may be significant.

Reverse osmosis is rarely used in Canada. Our questionnaire results show 3 firms using it and the Environment Canada (1987) study found only 2 metal finishers using reverse osmosis. The Ontario and Alberta studies do not specifically list the number of plants using reverse osmosis.

7.6 Electrolytic Recovery

Electrolytic recovery refers to the use of an electrolytic cell through which, metal ions in the wastewater are deposited onto a cathode while elemental metals and oxygen are produced at the anode. Conventional electrolytic recovery used stainless steel cathodes. More advanced methods have been developed which feature the use of stainless steel mesh cathodes, expanded meal-mesh electrodes or carbon filament mats cathodes.

The advantages of using electrolytic recovery are:

- This method is highly effective in recovering metals; rates of 90-98% have been realized with advanced systems. Recovering such a high percentage of metals significantly extends bath life.
- Cyanide in rinse water is destroyed through oxidation in this process and therefore pretreatment processes for cyanide are not necessary.
- Recovered metal foil or powder is of high purity and is valuable for reuse or resale.
- Installation, operating and service requirements for this relatively simple technology are lower than other recovery processes.

The use of electrolytic recovery is limited by the following disadvantages:

- Electrolytic recovery tends not to work when metal concentrations are low (e.g., below 100 mg/l).
- This method is generally not useful for treating organic wastes or viscous liquids.
- Fumes consisting of oxygen, hydrogen, chlorine and other gases may form and require a scrubbing system to be set up.
- The remaining waste requires further treatment. Usually the waste is batch treated and disposed of as sludge.

Electrolytic recovery is used by 13% of firms responding to this study's survey. Environment Canada (1987) found only about 1% of metal finishers employed this recovery technology. In Ontario, about 7% of firms use this method (Proctor & Redfern, 1991).

7.7 Electrodialysis

Electrodialysis is a relatively new waste recovery method which utilizes an electrical driving force over a series of ion exchange membranes. Positively and negatively charged ions move to opposite ends of alternating ion-permeable membranes. Alternating cells of dilute solutions and concentrated solutions are formed. Dilute solutions may be recycled as rinse water and concentrated solutions are returned to the plating tanks. This technique is generally used for treating rinse tanks to minimize build-up.

Electrodialysis has two major advantages:

- It can produce more concentrated solutions than reverse osmosis or ion exchange processes.
- Electrodialysis does not often require an accompanying evaporator when used with ambient temperature baths.

The disadvantages include:

- Electrodialysis is only partially effective in removing contaminants such as brighteners and wetting agents and is generally not feasible as a standard "turnkey" system.
- Electrical requirements for this system are generally high.
- Membranes may be fouled by precipitation of metals and would need to be replaced; particulate mater and oxidizing substances must be removed prior to processing.
- This method is not economically feasible for very dilute rinse water; other treatment methods may be required before final effluent is discharged.

Only one of the metal finishing companies responding to our questionnaire and interview questions uses electrodialysis for material recovery. The extent of electrodialysis use is not discussed in other reports.

7.8 Ultrafiltration

Ultrafiltration refers to the use of very fine filters of 5 microns to 0.5 microns to remove oils and solid materials from cleaner tanks. It is most often used with nickel chrome plating lines.

The advantage of ultrafiltration is that it is one of the only methods available to extend the life of cleaner solutions.

There are several disadvantages to using ultrafiltration:

- Ultrafiltration does not remove dissolved metals from cleaner solution, only oils and other solid matter.
- Ultrafiltration systems are relatively expensive and (as noted above) are limited in the materials they can recover; they are not economical for small to medium sized companies.

- These systems are quite complicated and require additional equipment, such as pumps, which take up extra space.

Our questionnaire responses suggest that 16% of metal finishers use ultrafiltration methods to recover waste. Ultrafiltration is not specifically discussed in other studies.

7.9 Summary of Findings

Prevalence

Exhibit 7.1 below summarizes the use of material recovery or recycling practices by Canadian metal finishing companies.

Exhibit 7.1
Summary of Material Recovery/Recycling Practices
Percentage of Total Firms Responding to Surveys

Practice	Canada 1983/84	Ontario 1989	Alberta 1991	Canada 1993
Rinse Water Reduction/Reuse				67
Counterflow Rinsing	27	46	46	na
Spray Rinsing	26	35	61	na
Still Rinsing	na	na	na	na
Cascade Rinsing	na	na	19	na
Improved Mixing	na	na	50	na
Flow Control	na	29	50	na
Conductivity Control	8	8	8	na
Timers	na	na	na	na
Drag-Out				50
Minimization/Recovery	32	37	78	32
Longer Withdrawal	32	na	35	na
Spill/Drip Collection	19	na	na	na
Effluent Segregation	na	16	28	na
Wetting Agents				
Evaporation	4	9	na	41
Ion Exchange	5	4	1	20
Reverse Osmosis	1	na	na	3
Electrolytic Recovery	1	7	na	13
Electrodialysis	na	na	na	2
Ultrafiltration	na	1	na	16

Sources: Environment Canada (1987), Proctor & Redfern (1991), Monenco (1992) and responses to the questionnaire and interview program conducted for this study.

Barriers to Increased Material Recovery and Recycling

Although nearly all (94%) metal finishers use at least one material recycling or recovery method, most companies identify barriers to increased material recycling and recovery. Exhibit 7.2 summarizes survey responses concerning barriers to increased material recovery and recycling. We discuss the most important barriers below.

Exhibit 7.2
Barriers to Increased Material Recovery/Recycling

Barrier	Percentage of Total Firms Responding
Cost Constraints	66
Lack of Markets for Recovered Materials	39
Space Constraints	35
Lack of Technical Knowledge	24
Government Regulations	16

Cost Constraints

Economic factors seem to be the most significant barrier for the majority of companies, with two-thirds of metal finishers identifying cost constraints as important. These cost constraints exist despite the following factors.

- 64% of metal finishers experience lower costs as a result of recycling and recovery practices. A small sample of firms indicated that operating costs are reduced by an average of 6%.
- 17% of metal finishers generate revenue by selling recovered materials. For example, some suppliers of electroless copper reportedly will take back "waste materials." Falconbridge and Inco also buy back relatively small quantities of metal-containing sludge.

These offsetting benefits, however, are apparently not sufficient to make recycling and recovery profitable activities.

Cost constraints are closely linked with the problems faced by many metal finishers in raising investment capital for material recovery and recycling. As described in Section 5 of the report, metal finishers cite difficulties in raising investment funds for recovery/recycling systems as a major factor affecting their competitiveness and financial viability.

Finally, more education and training of system operators could improve the effectiveness of recycling/recovery systems. This would increase the offsetting benefits, thereby increasing the overall economic viability of material recycling/recovery.

Lack of Markets for Recovered Materials

After cost constraints, the next most common barrier noted was the lack of markets for recovered materials. Thirty-nine percent of firms indicated this prevented increased use of recovery methods.

One important factor in the lack of markets for recovered materials is the small amounts generated by many metal finishers. Several small firms indicated that:

- the volume of waste material they generate is too small to warrant investing in recovery technology;
- metal producers will only accept recovered materials that will not upset their operations; and
- metal producers will only accept recovered materials in large quantities.

Space Constraints

Lack of space to install treatment systems was cited by 35% of metal finishers as a constraint to material recovery and recycling. Depending on plant lay-out, space constraints can increase significantly the cost of retrofitting metal finishing operations. For example, some plants may not have sufficient space around metal finishing lines for additional recovery and recycling equipment.

Lack of Technical Knowledge

Lack of technical knowledge refers to two related factors.

(i) Some metal finishers are unaware of the existing technical options for material recycling and recovery. The small size of job shops makes it difficult to quickly disseminate information on new recovery equipment. This is particularly true for new technical options.

(ii) Operation of some pollution control equipment requires knowledgeable operators. About one-quarter of metal finishers cite lack of knowledge as an impediment to material recycling and recovery.

Suppliers of pollution control equipment offer some training in the use of their products. However, some industry representatives indicate that this is not sufficient. There have been some attempts to develop provincial certification programs for treatment system operators to redress this problem.

Government Regulations

Government regulations were cited by 16% of metal finishers as being an impediment to increased material recycling and recovery. Metal finishers cite regulations regarding the transportation, storage and management of hazardous waste as being major constraints. More specifically, some metal finishing waste could be recycled if sent to metal refineries. While it is not economical for individual smaller finishing operations to ship their wastes to refineries, pooling wastes may be possible. However, provincial regulations generally require anyone pooling hazardous waste to be registered as a hazardous waste receiver.

8.0 Environmental Regulations Affecting Metal Finishing

This section of the report is meant to supplement information contained in CH2M Hill (1994). This previous background study reviewed regulations pertaining to air emissions, waste water and wastes promulgated in the following jurisdictions:

- Canada (federal, provincial and selected municipalities);
- United States (federal, state and municipalities); and
- Europe (European Economic Community, United Kingdom, France, Germany).

To provide a broader picture of environmental regulations affecting the metal finishing industry, this section describes regulations in the following jurisdictions:

- United States (additional federal effluent standards);
- Mexico;
- Hong Kong; and
- Singapore.

Repeated requests for information on regulations affecting the metal finishing industry were also sent to embassies and/or local economic and trade development offices for Japan, Malaysia, Korea, Taiwan and Indonesia. However, no responses were provided.

Information was also sought regarding compliance costs and monitoring and enforcement efforts in each of the above countries. Limited information was available for the United States.

8.1 United States

CH2M Hill (1994) reviews federal, state and municipal regulations for air emissions, effluent and waste. That information is not repeated here. However, additional information is presented on the costs of complying with U.S. federal effluent standards.

8.0 Environmental Regulations Affecting the Metal Finishing

Metal finishing effluent standards set by the U.S. Environmental Protection Agency are listed in Exhibit 8.1[20] Pretreatment Standards apply to those operations discharging to publicly-owned treatment plants. Best Available Technology Effluent Limits and New Source Performance Standards apply to operations discharging directly to waterways. "New sources" are defined as those operations starting up since 1983.

Other effluent standards may apply for captive shops in the following industries: nonferrous metal smelting and refining; coil coating; porcelain enamelling; battery manufacturing; iron and steel; metal castings foundries; aluminum forming; copper forming; plastic moulding and forming; nonferrous forming; and electrical and electronic components.

These standards represent minimum standards that metal finishers must achieve. State and municipal governments may impose more stringent requirements.

In addition to the effluent standards, all dischargers subject to a pretreatment standard or new source standards must produce Discharge Monitoring Reports every six months under Parts 403.12 (e) and 122 of the Regulations Code. These reports must indicate the nature and concentration of discharges of regulated pollutants as well as records of measured or estimated daily high, low and average releases. The control authority may specify further reporting requirements or develop alternative reporting methods such as certification statements with individual dischargers. Cyanide dischargers must self-monitor by:

- monitoring cyanide waste after treatment but before it is mixed with other effluent streams; or
- monitoring the final effluent flow given the plant's limits adjusted for the dilution ratio (cyanide waste flow to the effluent flow).

20 Existing, indirect discharging electroplating job shops and independent printed circuit board manufacturers are also subject to the U.S. EPA Electroplating Point Source Category Regulations (CFR Part 413). However, these older effluent standards are not as stringent as the newer effluent standards for the metal finishing industry.

Exhibit 8.1
Pretreatment Standards for U.S. Metal Finishing Effluent
(mg/l)

Pollutant	Best Available Technology Effluent Limits		Pretreatment Standards for Existing Sources		Pretreatment Standards for New Sources		New Source Performance Standards	
	1 Day Max.	30 Day Avg.	1 Day Max.	30 Day Avg.	1 Day Max.	30 Day Avg.	1 Day Max.	30 Day Avg.
Cadmium	0.69	0.26	0.69	0.26	0.11	0.07	0.11	0.07
Chromium	2.77	1.71	2.77	1.71	2.77	1.71	2.77	1.71
Copper	3.38	2.07	3.38	2.07	3.38	2.07	3.38	2.07
Lead	0.69	0.43	0.69	0.43	0.69	0.43	0.69	0.43
Nickel	3.98	2.38	3.98	2.38	3.98	2.38	3.98	2.38
Silver	0.43	0.24	0.43	0.24	0.43	0.24	0.43	0.24
Zinc	2.61	1.48	2.61	1.48	2.61	1.48	2.61	1.48
Cyanide	1.2	0.65	1.2	0.65	1.20	0.65	1.2	0.65
Total Toxic Organics	2.13	-	2.13	-	2.13	-	2.13	-

Source: *U.S. Code of Federal Regulations* Title 40, Part 433.

Estimated Compliance Costs[21]

The U.S. Environmental Protection Agency developed estimates of the costs of complying with the metal finishing effluent standards (U.S. EPA, 1982) and assessed the economic impacts of the standards. Cost estimates and impacts were assessed for three categories of metal finishers: job shops; captive shops; and independent printed circuit board manufacturers.

It is important to realize that these cost estimates are only the costs of the *incremental* reductions required by the metal finishing effluent guidelines. The costs of achieving reductions required by previous regulations are omitted.

Job Shops

It was expected that, on average, each direct discharging job shop would have incremental compliance costs of over US$2,890 per year. These figures are based on the fact that all shops in this category already met requirements for precipitation/clarification, hexavalent chrome reduction, alkaline chlorination and sludge dewatering. The only additional requirements were that shops comply with a "no dumping of total toxic organics" provision and invest in a multimedia filtration unit.

In addition, a one-time monitoring cost of $1,904 was expected to be incurred by 15% of direct discharging job shops. A further 2% of such shops were expected to incur this monitoring cost on an annual basis.

Indirect discharging job shops were expected to incur only monitoring costs of the same magnitude and frequency as direct discharging job shops.

Independent Printed Circuit Board (IPCB) Manufacturers

All independent circuit board manufacturers are already subject to effluent standards of stringency equal to metal finishing effluent standards. Therefore, only monitoring costs will be incurred by IPCB plants. All plants will incur a one-time monitoring cost of $1,904 and 27% of plants will incur annual monitoring costs of $2,890.

21 Cost estimates are taken from: U.S. EPA (1982) *Development Document for Effluent Limitations Guidelines and Standards for the Metal Finishing Point Source Category*; and U.S. EPA (1983) *Economic Impact Analysis of Effluent Standards and Limitations for the Metal Finishing Industry*. All estimates are in per plant 1982 U.S. dollars.

Captive Shops

Direct and indirect discharging captive shops compliance costs vary widely depending on the volume of their effluent stream. The annual costs of reduction measures range from $8,415 for plants with less than 10,000 gallons per day of effluent up to $154,814 for plants with greater than 500,000 gallons per day.

One time monitoring costs are expected to affect 36% of captive shops and result in an extra US$1,900 for each affected firm. Annual monitoring is expected to affect about 6% of captive shops and result in incremental costs of US$2,890 per year for each plant.

8.2 Mexico

The Mexican government has established limits for metal finishers that discharge into water bodies. It is not clear, however, whether these regulations apply to indirect dischargers as well as direct dischargers. The regulations have been designed to support codified water quality objectives and are supported with a series of test protocols. Exhibit 8.2 presents Mexico's metal finishing effluent standards.

Exhibit 8.2
Mexican Standards for Direct Discharges from Metal Finishing Operations

Parameter	Average Daily Limit (mg/L)	Instantaneous Limit (mg/L)
pH	6-9	6-9
Sedimentary Solids	1.0	1.2
Suspended Solids	50.0	60.0
Grease and oils	10.0	15.0
Hexavalent Chromium	0.1	0.2
Total Chromium	0.5	1.0
Copper	0.5	1.0
Nickel	2.0	2.4
Iron	1.0	1.2
Zinc	0.5	1.0
Cyanide	0.1	0.2
Cadmium	0.2	0.4
Lead	0.1	0.2
Aluminum	1.0	0.2
Barium	2.0	2.4
Manganese	2.0	2.4

In addition to these standards, metal finishing companies are requested to limit amounts chemical oxygen, dissolved solids, and fluorine in discharges as well as monitoring the temperature of discharge. However, no legally enforceable or voluntary standards are provided.

8.3 Hong Kong

It is estimated that there are about 1000 metal finishers in Hong Kong. Metal finishing operations in Hong Kong are subject to three environmental ordinances: the Water Pollution Control Ordinance, the Air Pollution Control Ordinance, and the Waste Disposal Ordinance.

Water Pollution

Under the Water Pollution Control Ordinance (WPCO) an area is first designated as a water control zone, and within each zone effluent discharge limits are established in a Technical Memorandum. These limits are then controlled through licensing. Currently 7 water control zones have been declared in Hong Kong and the government plans to declare remaining areas in the near future so that WPCO will be applied throughout the territory. All dischargers of waste or polluting materials into any inland, territorial, or tidal waters within a zone must have a license (with the exception of domestic sewage discharged into a foul sewer). The discharger must ensure that the effluent meets the standards stipulated in the license but the Government monitors discharges. The maximum penalty for a first offence is HK$100,000 (about $C17,000) and HK$200,000 for any subsequent offenses. Continuing offenses under WPCO may result in additional fines of $HK5,000 per day.

Exhibit 8.3 presents the limits on discharges of selected substances into sewers leading to government treatment plants. The technical memorandum also includes specific discharge levels for effluent discharged into 4 inland water groups and the seven water control zones.

Discharge levels permitted into inland waters and water control zones are typically much lower than the effluent discharged into sewers. Of the substances Environment Canada is interested in the following upper limits for discharges into inland waters and water control zone were noted:

Cadmium	Limits for cadmium are specified in all tables for inland waters and water control zones. Inland waters limits are much lower than sewers at 0.001 mg/L permitted for all flow rates. Water control zones set limits at the same level as sewers for high flow rates but usually have lower limits of 0.1 or 0.5 mg/L at flow rates under 400 m^3/day.
Copper	Copper is listed specifically only in two of the inland water areas. Limits are usually 0.2 mg/L or less for each flow rate.
Nickel	Only listed in one inland water area. Upper limit of 0.2 mg/L for flow rates up to 1000 m^3/day, at higher levels nickel is limited to 0.1 mg/L.
Chromium	Permissable discharge for chromium is listed specifically for one inland water region, at level of 0.05 mg/L for all flow rates.

Exhibit 8.3
Hong Kong Standards For Effluents Discharged into Foul Sewers Leading into Government Sewage Treatment Plants
(upper limits expressed in mg/L)

Substance	Flow Rate (m³/d)												
	≤10	>10 and ≤100	>100 and ≤200	>200 and ≤400	>400 and ≤600	>600 and ≤800	>800 and ≤1000	>1000 and ≤1500	>1500 and ≤2000	>2000 and ≤3000	>3000 and ≤4000	>4000 and ≤5000	>5000 and ≤6000
Cadmium	.2	.15	.1	.001	.001	.001	.001	.001	.001	.001	.001	.001	.001
Copper	4	4	4	3	1.5	1.5	1	1	1	1	1	1	1
Copper*	1.5	1	1	1	0.8	0.6	0.5	0.4	0.3	0.2	0.15	0.1	0.05
Nickel	4	3	3	2	1.5	1	1	0.8	0.7	0.7	0.6	0.6	0.6
Chromium	2	2	2	2	1	0.7	0.6	0.4	0.3	0.2	0.1	0.1	0.1
Zinc	5	5	4	3	1.5	1.5	1	0.8	0.7	0.7	0.6	0.6	0.6

* standard for copper discharged into foul sewers leading to government sewage treatment plants with microbial treatment.

Source: Hong Kong Water Pollution Control Ordinance, Technical Memorandum: Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters.

Zinc — **Zinc levels are specified for only one inland water region, at 1 mg/L for all flow rates.**

Lead — **Lead is not specified in sewer discharge limits but is noted in 2 of the inland water regions. Permissible upper limits are usually 0.1 or 0.2 mg/L or less for all flow rates.**

Compliance rates for metal finishers were not available. Costs of compliance vary from firm to firm however, ensuring upper limits are not exceeded may involve installing pre-treatment systems.

Air Pollution

The Air Pollution Control Ordinance (APCO) was signed in 1989. This ordinance controls emissions of air pollutants form stationary sources including metal finishing operations. The government may declare any region in Hong Kong to be an air control zone and set air quality objectives within each zone. In general 23 processes have been identified as specific processes for which a license is required. Factories are required to do their own sampling and submit monitoring data to the Environmental Protection Department. The EPD also does emission/effluent sampling to collect evidence for prosecution. Penalties for non-compliance with air pollution control measures vary depending on the offence; maximum fines range from HK$5,000 to HK$50,000 with potential additional fines for continued non-compliance.

Draft Codes of practice have been established for several types of operations that are subject to APCO including electroplating, metal pickling processes and spray painting. These codes are expected to be introduced in 1994/95. Exhibit 8.4 outlines the pollution limits presented in the draft codes of practice.

Information on rates of compliance among metal finishers was not available for air pollution controls. Costs of compliance includes installing suitable air pollution control equipment, and if necessary, undergoing modification and/or material substitution.

Waste Disposal

The Waste Control Ordinance (WDO) is the legislative mechanism which governs chemical waste. This ordinance has been in effect only since May 1993. Under the WDO, chemical waste producers are required to register with the Environmental Protection Department and must comply with labelling and storage of their chemical waste. Chemical waste includes any substance or thing that is scrap material, effluent or by-product from processes that involve chemicals listed on the prescribed schedule and that cause pollution or endanger health. Chemical wastes must be collected and transported by licensed collector to licensed facilities for treatment and disposal.

Exhibit 8.4
Hong Kong Draft Codes of Practice
Ambient Air Pollution Standards and Limits

	1-Hr Ambient Standard ($\mu g/m^3$)	Emission Limit (g/m^3)
Electroplating		
H_2SO_4	100	0.5
HCl	70	0.4
H_3PO_4	30	0.5
NH_3	180	0.5
Cr^{+6} compounds	0.25	0.01
Cr compounds	0.3	0.02
CN^-	50	0.01
Ni compounds	0.5	0.02
Sn compounds	20	0.02
Metal Pickling Processes		
NHO_3	300	0.5
NO_2	100	0.5
H_2SO_4	100	0.1*
H_3SO_4	30	0.4
HCl	70	0.4
HF	30	0.4

* expressed as SO_3

Source: Hong Kong Air Pollution Control Ordinance, Appendix B - Codes of Practice.

A government-owned chemical waste treatment centre has been established to enable chemical waste producers to comply with the regulations. The maximum fines for non-compliance is HK$200,000 and 6 months in prison. The government is considering implementing a charging scheme on disposal of chemical waste at present which would significantly affect the costs of compliance with WDO.

8.4 Singapore

Singapore's Ministry of the Environment (MOE) has established allowable limits for metal finishing effluent discharges to sewers, water courses and controlled watercourses. Controlled watercourses are those waterways from which potable water is supplied by the Public Utilities Board but does not include a watercourse from which water is pumped into a PUB water main. Exhibit 8.5 shows Singapore's effluent discharge limits.

Metal finishing plants that generate effluent that exceeds the limits listed above are required to install, operate and maintain a treatment system that reduces contaminants to the allowable limits. Diluting effluent with potable water, rainwater and industrial water to comply with effluent standards is not permitted. The Ministry of the Environment has issued technical requirements for the waste treatment systems which includes requirements for pH self-monitoring and effluent inspection equipment. Failure to meet effluent limits will render the factory liable to prosecution.

The MOE also requires that chemicals and oil be stored in a designated covered storage area that will contain any leakage and spillage. Spills and leaks must not be able to reach a stormwater drain or sewer. All spillage must be collected and disposed of as toxic industrial waste.

8.5 Summary

In many cases, it is difficult to compare metal finishing regulations across countries. Some of the difficulties encountered are that:

- some countries have standards that vary with flow rates;
- some countries have standards that vary depending on the ambient quality of the receiving waterbody;
- some countries have special standards for new sources; and
- the substances controlled by regulations vary across countries.

Nevertheless, Exhibit 8.6 summarizes metal finishing effluent standards from 8 countries. Readers are advised to refer back to the original discussions for details on each set of standards.

Exhibit 8.5
Singapore's Allowable Limits for Effluent Discharges
(mg/L unless otherwise noted)

Substance	Sewer	Watercourse	Controlled Watercourse
pH Value	6-9	6-9	6-9
Total Suspended Solids	400	50	30
Total Dissolved Solids	3000	2000	1000
Chloride (as chloride ion)	1000	600	400
Sulphate (as SO_4)	1000	500	200
Sulphide (as sulphur)	1	0.2	0.2
Cyanide (as CN)	2	0.1	0.1
Grease and Oil	60	10	5
Arsenic	5	1	0.05
Barium	10	5	5
Tin	10	10	5
Iron	50	20	1
Manganese	10	5	0.5
Phenolic Compounds	0.5	0.2	Nil
Cadmium	1	0.1	0.01
Chromium (trivalent and hexavalent)	5	1	0.05
Copper	5	0.1	0.1
Lead	5	0.1	0.1
Mercury	0.5	0.05	0.001
Nickel	10	1	0.1
Selenium	10	0.5	0.01
Silver	5	0.1	0.1
Zinc	10	1	0.5
Metals in Total	10	1	0.5
Chlorine (Free)	10	1	0.5

Source: Singapore Ministry of the Environment.

Exhibit 8.6
Summary of Metal Finishing Effluent Standards (in mg/l)

Regulation	Cadmium	Chromium	Copper	Cyanide	Lead	Nickel	Zinc
Canada *Federal Metal Finishing Liquid Effluent Guidelines*	1.5	1.0	1.0	0.1 (oxidizable) 3.0 (total)	1.5	2.0	2.0
Canada *Sanitary Sewer Use Effluent Limits (survey of 17 municipalities)*	0.05-4.0	0.05-5.0	0.3-5.0	1.0-3.0	0.2-5.0	0.5-5.0	0.5-10.0
France *Effluent Standards for Metal Finishing*	0.2	0.1 (IV) 3.0 (III)	na	na	1.0	5.0	na
Germany *Proposed Bavaria Sewer Effluent Limits*	0.1-0.5	0.5-2.0	0.3-2.0	na	0.3-2.0	0.3-2.0	na
Hong Kong *Standards for Indirect Discharges*	0.001-0.2	0.1-2.0	0.05-4.0	na	na	0.6-4.0	0.6-5.0
Mexico *Standards for Metal Finishing Direct Discharges (average daily limit)*	0.2	0.5	0.5	na	na	na	na
Singapore *Effluent Limits for Direct Discharges*	0.01-0.1	0.05-1	0.1	0.1-0.1	0.1	0.1-1.0	0.5-1.0
United Kingdom *"Typical" limits applied to Indirect Discharges*	<1.0	2.0-5.0	2.0-5.0	1.0-10.0	2.0-5.0	2.0-5.0	5.0-10.0
United States *Metal Finishing Effluent Regulations*	0.07-0.69	1.71-2.77	2.07-3.38	0.65-1.20	0.69-0.43	2.38-3.98	1.48-2.61

Sources: Exhibits 8.1 to 8.5 and CH2M Hill (1993).

While comparisons are difficult, Exhibit 8.6 reveals that:

- the most stringent sewer use effluent limits in Canada are comparable to the most stringent limits in all the countries surveyed;
- the least stringent sewer effluent limits in Canada are often less stringent than limits in other countries; and
- Canada's Federal Metal Finishing Liquid Effluent Guidelines tend to fall between the most and least stringent sewer use effluent limits imposed by Canadian municipal governments.

Appendix A

Questionnaire

September 22, 1993

ATTENTION METAL FINISHERS

Under the Federal Green Plan, Environment Canada is committed to evaluating the toxicity of substances commonly found in the wastes of metal finishing operations. If the toxicity of these substances is confirmed, Environment Canada will implement policies to limit their release.

Before implementing any policy, Environment Canada will assess policy options to determine how they would affect the competitiveness and financial stability of metal finishing operations. Environment Canada is committed to selecting policies that meet environmental objectives without unduly burdening the metal finishing industry. But your help is needed.

To understand the impact environmental policies may have on the metal finishing industry, an understanding of the current economic situation of the industry is needed. Environment Canada has contracted Apogee Research, in association with Mr. Ken Coulter, to provide a socio-economic assessment of the Canadian metal finishing industry.

Apogee Research is undertaking an extensive research program with over 600 metal finishers and metal finishing suppliers across the country. Please help by completing and returning all or a portion of the attached questionnaire.

Measures have been taken to respect the confidential nature of the information requested. Apogee Research will assess the questionnaire responses and provide conclusions for the industry as a whole. No information contained in the study reports will be attributable to any individual company. Apogee Research will not provide information on individual companies to Environment Canada or any other agent.

Please complete the questionnaire and return it to: Mr. Ken Watson, Apogee Research International Ltd., 144 Front Street, Suite 500, Toronto, Ontario M5J 2L7.

Thank you in advance for your cooperation. It is only with your help that Canada's environmental goals can be met without imposing undue costs on the metal finishing industry.

Jack Dupuis, Executive Director
Canadian Association of Metal Finishers

Arthur Sheffield, Chief
Regulatory and Economic Affairs
Environment Canada

Serge Archambault, Chairman
Metal Finishing Suppliers Association

Walter Wikaruk, Secretary
American Electroplaters & Surface Finishers Society

A Note on Confidentiality...

Your responses to this questionnaire will be aggregated with responses from other firms. Information on individual firms will not be provided to Environment Canada or any other agent. The report outlining the results will not identify any individual firm, either in the text of the report or the tables. Drafts of the report will be sent to the Canadian Association of Metal Finishers for review. Final copies of the report will be available upon request from:

Mike Barré
Regulatory and Economic Affairs Division
Environment Canada
(819) 953-2054

Company Identification...

It is *not* necessary to identify your company. However, if you would like to participate in any follow-up work on how environmental regulations may affect your company, please provide the following information.

Company: ______________________________
Address: ______________________________
____
____
Telephone: ______________ Fax: ______________
Contact: ______________________________

For Assistance or Comments...

Any questions or comments on this questionnaire can be directed, anonymously or otherwise, to:

Ken Watson
Apogee Research
(416) 971-7201

1. Please check any metal finishing processes used in your operations.

Mechanical deburring/sandblasting	_____
Hot dip galvanizing	_____
Electroplating	_____
Electroless plating	_____
Electrocleaning	_____
Anodizing	_____
Alkaline cleaning	_____
Acid pickling	_____
Acid bright dipping	_____
Stripping electrodeposits	_____
Etching	_____
Chemical conversion coating	_____
Electropolishing	_____
Electronic-component operations	_____

Other (specify):

____

____

2. Did you check any of the above metal finishing processes?

IF YES — Please continue the questionnaire
IF NO — Please return the uncompleted survey to Apogee Research

3. Are any of the following substances used in the metal finishing processes of your plant?

Cadmium	_____	Lead	_____
Chromium	_____	Nickel	_____
Copper	_____	Zinc	_____

4. Did you check any of the above substances?

IF YES — Please complete the remainder of the questionnaire
IF NO — Please return the uncompleted survey to Apogee Research

5. In what province(s) are your metal finishing operations located?

____

6. How would you describe your metal finishing operations?

_____ Job Shop
_____ Captive Shop

7. How would you describe the ownership of your company?

_____ Single-Owner/Operator
_____ Partnership
_____ Corporation
_____ Other:_____________________________

8. Over the last five years (1988-1992), how many workers have been employed in your metal finishing operations?

Type of Employee		5-Year Average	5-Year High	5-Year Low	Current
Production Workers	Full-Time				
	Part-Time				
Administration Workers	Full-Time				
	Part-Time				
Total					

9. **Please check any material recovery/recycling practices used in your operations.**

____ reuse of rinsewater
____ evaporation
____ ion exchange
____ electrolytic recovery
____ reverse osmosis
____ electrodialysis
____ ultrafiltration
____ drag out recovery
____ longer drag out time
____ other: ______________________________

10. Do these recovery/recycling practices:

	YES	NO
lower the operating costs of your plant?	___	___
generate revenue from the sale of recovered materials?	___	___

11. Please check any barriers preventing increased material recovery/recycling in your plant.

✓	Possible Barrier
	Technical Knowledge
	Cost Constraints
	Space Constraints
	Lack of Markets for Recovered Materials
	Government Regulations
	Other (specify):

12. Please identify the major sectors your metal finishing operations serve:

✓	Market	% of Total Sales
	Auto Parts	%
	Steel Strip Mills	%
	Pole Hardware and Heavy Steel	%
	Hardware	%
	Electrical Appliances	%
	Wire Goods	%
	Plumbing Fixtures	%
	Electrical Equipment	%
	Furniture	%
	Electronics	%
	Printed Circuit Boards	%
	Engine and Worn Parts	%
	Hollowware and Flatware	%
	Jewellery	%
	Construction	%
	Military	%
	Aircraft	%
	Other (specify):	%

13. What percent of your total sales are accounted for by your largest three customers?
_______%

14. Approximately what percent of your total sales are exported (either by your company or by your customers)? ______%

15. **What are the major trends affecting the markets for your metal finishing services?**

____
____
____
____
____
____
____
____

16. How do you expect the size of your markets to change over the next five years?

Increase by more than 10%	____
Increase by 1% to 10%	____
No Change	____
Decrease by 1% to 10%	____
Decrease by more than 10%	____

17. Is pressure from foreign competitors important to your company's competitiveness and financial stability? (Y/N) ____

If yes, in what countries are these competitors located?

____________________ ____________________
____________________ ____________________

18. Please rate the following factors in terms of their importance to the competitiveness and financial stability of your metal finishing operations. For each factor, place a check in one column. Rank no more than 5 factors as most important.

Factor	Most Important	Important	Not Very Important	Not At All Important
Scarcity of Qualified Labour				
Wage Rates and Benefits				
Increasing Cost of Materials				
Access to New Technology				
Ability to Raise Investment Capital for Production Equipment				
Ability to Raise Investment Capital for Pollution Control Equipment				
Ability to Obtain Operating Credit				
Ability to Achieve Economies of Scale				
Ability to Meet Quality Control Requirements				
Long-Term Decline in Customers' Activity				
Short-Term Decline in Customers' Activity				
Location of Customers				
Interest Rates				
Exchange Rates				
Interprovincial Trade Barriers				
International Trade Barriers				
Federal Tax Structure				
Provincial Tax Structure				
Access to Federal Subsidies				

...continued on next page

Factor	**Most Important**	**Important**	**Not Very Important**	**Not At All Important**
Access to Provincial Subsidies				
Existing Environment Regulations				
Other Government Regulations				
Pressure from Environmental Lobby Groups				
Pressure from Organized Labour				
Other (specify):				
Other (specify):				

If you have the time and would like to provide any additional comments on the factors affecting the competitiveness or financial stability of your firm, please attach a separate sheet of paper.

19. Please check the range in which your company's sales fall.

Sales Range	5-Year Average	5-Year Low	5-Year High	1992 Fiscal Year
$0 to $500,000				
$500,000 to $1 million				
$1 million to $2 million				
$2 million to $5 million				
Over $5 million				

20. **Please check the range of your company's annual investment in metal finishing equipment, machinery and buildings.**

Investment Range	**5-Year Average**	**5-Year Low**	**5-Year High**	**1992 Fiscal Year**
$0 to $50,000				
$50,000 to $150,000				
$150,000 to $500,000				
Over $750,000				

21. Approximately what percent of annual investment in your metal finishing operations is devoted to environmental protection? _____%

22. For the following annual ratios, please indicate your company's five year average (1988-1992).

Ratio	**Definition**	**5-Year Average**
Return on Sales	After Tax Earnings ÷ Sales	
Cash Flow/Total Debt	(After Tax Earnings + Depreciation) ÷ Total Debt	
Return on Assets	After Tax Earnings ÷ Total Assets	
Total Debt/Total Assets	Total Debt ÷ Total Assets	

Appendix B

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