EPA/310-R-95-009

EPA Office of Compliance Sector Notebook Project

Profile of the: Motor Vehicle Assembly Industry

September 1995

Office of Compliance
Office of Enforcement and Compliance Assurance
U.S. Environmental Protection Agency
401 M St., SW (MC 2221-A)
Washington, DC 20460

This report is one in a series of volumes published by the U.S. Environmental Protection Agency (EPA) to provide information of general interest regarding environmental issues associated with specific industrial sectors. The documents were developed under contract by Abt Associates (Cambridge, MA), and Booz-Allen & Hamilton, Inc. (McLean, VA). This publication may be **purchased** from the Superintendent of Documents, U.S. Government Printing Office. A listing of available Sector Notebooks and document numbers is included at the end of this document.

All telephone orders should be directed to:

Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402
(202) 512-1800
FAX (202) 512-2250
8:00 a.m. to 4:30 p.m., EST, M-F

Using the form provided at the end of this document, all mail orders should be directed to:

U.S. Government Printing Office
P.O. Box 371954
Pittsburgh, PA 15250-7954

Complimentary volumes are available to certain groups or subscribers, such as public and academic libraries, Federal, State, local, and foreign governments, and the media. For further information, and for answers to questions pertaining to these documents, please refer to the contact names and numbers provided within this volume.

Electronic versions of all Sector Notebooks are available on the EPA Enviroene Bulletin Board and via Internet on the Enviroene World Wide Web. Downloading procedures are described in Appendix A of this document.

Cover photograph courtesy of Saturn Motors, Spring Hill, Tennessee. Special thanks to Jennifer Graham for providing photographs.

Contacts for Available Sector Notebooks

The Sector Notebooks were developed by the EPA Office of Compliance. Particular questions regarding the Sector Notebook Project in general can be directed to the EPA Work Assignment Managers:

Michael Barrette
US EPA Office of Compliance
401 M St., SW (2223-A)
Washington, DC 20460
(202) 564-7019

Gregory Waldrip
US EPA Office of Compliance
401 M St., SW (2223-A)
Washington, DC 20460
(202) 564-7024

Questions and comments regarding the individual documents can be directed to the appropriate specialists listed below.

Document Number	Industry	Contact	Phone (202)
EPA/310-R-95-001.	Dry Cleaning Industry	Joyce Chandler	564-7073
EPA/310-R-95-002.	Electronics and Computer Industry	Steve Hoover	564-7007
EPA/310-R-95-003.	Wood Furniture and Fixtures Industry	Bob Marshall	564-7021
EPA/310-R-95-004.	Inorganic Chemical Industry	Walter DeRieux	564-7067
EPA/310-R-95-005.	Iron and Steel Industry	Maria Malave	564-7027
EPA/310-R-95-006.	Lumber and Wood Products Industry	Seth Heminway	564-7017
EPA/310-R-95-007.	Fabricated Metal Products Industry	Greg Waldrip	564-7024
EPA/310-R-95-008.	Metal Mining Industry	Keith Brown	564-7124
EPA/310-R-95-009.	Motor Vehicle Assembly Industry	Suzanne Childress	564-7018
EPA/310-R-95-010.	Nonferrous Metals Industry	Jane Engert	564-5021
EPA/310-R-95-011.	Non-Fuel, Non-Metal Mining Industry	Keith Brown	564-7124
EPA/310-R-95-012.	Organic Chemical Industry	Walter DeRieux	564-7067
EPA/310-R-95-013.	Petroleum Refining Industry	Tom Ripp	564-7003
EPA/310-R-95-014.	Printing Industry	Ginger Gotliffe	564-7072
EPA/310-R-95-015.	Pulp and Paper Industry	Maria Eisemann	564-7016
EPA/310-R-95-016.	Rubber and Plastic Industry	Maria Malave	564-7027
EPA/310-R-95-017.	Stone, Clay, Glass and Concrete Industry	Scott Throwe	564-7013
EPA/310-R-95-018.	Transportation Equipment Cleaning Industry	Virginia Lathrop	564-7057

MOTOR VEHICLE ASSEMBLY INDUSTRY
(SIC 37)
TABLE OF CONTENTS

MOTOR VEHICLE ASSEMBLY INDUSTRY

(SIC 37)
TABLE OF CONTENTS (CONT'D)

Motor Vehicle Assembly Industry

(SIC 37)
TABLE OF CONTENTS (CONT'D)

Page

MOTOR VEHICLE ASSEMBLY INDUSTRY

(SIC 37)
TABLE OF CONTENTS (CONT'D)

Motor Vehicle Assembly Industry

(SIC 37)
EXHIBITS INDEX

MOTOR VEHICLE ASSEMBLY INDUSTRY
(SIC 37)
EXHIBITS INDEX (CONT'D)

MOTOR VEHICLE ASSEMBLY INDUSTRY
(SIC 37)
LIST OF ACRONYMS

AFS - AIRS Facility Subsystem (CAA database)
AIRS - Aerometric Information Retrieval System (CAA database)
BIFs - Boilers and Industrial Furnaces (RCRA)
BOD - Biochemical Oxygen Demand
CAA - Clean Air Act
CAAA - Clean Air Act Amendments of 1990
CERCLA - Comprehensive Environmental Response, Compensation and Liability Act
CERCLIS - CERCLA Information System
CFCs - Chlorofluorocarbons
CO - Carbon Monoxide
COD - Chemical Oxygen Demand
CSI - Common Sense Initiative
CWA - Clean Water Act
D&B - Dun and Bradstreet Marketing Index
ELP - Environmental Leadership Program
EPA - United States Environmental Protection Agency
EPCRA - Emergency Planning and Community Right-to-Know Act
FIFRA - Federal Insecticide, Fungicide, and Rodenticide Act
FINDS - Facility Indexing System
HAPs - Hazardous Air Pollutants (CAA)
HSDB - Hazardous Substances Data Bank
IDEA - Integrated Data for Enforcement Analysis
LDR - Land Disposal Restrictions (RCRA)
LEPCs - Local Emergency Planning Committees
MACT - Maximum Achievable Control Technology (CAA)
MCLGs - Maximum Contaminant Level Goals
MCLs - Maximum Contaminant Levels
MEK - Methyl Ethyl Ketone
MSDSs - Material Safety Data Sheets
NAAQS - National Ambient Air Quality Standards (CAA)
NAFTA - North American Free Trade Agreement
NCDB - National Compliance Database (for TSCA, FIFRA, EPCRA)
NCP - National Oil and Hazardous Substances Pollution Contingency Plan
NEIC - National Enforcement Investigation Center
NESHAP - National Emission Standards for Hazardous Air Pollutants
NO_2 - Nitrogen Dioxide
NOV - Notice of Violation
NO_X - Nitrogen Oxide
NPDES - National Pollution Discharge Elimination System (CWA)

MOTOR VEHICLE ASSEMBLY INDUSTRY
(SIC 37)
LIST OF ACRONYMS (CONT'D)

NPL - National Priorities List
NRC - National Response Center
NSPS - New Source Performance Standards (CAA)
OAR - Office of Air and Radiation
OECA - Office of Enforcement of Compliance Assurance
OPA - Oil Pollution Act
OPPTS - Office of Prevention, Pesticides, and Toxic Substances
OSHA - Occupational Safety and Health Administration
OSW - Office of Solid Waste
OSWER - Office of Solid Waste and Emergency Response
OW - Office of Water
P2 - Pollution Prevention
PCS - Permit Compliance System (CWA Database)
POTW - Publicly Owned Treatments Works
RCRA - Resource Conservation and Recovery Act
RCRIS - RCRA Information System
SARA - Superfund Amendments and Reauthorization Act
SDWA - Safe Drinking Water Act
SEPs - Supplementary Environmental Projects
SERCs - State Emergency Response Commissions
SIC - Standard Industrial Classification
SO_2 - Sulfur Dioxide
TOC - Total Organic Carbon
TRI - Toxic Release Inventory
TRIS - Toxic Release Inventory System
TCRIS - Toxic Chemical Release Inventory System
TSCA - Toxic Substances Control Act
TSS - Total Suspended Solids
UIC - Underground Injection Control (SDWA)
UST - Underground Storage Tanks (RCRA)
VOCs - Volatile Organic Compounds

MOTOR VEHICLE ASSEMBLY INDUSTRY (SIC 37)

I. INTRODUCTION TO THE SECTOR NOTEBOOK PROJECT

I.A. Summary of the Sector Notebook Project

Environmental policies based upon comprehensive analysis of air, water, and land pollution are an inevitable and logical supplement to traditional single-media approaches to environmental protection. Environmental regulatory agencies are beginning to embrace comprehensive, multi-statute solutions to facility permitting, enforcement and compliance assurance, education/outreach, research, and regulatory development issues. The central concepts driving the new policy direction are that pollutant releases to each environmental medium (air, water, and land) affect each other, and that environmental strategies must actively identify and address these inter-relationships by designing policies for the "whole" facility. One way to achieve a whole facility focus is to design environmental policies for similar industrial facilities. By doing so, environmental concerns that are common to the manufacturing of similar products can be addressed in a comprehensive manner. Recognition of the need to develop the industrial "sector-basedÓ approach within the EPA Office of Compliance led to the creation of this document.

The Sector Notebook Project was initiated by the Office of Compliance within the Office of Enforcement and Compliance Assurance (OECA) to provide its staff and managers with summary information for eighteen specific industrial sectors. As other EPA offices, States, the regulated community, environmental groups, and the public became interested in this project, the scope of the original project was expanded. The ability to design comprehensive, common sense environmental protection measures for specific industries is dependent on knowledge of several inter-related topics. For the purposes of this project, the key elements chosen for inclusion are: general industry information (economic and geographic); a description of industrial processes; pollution outputs; pollution prevention opportunities; Federal statutory and regulatory framework; compliance history; and a description of partnerships that have been formed between regulatory agencies, the regulated community, and the public.

For any given industry, each topic listed above could alone be the subject of a lengthy volume. However, in order to produce a manageable document, this project focuses on providing summary information for each topic. This format provides the reader with a synopsis of each issue, and references where more in-depth information is available. Text within each profile was researched from a variety of sources, and was usually condensed from more detailed sources pertaining to specific topics. This approach allows for a wide coverage of activities that can be further explored based upon the citations and references listed at the end of this profile. As a check on the information included, each notebook went through an external review process. The Office of Compliance appreciates the efforts of all those that participated in this process and enabled us to develop more complete, accurate, and up-to-date summaries. Many of those who reviewed this notebook are listed as contacts in Section IX and may be sources of additional information. The individuals and groups on this list do not necessarily concur with all statements within this notebook.

I.B. Additional Information

Providing Comments

OECA's Office of Compliance plans to periodically review and update the notebooks and will make these updates available both in hard copy and electronically. If you have any comments on the existing notebook, or if you would like to provide additional information, please send a hard copy and computer disk to the EPA Office of Compliance, Sector Notebook Project, 401 M St., SW (2223-A), Washington, DC 20460. Comments can also be uploaded to the Enviroene Bulletin Board or the Enviroene World Wide Web for general access to all users of the system. Follow instructions in Appendix A for accessing these data systems. Once you have logged in, procedures for uploading text are available from the on-line Enviroene Help System.

Adapting Notebooks to Particular Needs

The scope of the existing notebooks reflect an approximation of the relative national occurrence of facility types that occur within each sector. In many instances, industries within specific geographic regions or States may have unique characteristics that are not fully captured in these profiles. For this reason, the Office of Compliance encourages State and local environmental agencies and other groups to supplement or re-package the information included in this notebook to include more specific industrial and regulatory information that may be available. Additionally, interested States may want to supplement the "Summary of Applicable Federal Statutes and Regulations" section with State and local requirements. Compliance or technical assistance providers may also want to develop the "Pollution Prevention" section in more detail. Please contact the appropriate specialist listed on the opening page of this notebook if your office is interested in assisting us in the further development of the information or policies addressed within this volume.

If you are interested in assisting in the development of new notebooks for sectors not covered in the original eighteen, please contact the Office of Compliance at 202-564-2395.

II. Introduction to the Motor Vehicles and Motor Vehicle Equipment Industry

This section provides background information on the size, geographic distribution, employment, production, sales, and economic condition of the Motor Vehicle Equipment industry. The type of facilities described within the document are also described in terms of their Standard Industrial Classification (SIC) codes. Additionally, this section contains a list of the largest companies in terms of sales.

II.A. Introduction, Background, and Scope of the Notebook

This industry notebook is designed to provide an overview of the motor vehicles and motor vehicle equipment industry as listed under the Standard Industrial Classification (SIC) code 37. Establishments listed under this code are engaged primarily in the manufacture and assembly of equipment for the transportation of passengers and cargo by land, air, and water.

Due to the broad scope of the industries listed under SIC 37, this notebook will focus on the three-digit SIC 371 which is limited to motor vehicles and motor vehicle equipment (also known as the automotive industry). The primary focus within SIC 371 are numbers 3711 - motor vehicles and passenger car bodies, 3713 - truck and bus bodies, and 3714 - motor vehicle parts and accessories.

Industry groups not covered by this profile include: SIC 372 - Aircraft and Parts; 373 - Ship and Boat Building and Repairing; 374 - Railroad Equipment; 375 - Motorcycles, Bicycles, and Parts; 376 - Guided Missiles and Space Vehicles and Parts; and 379 - Miscellaneous Transportation Equipment. The following automotive products are also not covered in this profile: diesel engines, tires, automobile stampings, vehicular lighting equipment, carburetors, pistons, ignition systems, and cabs for off-highway construction trucks.

II.B. Characterization of Motor Vehicle and Motor Vehicle Equipment Industry

The U.S. motor vehicle and motor vehicle equipment industry is a diverse and technically dynamic industry which plays a vital role in the U.S. economy. The massive size of the automotive industry and the diverse nature of parts required to produce a car requires the support of many other major U.S. industries such as the plastics and rubber industry and the electronic components industry.

Facilities involved with the manufacturing of automobiles are located across the U.S. and are organized based on the types of products produced. Businesses involved in the manufacturing of these products range from the large ÒBig ThreeÓ automakers, General Motors Corporation (GM), Ford Motor Company., and Chrysler Corporation, to smaller, independent automotive parts suppliers such as Dana Corporation, Allied Signal, and Borg Warner. Other facilities involved in the manufacture of automobiles include Toyota, Honda, Nissan, Subaru, Isuzu, Auto Alliance, BMW, and Mitsubishi.

II.B.1. Industry Size and Geographic Distribution

The motor vehicle and motor vehicle equipment industry is a key component in the U.S. economy, accounting for a substantial percentage of direct and indirect employment as well as overall industrial output. The vast size and scope of the industry is best understood by examining the quantity and distribution of automotive facilities located around the U.S and the number of individuals employed by these facilities.

The U.S. Industrial Outlook 1994 states that an estimated 6.7 million persons were employed directly and in allied automotive industries in 1991. According to the Department of CommerceÕs *U.S. Global Trade Outlook, 1995-2000,* in 1992 the total direct employment for SIC 3711, industries manufacturing just motor vehicles and passenger car bodies alone, was 314,000. This figure is down from a peak high in 1985 of 408,000. The U.S. Bureau of Labor Statistics estimates that an additional six percent employment loss will occur by 2005 in the motor vehicles manufacturing industry. This loss in jobs will most likely result from a decrease in the number of individuals needed to manufacture a car.

Most individuals employed by the motor vehicle and motor vehicle equipment industry work at facilities employing between 20 and 49 individuals (See Exhibit 1). These facilities, as well as the larger and smaller operations, are located throughout the United States. The vast majority of production is concentrated in the Great Lakes Region. According to 1991 data in the *AAMA Motor Vehicle Facts and Figures Ô94,* the Great Lakes Region contains over 1,700 motor vehicle and equipment manufacturers. This figure represents 39 percent of the 4,467 facilities in the United States. California, Missouri, and Texas also post a large number of automotive industries. The number of establishments manufacturing motor vehicles and motor vehicle equipment increased for all size facilities from 1982 to 1987. The value of shipments also increased during the same five year period.

Exhibit 1
Size Distribution of Motor Vehicle and Motor Vehicle Equipment Manufacturing Establishments

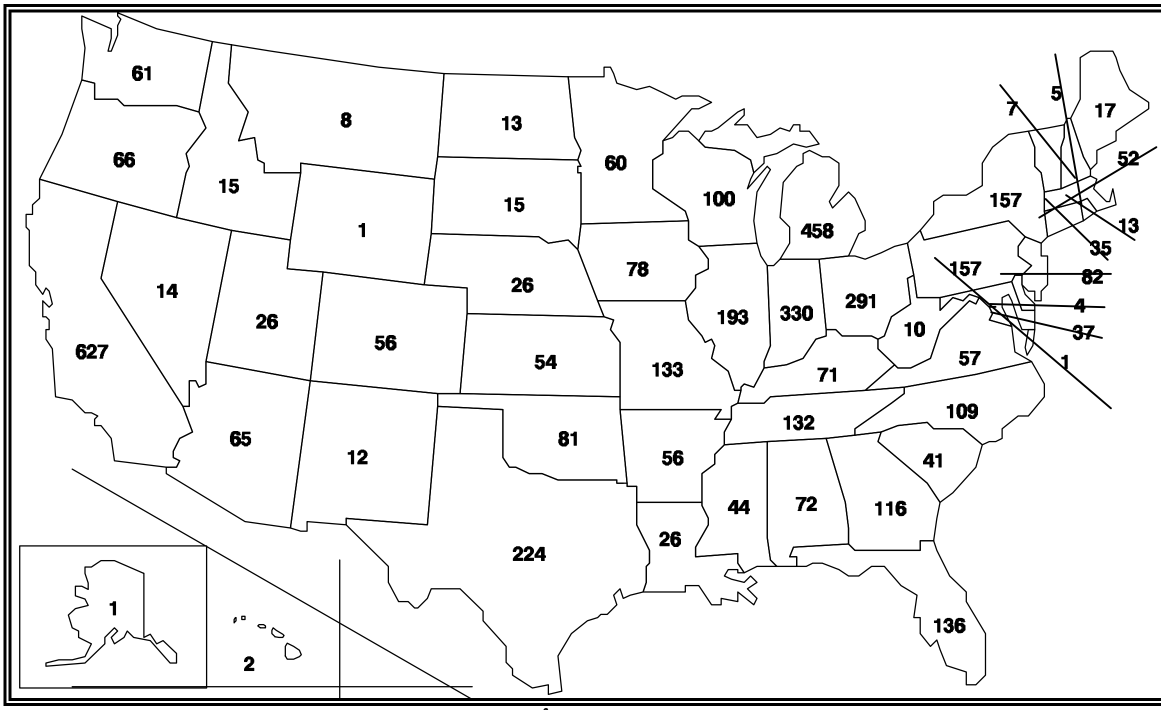
	1982		1987	
Number of Employees	**Number of Establishments**	**Value of Shipments (millions of dollars)**	**Number of Establishments**	**Value of Shipments (millions of dollars)**

1-4	851	127.5	918	197.7
5-9	502	246.5	549	407.3
10-19	562	567.5	647	895.9
20-49	579	1,306.9	650	2,132.4
50-99	320	1,897.5	382	2,919.8
100-249	295	4,062.0	362	6,761.1
250-499	148	4,739.9	202	9,475.3
³500	218	96,580.0	226	177,151.5
Totals	**3,475**	**128,057.4**	**3,936**	**199,941.0**

Source: Census of Manufacturers: 1982, 1987, Bureau of the Census, U.S. Department of Commerce.

States in the Great Lakes Region are home to the majority of automotive assembly plants. As International companies have moved facilities to the U.S., additional States, including Tennessee, California, and Kentucky have become the site of automotive plants. The geographic distribution of manufacturing plants will further increase with the completion of a BMW plant in Spartansburg, SC in 1995 and start of production at the Mercedes Benz plant in January 1997 in Tuscaloosa, AL. Exhibit 2 shows the geographic distribution of industries listed under SIC 37 producing motor vehicles and motor vehicle equipment.

Exhibit 2
Geographic Distribution of the Motor Vehicles and Motor Vehicle Equipment Industry



Source: AAMA Motor Vehicle Facts & Figures Ô94, compiled from 1991 U.S. Department of Commerce, Bureau of the Census data.

Motor Vehicle Equipment

In 1992, the largest number of automotive parts producers, including approximately 450 relatively small aftermarket part manufacturers, were located in California, while approximately 315 original equipment parts manufacturers were located in Michigan. Indiana and Ohio were the sites of 228 and 205 equipment parts manufacturers respectively. In order to minimize transportation costs and maximize responsiveness to automakers, producers of original equipment parts are located in close proximity to auto assembly facilities; most are located in Michigan, Indiana, Illinois, and Ohio. Conversely, aftermarket suppliers have little incentive to locate near automotive plants and are thus located across the country. A concentration of aftermarket suppliers are located in California, Texas, and Florida.

The U.S. automotive industry is the largest manufacturing industry in North America, accounting for approximately four percent of the gross national product (GNP). The U.S. automotive industry contains the number one and two manufacturers of automobiles in the world, GM and Ford (see Exhibit 3). According to 1993 data from the American Automobile Manufacturers Association (AAMA), the U.S. was the third largest producer of cars in the world, behind Europe and Asia respectively, dominating 30.3 percent of the market.

Exhibit 3
Top 10 Motor Vehicle Manufacturers
Ranked by World Production-1994

Manufacturer	Country	Passenger Cars	Commercial Vehicles	Total
General Motors	United States	4,989,938	875,890	6,865,828
Ford	United States	3,685,415	2,058,877	5,744,294
Toyota	Japan	3,649,640	838,251	4,487,891
Volkswagen	Germany	3,119,997	165,699	3,285,696
Nissan	Japan	2,222,985	675,200	2,898,185
PSA	France	2,252,121	185,605	2,437,726
Renault	France	1,929,858	334,473	2,264,331
Chrysler	United States	727,928	1,254,748	1,982,676
Fiat	Italy	1,557,556	242,844	1,800,400
Honda	Japan	1,629,666	132,531	1,762,19

Source: AAMA Motor Vehicle Facts & Figures Õ94.

II.B.2. Product Characterization

The motor vehicles and motor vehicle equipment industry produces a wide range of diverse products from ambulances and automobiles to the cylinder heads, ball joints, and horns that go in these vehicles. The Bureau of the CensusÕ SIC code categorizes the automotive industry based on the type of products manufactured. The following is a list of the four-digit SIC codes found under Industry Group Number 371:

SIC 3711 - Motor Vehicle and Passenger Car Bodies
SIC 3713 - Truck and Bus Bodies
SIC 3714 - Motor Vehicle Parts and Accessories
SIC 3715 - Truck Trailers - (not covered in this profile)
SIC 3716 - Motor Homes - (not covered in this profile)

The motor vehicle and motor vehicle equipment industry is organized into four primary areas based on the types of product produced. These areas are: (1) passenger cars and light trucks; (2) medium and heavy duty trucks; (3) truck trailers; (4) and automotive parts and accessories. The automotive parts industry is further broken down into two sectors, original equipment suppliers and aftermarket suppliers. Original equipment suppliers provide parts directly to automakers while aftermarket suppliers provide parts exclusively to the replacement parts market. The original equipment market accounts for approximately 80 percent of all motor vehicle parts and accessories consumed in the U.S., with the remaining 20 percent accounted for by the aftermarket.

II.B.3. Economic Trends

Economic Health

Motor Vehicles

According to the Department of CommerceÕs *U.S. Global Trade Outlook, 1995-2000*, worldwide sales volume of cars, trucks, and buses have grown 1.2 percent annually during the past ten years. Slow growth in the industry can be attributed to the saturation of the market in developed nations. In order to adjust to the long-term changes in demand, the motor vehicle industry is currently undergoing a global reorganization. Within the next ten years, as companies consolidate and restructure, perhaps as few as ten mega-manufacturing alliances will dominate developed markets.

The Big Three suffered global net losses in 1992 of $30 billion, due in large part to competition from foreign manufacturers. These competitive pressures have stimulated the development of a number of cooperative manufacturing and marketing ventures. Examples of such ventures include GMÕs ÒGeo,Ó a compact sedan manufactured in a 50-50 joint venture between GM and Toyota, and a sport-utility vehicle produced in a 50-50 joint venture between GM and Suzuki. Another example is the Ford and Auto Alliance Michigan plant, which manufactures the Ford Probe and the Mazda MX-6 in a 50-50 venture between Ford and Mazda.

Production of passenger cars and light trucks increased 13 percent in 1993. Total sales also increased nine percent from 1992. These increases are likely the result of improvements in vehicle design and added features, product quality, and manufacturing technology. One factor dampening sales in the U.S. market is the fact that the general population is keeping their cars longer. Data collected by the AAMA shows that the mean average age of the passenger cars in the U.S. automobile fleet in 1993 was 8.3 years - the highest since 1948. Another factor expected to effect sales is that fewer individuals will be reaching driving age in the next several years. This negative impact could potentially be offset by the baby boomÕs entry into their peak earning years, a time when they can afford more expensive cars.

Future growth in the passenger car and light truck sector of the automotive industry is expected to be no more than one to two percent in the coming years. In response to an essentially saturated U.S. market for new passenger cars and light trucks, competition among foreign and U.S. manufacturers is growing. As a result of this competition, many companies have gone out of business, while others have become more competitive and increased their market share, often by investing in new or renovated facilities. In 1993, motor vehicle and equipment manufacturers spent approximately $12 billion on new plant facilities and equipment (AAMA, 1995), and AAMA estimates that motor vehicle and equipment manufactures spent an additional estimated $15.7 billion in 1994. Another benefit of the increased competition has been a reduction of operating expenses as manufacturers have made strides in improving technology and increasing productivity while reducing overhead.

In 1992, 28 percent of all vehicle miles traveled in the U.S. can be attributed to commercial truck use (AAMA Facts and Figures, 1994). In fact, the U.S. truck market tends to be a magnification of the U.S. economyÕs business cycle (outside of normal replacement cycles). U.S. sales of medium-and heavy-duty trucks (14,050 gross vehicle weight rating (GVWR) and greater), grew 16 percent between 1993 and 1994, an increase of approximately 50,000 units. Sales for the industry through the first five months of 1995 were 167,000 units, a 22 percent increase over the same period in 1994. New safety regulations outlined by the National Highway Traffic Safety Administration (NHTSA) will impact the truck and trailer industry. Safety performance standards for new anti-lock brake systems are expected to be complete by October 1995. Regulations for automatically adjustable brakes went into effect in October 1993 for hydraulic brakes and for air brakes in October 1994. Regulations proposed by NHTSA for under-ride guards are in the early stages of the regulatory development process. Once in place, these new regulations should reduce the number of fatalities that are attributed to rear-end collisions involving straight body trucks and truck trailers.

Motor Vehicle Equipment

According to the Department of CommerceÕs *U.S. Global Trade Outlook, 1995-2000*, the U.S. automotive parts industry is emerging from a massive restructuring that has enabled it to greatly strengthen its competitive position in relation to Japan, its major rival. Since 1987, productivity has increased about three percent annually and quality has improved greatly. The global automotive parts market will total about $460 billion in 1995 and an estimated $519 billion in 2000.

In 1992, the U.S. International Trade Commission estimated that there were approximately 5,000 U.S. parts and accessories manufacturers. These manufacturers are estimated to produce 22 percent, or $65 billion, of world production of certain motor vehicle parts. The U.S. is the third largest producer of automotive parts, behind Japan at 35 percent and the European Union at 23 percent of worldwide production. A reduction in passenger car production and an increase in the use of foreign-produced parts has resulted in a decline in shipments of U.S. parts, from $68 billion in 1988 to $65 billion in 1992. The drop in production has resulted in a decline of sales and employment. In 1988, 453,000 were employed in the motor vehicle equipment industry. Employment dropped to a low of 407,000 in 1991 before increasing to 437,000 in 1992.

The industry is currently undergoing a significant restructuring. Factors influencing this restructuring include: increased competition from Japan, new and innovative organizational systems, and the passage of the North American Free Trade Agreement (NAFTA). U.S. automakers and parts producers are trying to produce higher-quality motor vehicles and parts in a more cost effective manner. To accomplish this goal, lean and/or agile production techniques are being implemented. These techniques, which ultimately use less of everything in the production process, also limit the number of direct suppliers of components.

Original equipment suppliers have been subject to changes in supplier relations with the Big Three automakers over the past few years. Between 1988 and 1991, taking advantage of new manufacturing technologies, the Big Three gradually reduced the number of suppliers needed. Chrysler, for example, ordered parts from more than 3,000 suppliers in the 1970s, but by 1993 reduced the number of suppliers to between 600 and 800 per model line. As a result of this change in supplier relationships, original equipment manufacturers have altered their role in the industry by providing automakers with services such as financing for research and development, inventory, logistics, and tooling.

Economic uncertainties caused consumers to defer scheduled maintenance and servicing of their cars between 1988 and 1992. This resulted in a leveling off of aftermarket parts sales during the same years. Industry sources claim that better designed and engineered original equipment parts, such as longer lasting shock absorbers, also contributed to the flat market. New diagnostic technologies which identify possible faulty parts and reduce the need for preventative maintenance also played a role. The market is predicted to see a turn-around based on the Clean Air Act Amendments of 1990 and stricter emissions standards, which is anticipated to result in more used car repairs and an increase in replacement parts.

Future Economic Outlook

Estimates of third-quarter earnings for 1994 show that earnings of U.S. automakers will likely triple from the previous year. This boom in business comes despite plant closures that are traditional during the third quarter due to employee vacations and production changeovers for new fall models. AAMA estimates that the Big Three earned $2.3 billion during the period, compared to $773 million during third-quarter 1993. AAMA indicates that sales and earnings may be dropping in 1995.

According to AAMA, growth has continued through the first quarter of 1995, compared to the same period in 1994, with a combined earnings for the Big Three of about $4.3 billion. Financial strength over the last few quarters has been due, in part, to plants operating at high capacity, and to new models being sold without discounts. The weak dollar and strong Japanese yen also have played a role. Predictions for continued growth of that magnitude through the remainder of 1995, however, are less certain.

In the past 25 years, a growing number of foreign automobile manufacturers have started doing business in the U.S., and they now play an important role in the U.S. economy. Since the mid-1980s, seven large foreign automobile manufacturing plants have been constructed, representing an investment of over $11 billion (See Exhibit 4). According to AIAM, factories which produce automobile brands such as Honda, Isuzu, Mazda, Mitsubishi, Nissan, Subaru, and Toyota, provide approximately 36,000 manufacturing jobs in the U.S.; with over 216,000 jobs in the automotive supply industries. These plants have proven to be extremely efficient, with output increasing 90 percent since 1988. In 1992 alone, 1,787,500 passenger cars were produced in new U.S. factories by international companies, a figure second only to GMÕs output. One out of every four passenger cars produced in the U.S. today is the product of a foreign manufacturer.

Exhibit 4
Distribution of Automotive Assembly Plants - 1992

State	Number of Big Three Plants	Number of Foreign-Owned Plants
Michigan	16	1
Ohio	2	2
Kentucky	2	1
Illinois	2	1
Tennessee	1	1
Indiana	1	1
California	U.S. Foreign Joint Ventures 1	

Source: WardOs Automotive Reports, *Automotive News Market Data Book.*

The recent passage of the NAFTA should prove beneficial to the auto industry as goods and services will be able to flow more freely between the U.S. and Mexico and Canada. Although Mexico has been a strong market for U.S. automotive and heavy-duty aftermarket components in the past, exports to Mexico have been limited by quotas and other trade restrictions. The passage of NAFTA and the elimination of past barriers to truck imports should also prove beneficial to medium- and heavy-duty trucks manufacturers, and Mexico could prove to be one of the fastest growing truck markets of this decade.

Another recent development that should facilitate further trade between the U.S. and Mexico was the creation of the Pan American Automotive Components Exposition (PAACE). PAACE, which had its first meeting in July 1994, is sponsored by 12 North American associations. The purpose of the exposition is to bring an international show to the Mexican marketplace as well as establish PAACE as the dominant show for automotive and heavy duty equipment in the future. Plans are currently underway for PAACE 1995.

III. INDUSTRIAL PROCESS DESCRIPTION

This section describes the major industrial processes within the Motor Vehicles and Motor Vehicle Equipment industry, including the materials and equipment used, and the processes employed. The section is designed for those interested in gaining a general understanding of the industry, and for those interested in the inter-relationship between the industrial process and the topics described in subsequent sections of this profile -- pollutant outputs, pollution prevention opportunities, and Federal regulations. This section does not attempt to replicate published engineering information that is available for this industry. Refer to Section IX for a list of reference documents that are available.

This section specifically contains a description of commonly used production processes, associated raw materials, the byproducts produced or released, and the materials either recycled or transferred off-site. This discussion, coupled with schematic drawings of the identified processes, provide a concise description of where wastes may be produced in the process. This section also describes the potential fate (air, water, land) of these waste products.

III.A. Industrial Processes in the Motor Vehicle and Motor Vehicle Equipment Industry

There is no single production process for Industry Group Number 371. Instead, numerous processes are employed to manufacture motor vehicles and motor vehicle equipment. This section will focus on the significant production processes including those used in the foundry, metal shop, assembly line, and paint shop.

III.A.1. Motor Vehicle Equipment Manufacturing

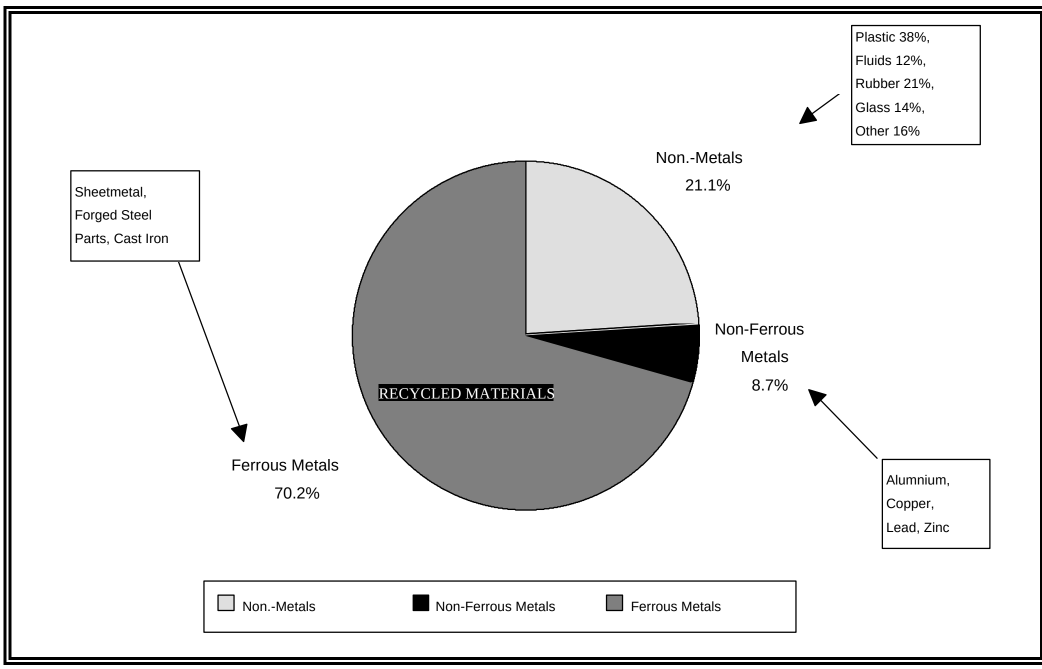
Motor vehicle parts and accessories include both finished and semi-finished components. Approximately 8,000 to 10,000 different parts are ultimately assembled into approximately 100 major motor vehicle components, including suspension systems, transmissions, and radiators. These parts are eventually transported to an automotive manufacturing plant for assembly.

According to a 1993 publication by the University of Michigan Transportation Research Institute entitled ÒMaterial Selection Process in the Automotive Industry,Ó material selection plays a vital role in the production process. Materials are ultimately selected based on factors such as performance (strength vs. durability, surface finish, corrosion resistance), cost, component manufacturing, consumer preference, and competitive responses.

In the past, automobiles have been composed primarily of iron and steel. Steel has remained a major automotive component because of its structural integrity and ability to maintain dimensional geometry throughout the manufacturing process (See Exhibit 5).

In response to increasing demands for more fuel efficient cars, the past ten years have seen changes in the composition of materials used in automobiles (See Exhibit 6). Iron and steel use has steadily decreased, while plastics and aluminum has steadily increased. Aluminum and plastics are valuable car components not only for their lighter weight, but also because of their inherent corrosion resistance. Although the use of plastics in the automotive industry is increasing, expansion in this area is finite because of limitations in current plastics materials.

Exhibit 5
Automobile Composition and Disposition, 1994



Source: Automotive Industries, 1992 - from AAMA Motor Vehicle Facts and Figures '94.

Exhibit 6
Automotive Material Usage 1984 to 1994 Model Year
(in pounds)*

Material	1994	1992	1990	1988	1986	1984
Conventional Steel	1,388.5	1,379.0	1,246.5	1,337.0	1,446.0	1,487.5
High Strength Steel	263.0	247.0	233.0	227.5	221.0	214.0
Stainless Steel	45.0	41.5	31.5	31.0	30.0	29.0
Other Steels	42.5	42.0	53.0	46.5	47.0	45.0
Iron	408.0	429.5	398.0	426.5	446.5	454.5
Aluminum	182.0	173.5	158.5	150.0	141.5	137.0
Rubber	134.0	133.0	128.0	130.0	131.5	133.5
Plastics/Composites	245.5	243.0	222.0	219.5	216.0	206.5
Glass	89.0	88.0	82.5	86.0	86.5	87.0
Copper and Brass	42.0	45.0	46.0	49.5	43.0	44.0
Zinc Die Castings	16.0	16.0	19.0	19.5	17.0	17.0
Powder Metal Parts	27.0	25.0	23.0	21.5	20.0	18.5
Fluids and Lubricants	189.5	177.0	167.0	176.5	182.5	180.0
Other Materials	99.0	96.0	88.0	89.0	89.5	88.0
TOTAL	**3,171.0**	**3,135.5**	**2,896.0**	**3,010.0**	**3,118.0**	**3,141.5**

Source: ÒMaterial Usage, Vehicles Retired From Use and Vehicle RecyclingÓ - from AAMA Motor Vehicle Facts & Figures Ô94.

* Represents consumption per passenger car unit built in the U.S., rounded to the nearest tenth of a pound.

The manufacturing processes used to produce the thousands of discrete parts and accessories vary depending on the end product and materials used. Different process are employed for the production of metal components versus the production of plastic components. Most processes, however, typically include casting, forging, molding, extrusion, stamping, and welding. Exhibit 7 lists major automotive parts and the primary materials and production processes used to manufacture them.

III.A.1.a. *Foundry Operations*

Foundries, whether they are integrated with automotive assembly facilities or independent shops, cast metal products which play a key role in the production of motor vehicles and motor vehicle equipment. As discussed previously, even though aluminum and other metals are used increasingly in the production of automobiles and their parts, iron and steel are still the major metal components of an automobile. Because of this, the following discussion will focus on iron foundries and the typical production processes.

The main steps in producing cast iron motor vehicle products are as follows (see Exhibit 8):

¥ Pattern design and production
¥ Sand formulation
¥ Mold and core production

¥ Metal heating and alloying
¥ Metal molding
¥ Mold shakeout
¥ Product finishing and heat treating
¥ Inspection.

The process begins with the mixing of moist silica sand with clay (3 to 20 percent) and water (two to five percent) to produce the "green sand," which forms the basis of the mold. Other additives, including organics such as seacoal or oat hulls, may be added to the green sand to help prevent casting defects. The core is then created using molded sand and often includes binders, such as resins, phenol, and/or formaldehyde. The core is the internal section of a casting used to produce the open areas needed inside such items as an engine or a drive train. After the core has been molded, it is baked to ensure its shape, and then combined with the rest of the casting mold in preparation for casting. At the same time the core is being created, iron is being melted. The iron charge, whether it be scrap or new iron, is combined with coal (as a fuel) and other additives such a calcium carbide and magnesium, and fed into a furnace, which removes sulfur, (usually an electric arc, an electric induction, or a cupola furnace).

Calcium carbide may be added for certain kinds of iron casting, and magnesium is added to produce a more ductile iron. Once the iron reaches the appropriate temperature, it is poured into the prepared mold. The mold then proceeds through the cooling tunnel and is placed on a grid to undergo a process called "shakeout. " During shakeout the grid vibrates, shaking loose the mold and core sand from the casting. The mold and core are then separated from the product which is ready for finishing.

The finishing process is made up of many different steps depending upon the final product. The surface may be smoothed using an oxygen torch to remove any metal snags or chips, it may be blast-cleaned to remove any remaining sand, or it may be pickled using acids to achieve the correct surface. If necessary, the item may be welded to ensure the tightness of any seams or seals. After finishing, the item undergoes a final heat treatment to ensure it has the proper metallurgical properties. The item is then ready for inspection. Inspection may take place in any number of ways be it visually, by x- or gamma ray, ultrasonic, or magnetic particle. Once an item passes inspection, it is ready to be shipped to the assembly area.

Exhibit 7
Identification of Major Automobile Parts by Material and Process

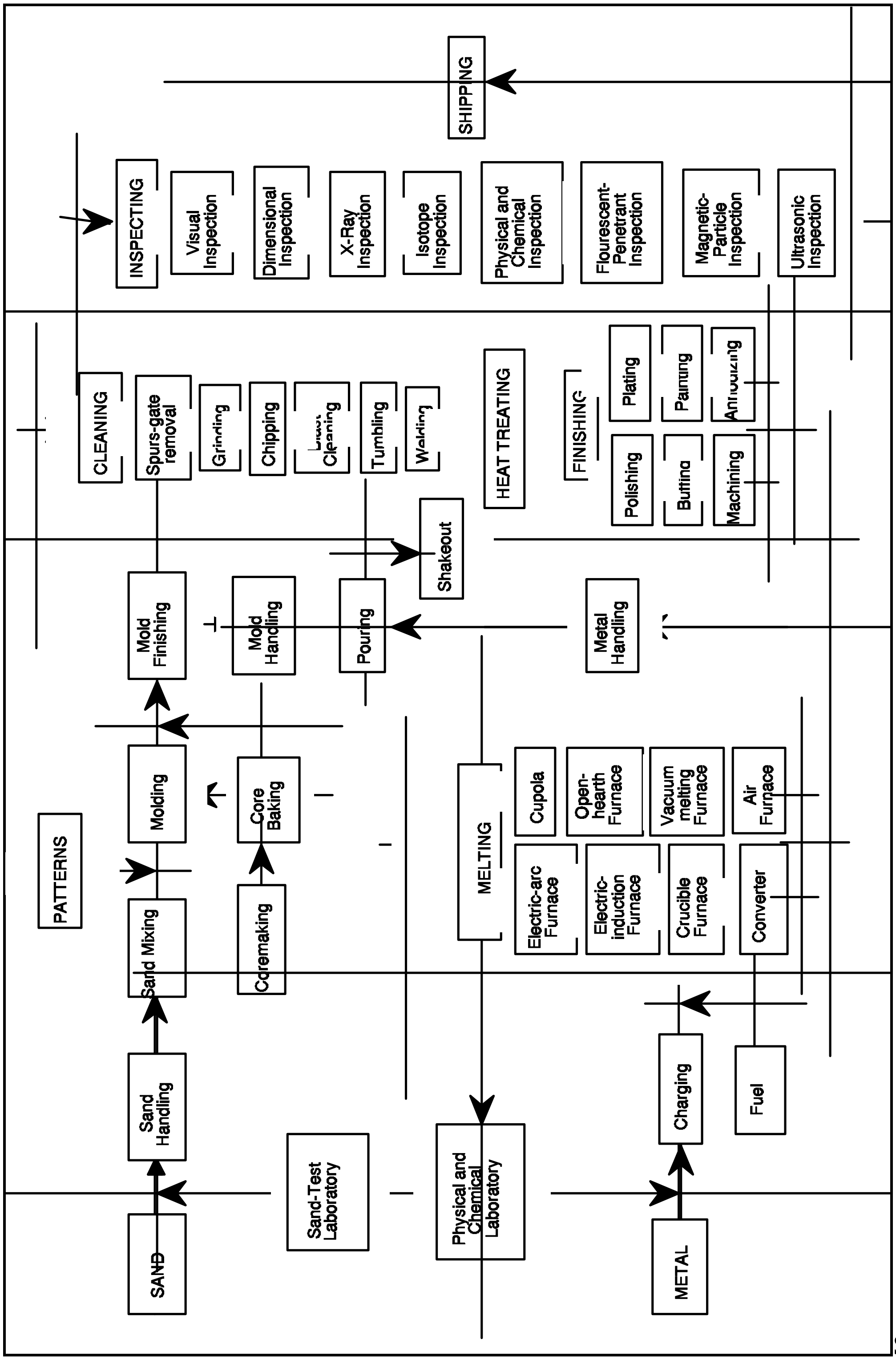
Automotive Part	Primary Materials	Primary Process
ENGINE		
Block	Iron Aluminum	Casting
Cylinder Head	Iron Aluminum	Casting Machining
Intake Manifold	Plastic Aluminum	Casting Molding Machining
Connecting Rods	Powder Metal Steel	Molding Forging Machining
Pistons	Aluminum	Forging Machining
Camshaft	Iron Steel Powder Metal	Molding Forging Machining
Valves	Steel Magnesium	Stamping Machining
Exhaust Systems	Stainless Steel Aluminum Iron	Extruding Stamping
TRANSAXLE		
Transmission Case	Aluminum Magnesium	Casting Machining
Gear Sets	Steel	Blanking Machining
Torque Converter	Magnesium Steel	Stamping Casting
CV Joint Assemblies	Steel Rubber	Casting Forging Extruding Stamping
BODY STRUCTURE		
Body Panels	Steel Plastic Aluminum	Stamping Molding
Bumper Assemblies	Steel Plastic Aluminum	Stamping Molding

Exhibit 7 (cont'd)
Identification of Major Automobile Parts by Material and Process

Automotive Part	Primary Materials	Primary Process
CHASSIS/SUSPENSION		
Steering Gear/Column	Steel Magnesium Aluminum	Casting Stamping Forging Machining
Rear Axle Assembly	Steel Plastic	Stamping Molding
Front Suspension	Steel Aluminum	Stamping Forging
Wheels	Steel Aluminum	Stamping Forging
Brakes	Steel Friction Materials	Stamping Forging
SEATS/TRIM		
Seats	Steel Fabric Foam	Molding Stamping
Instrument Panel	Steel Fabric Foam	Molding Stamping
Headliner/Carpeting	Synthetic Fiber	Molding
Exterior Trim	Plastic Aluminum Zinc Die Casting	Molding Casting Stamping
HVAC SYSTEM		
A/C Compressor	Aluminum Steel Plastic	Casting Molding Stamping
Radiator/Heater Core	Copper Aluminum Plastic	Extruding Molding
Engine Fan	Plastic Steel	Stamping Molding

Source: University of Michigan Transportation Research Institute, ÒMaterial Selection in the Automotive Industry,Ó 1993.

Exhibit 8
General Foundry Flow Diagram



Source: American Foundrymen's Society Inc.

III.A.1.b. *Metal Fabricating*

Another major process in the manufacturing of automotive parts is metal fabrication. Metal fabrication involves the shaping of metal components. Many automotive parts, including fenders, hubcaps, and body parts are manufactured in metal fabricating shops. A typical large-scale production of these items starts with molten metal (ferrous or nonferrous) containing the correct metallurgical properties. Once the metal has been produced, it is cast into a shape that can enter the rolling process. Shearing and forming operations are then performed to cut materials into a desired shape and size and bend or form materials into specified shapes.

Shearing (or cutting) operations include punching, piercing, blanking, cutoff, parting, shearing, and trimming. Basically, these are operations that produce holes or openings, or that produce blanks or parts. The most common hole-making operation is punching. Piercing is similar to punching, but produces a raised-edge hole rather than a cut hole. Cutoff, parting, and shearing are similar operations with different applications: parting produces both a part and scrap pieces; cutoff and shearing produce parts with no scrap; shearing is used where the cut edge is straight; and cutoff produces an edge shape other than straight. Trimming is performed to shape or remove excess material from the edges of parts.

Forming operations shape parts by forcing them into a specified configuration, and include bending, forming, extruding, drawing, rolling, spinning, coining, and forging. Bending is the simplest forming operation; the part is simply bent to a specific angle or shape. Bending operations normally produce flat-shapes, while forming produces both two- and three-dimensional shapes.

Extruding is the process of forming a specific shape from a solid blank by forcing the blank through a die of the desired shape. Complicated and intricate cross-sectional shapes can be produced by extruding. Rolling is a process that passes the material through a set or series of rollers that bend and form the part into the desired shape. Coining is a process that alters the form of the part by changing its thickness; it produces a three-dimensional relief on one or both sides of the part, as found on coins.

Drawing and spinning form sheet stock into three-dimensional shapes. Drawing uses a punch to force the sheet stock into a die, where the desired part shape is formed in the space between the punch and die. In spinning, pressure is applied to the sheet while it spins on a rotating form so that the sheet acquires the shape of the form.

Forging operations produce a specific part shape, much like casting. The forging process is used in the automotive industry when manufacturing parts such as pistons, connecting rods, and the aluminum and steel portion of the wheels.

However, rather than using molten materials, forging uses externally applied pressure that either strikes or squeezes a heated blank into a die of the required shape. Forging operations use machines that apply repeated hammer blows to a red-hot blank to force the material to conform to the shape of the die opening. Squeezing acts in much the same way, except it uses pressure to squeeze rather than strike the blank. Forging uses a series of die cavities to change the shape of the blank in increments. The blank is moved from station to station in the die to form the part. Depending on the shape, a forging die can have from one to over a dozen individual cavities.

Once shearing and forming activities are complete, the material is machined. This entails shaping or forming a workpiece by removing material from pieces of raw stock with machine tools. The principal processes involved in machining are hole-making, milling, turning, shaping/planing, broaching, sawing, and grinding.

III.A.1.c. *Metal Finishing/Electroplating*

Numerous methods are used to finish metal products. However, prior to applying the finishing application, the surface must be prepared. One of the most important aspects of a finished product is the surface cleanliness and quality. Without a properly cleaned surface, even the most expensive coatings will fail to adhere or prevent corrosion.

Pickling and salt bath processes are used to finish steel products by chemically removing oxides and scale from the surface of the steel. Most carbon steel is pickled with sulfuric or hydrochloric acid, while stainless steel is pickled with hydrochloric, nitric, and hydrofluoric acids. Steel generally passes from the pickling bath through a series of rinses. Alkaline cleansers are used to remove mineral oils and animal fats and oils from the steel surface. Common alkaline cleaning agents include: caustic soda, soda ash, alkaline silicates, and phosphates. Electrolytic cleaning as well as various abrasive methods, such as sand blasting, are also commonly used to remove surface oxides.

Steel products are often coated to inhibit oxidation and extend the life of the product. Coated products can also be painted to further inhibit corrosion. Common coating processes include galvanizing, tin coating, chromium coating, and terne coating (lead and tin). An example of a coated automotive part is the radiator, which is usually spray painted with a chromium coat to prevent corrosion; some water based coats are now being utilized. Rinse water from the coating process may contain zinc, lead, cadmium, or chromium.

Metal finishing and electroplating activities are performed on a number of metals and serve a variety of purposes; the primary purpose being protection against corrosion. This is particularly important to the automotive industry because of the harsh weather and road conditions to which automobiles may be subject. Metal finishing and electroplating can also be performed for decorative purposes. These plating processes involve immersing the article to be coated/plated into a bath consisting of acids, bases, salts, etc.

The metals used in electroplating operations (both common and precious metal plating) include cadmium, lead, chromium, copper, nickel, zinc, gold, and silver. Cyanides are also used extensively in electroplating solutions and in some stripping and cleaning solutions.

Electroless plating is the chemical deposition of a metal coating onto a metal object, by immersion of the object in an appropriate plating solution. In electroless nickel plating, the source of nickel is a salt, and a reducer is used to reduce the nickel to its base state. A complexing agent is used to hold the metal ion in the solution. Immersion plating produces a metal deposit by chemical displacement. Immersion plating baths are usually formulations of metal salts, alkalies, and complexing agents (typically cyanide or ammonia).

Etching is the process used to produce specific design configurations or surface appearances on parts by controlled dissolution with chemical reagents or etchants. Etching solutions are commonly made up of strong acids or bases with spent etchants containing high concentrations of spent metal. The solutions include ferric chloride, nitric acid, ammonium persulfate, chromic acid, cupric chloride, and hydrochloric acid.

Anodizing uses the piece to be coated, generally with an aluminum surface, as an anode in an electrolytic cell. Anodizing provides aluminum parts with a hard abrasion- and corrosion-resistant film. This coating is porous, allowing it to be dyed or to absorb lubricants. This method is used both in decorative applications, including automotive trim and bumper systems, and in engineering applications such as aircraft landing gear struts. Anodizing is usually performed using either sulfuric or chromic acid often followed by a hot water bath, though nickel acetate or sodium potassium dichromate seal may also be used.

III.A.2. Motor Vehicle Assembly

Once the various automotive parts are produced, they are ready to be brought together for assembly. Automotive assembly is a complex process that involves many different steps. Assembly begins with parts which arrive in the assembly plant Òjust-in-time.Ó ÒJust-in-timeÓ is a concept that means parts arrive only when they are needed for assembly; only enough product is sent for a given dayÕs work. This concept, which revolutionized the automotive industry, has improved productivity, lowered costs, and provided for better quality management.

Although techniques used to assemble an automobile vary from manufacturer to manufacturer, the first major step in assembly is the body shop. At this stage the car begins to take shape as sides are welded together and then attached to the underbody of the car. The underbody is composed of three primary pieces of galvanized steel which include the floor pan and components for the engine and trunk. After the underbody has been welded together by robotics, it is tested for dimensional and structural accuracy. It is then joined together in a tab-slot fashion with the side frame and various other side-assemblies. A worker then taps tabs into slots, and a robot clamps the tabs. Roof supports and the roof are now ready for installation. The car is now ready for final welding. Approximately 3,500-4,000 spots require welding. Most welding is done by robots, with workers doing only spot jobs. Trunk lids and hoods will then be installed.

III.A.3. Motor Vehicle Painting/Finishing

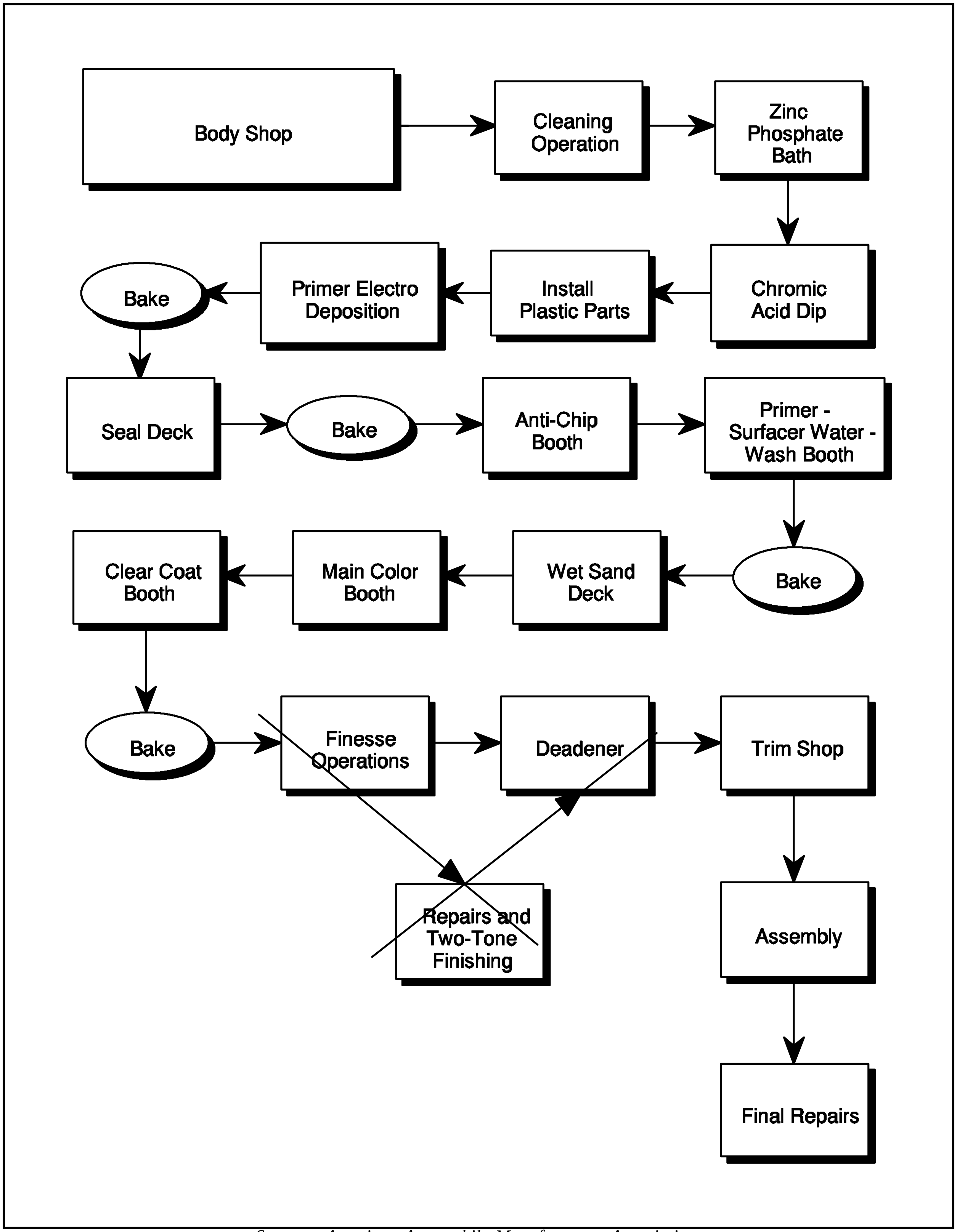
Automotive finishing is a multi-step process subdivided into four categories: 1) anti-corrosion operations, consisting of cleaning applications, a phosphate bath, and a chromic acid bath; 2) priming operations, consisting of a electrodeposition primer bath, an anti-chip application, and a primer-surfacer application; 3) joint sealant application; and 4) finishing operations, consisting of a color coat application, a clear coat application, and any painting necessary for two-tone color or touch-up applications. The stages of the automotive finishing process are illustrated in Exhibit 9.

After the automobile body has been assembled, anti-corrosion operations prepare the body for the painting/finishing process. Initially, the body is sprayed with and immersed in a cleaning agent, typically consisting of detergents, to remove residual oils and dirt. The body is then dipped into a phosphate bath, typically zinc phosphate, to prevent corrosion. The phosphate process also improves the adhesion of the primer to the metal. The body is then rinsed with chromic acid, further enhancing the anti-corrosion properties of the zinc phosphate coating. The anti-corrosion operations conclude with another series of rinsing steps.

Priming operations further prepare the body for finishing by applying various layers of coatings designed to protect the metal surface from corrosion and assure good adhesion of subsequent coatings. Prior to the application of these primer coats, however, plastic parts to be painted and finished with the body are installed.

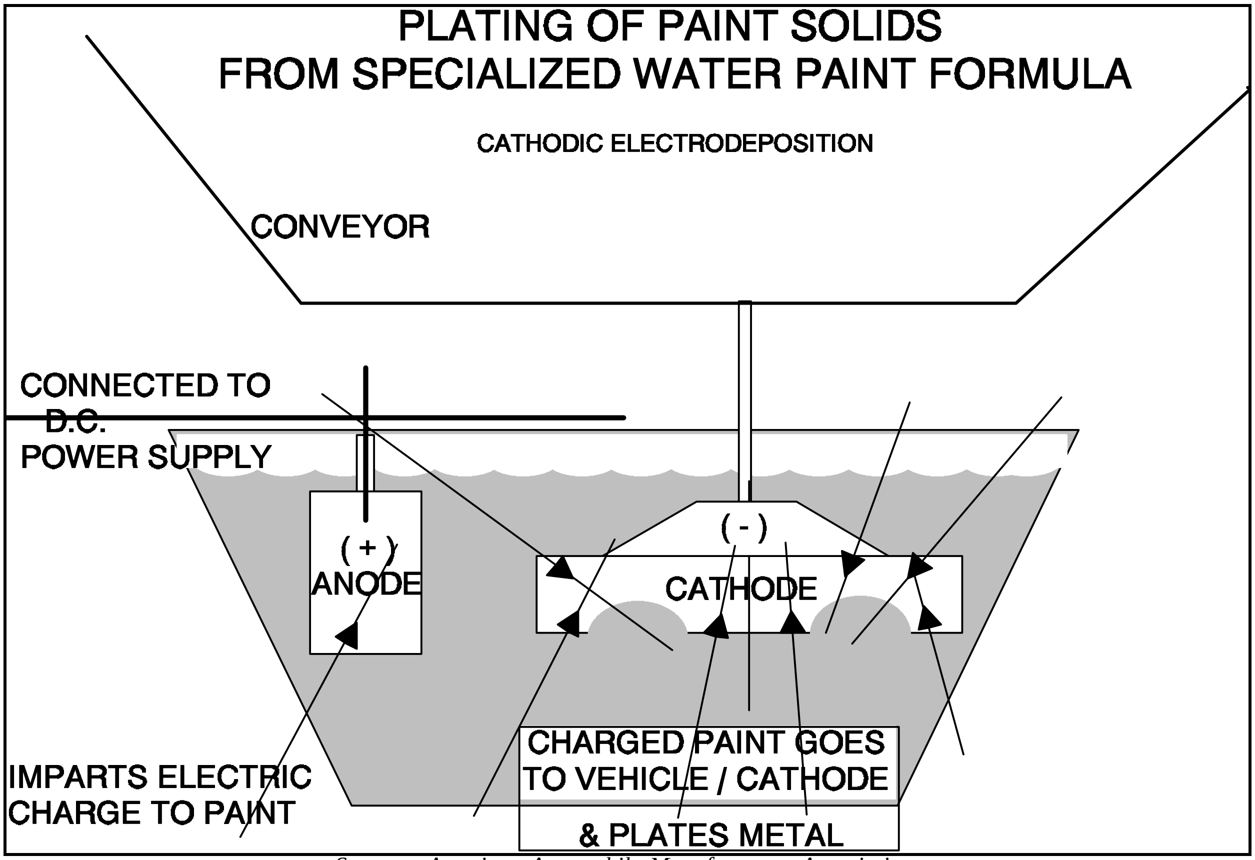
As illustrated in Exhibit 10, a primer coating is applied to the body using an electrodeposition method, creating a strong bond between the coating and the body to provide a more durable coating. In electrodeposition, a negatively-charged auto body is immersed in a positively-charged 60,000 to 80,000 gallon bath of primer for approximately three minutes. The coating particles, insoluble in the liquid and positively-charged, migrate toward the body and are, in effect, "plated" onto the body surface.

Exhibit 9
Car Painting Process



Source: American Automobile Manufacturers Association.

Exhibit 10
Plating of Paint Solids from Specialized Water Paint Formula



Source: American Automobile Manufacturers Association.

Although the primer bath is mostly water-based with only small amounts of organic solvent (less than five to ten percent), fugitive emissions consisting of volatile organic compounds (VOCs) can occur. However, the amount of these emissions is quite small. In addition to solvents and pigments, the electrodeposition bath contains lead, although the amount of lead used has been decreasing over the years.

Prior to baking, excess primer is removed through several rinsing stages. The rinsing operations use various systems to recover excess electrodeposited primer. Once the body is thoroughly rinsed, it is baked for approximately 20 minutes at 350 to 380 degrees Fahrenheit. VOC emissions resulting from the baking stage are incinerated at approximately 90 percent of automotive and automotive parts facilities.

Next, the body is further water-proofed by sealing spot-welded joints of the body. Water-proofing is accomplished through the application of a paste or putty-like substance. This sealant usually consists of polyvinyl chloride and small amounts of solvents. The body is again baked to ensure that the sealant adheres thoroughly to the spot-welded areas.

After water-proofing, the automobile body proceeds to the anti-chip booth. Here, a substance usually consisting of a urethane or an epoxy ester resin, in conjunction with solvents, is applied locally to certain areas along the base of the body, such as the rocker panel or the front of the car. This anti-chip substance protects the lower portions of the automobile body from small objects, such as rocks, which can fly up and damage automotive finishes.

The primer-surfacer coating, unlike the initial electrodeposition primer coating, is applied by spray application in a water-wash spray booth. The primer-surfacer consists primarily of pigments, polyester or epoxy ester resins, and solvents. Due to the composition of this coating, the primer-surfacer creates a durable finish which can be sanded. The pigments used in this finish provide additional color layers in case the primary color coating is damaged. The water-wash spray booth is generally 100 to 150 feet long and applies the primer-surfacer in a constant air stream through which the automobile body moves. A continuous stream of air, usually from ceiling to floor, is used to transport airborne particulates and solvents from primer-surfacer overspray. The air passes through a water curtain which captures a portion of the airborne solvents for reuse or treatment at a waste water facility. Efforts have been made at certain facilities to recycle this air to reduce VOC emissions.

After the primer-surfacer coating is baked, the body is then sanded, if necessary, to remove any dirt or coating flaws. This is accomplished using a dry sanding technique. The primary environmental concern at this stage of the finishing process is the generation of particulate matter.

The next step of the finishing process is the application of the primary color coating. This is accomplished in a manner similar to the application of primer-surfacer. One difference between these two steps is the amount of pigments and solvents used in the application process. VOC emissions from primary color coating operations can be double that released from primer-surfacer operations. In addition to the pigments and solvents, aluminum or mica flakes can be added to the primary color coating to create a finish with unique reflective qualities. Instead of baking, the primary color coat is allowed to "flash off," in other words, the solvent evaporates without the application of heat.

Pigments, used to formulate both primers and paints, are an integral part of the paint formulation, which also contains other substances. The pigmented resin forms a coating on the body surface as the solvent dries. The chemical composition of a pigment varies according to its color, as illustrated in Exhibit 11.

Exhibit 11
Chemical Components of Pigments Found in Paint

Pigment Color	Chemical Components
White	Titanium dioxide, white lead, zinc oxide
Red	Iron oxides, calcium sulfate, cadmium selenide
Orange	Lead chromate-molybdate
Brown	Iron oxides
Yellow	Iron oxides, lead chromate, calcium sulfide
Green	Chromium oxide, copper, phosphotungstic acid, phosphomolybdic acid
Blue	Ferric ferrocyanide, copper
Purple	Manganese phosphate
Black	Black iron oxide
Metallic	Aluminum, bronze, copper, lead, nickel, stainless steel, silver, powdered zinc

Source: McGraw Hill Encyclopedia of Science and Technology, 1987.

After the primary color coating is allowed to air-dry briefly, the final coating, a clear coat, is applied. The clear coat adds luster and durability to the automotive finish. This coating generally consists of a modified acrylic or a urethane and is baked for approximately 30 minutes.

Following the baking of the clear coat, the body is inspected for imperfections in the finish. Operators finesse minor flaws through light sanding and polishing and without any repainting.

Once the clear coat is baked, a coating known as deadener is applied to certain areas of the automobile underbody. Deadener, generally a solvent-based resin of tar-like consistency, is applied to areas such as the inside of wheel wells to reduce noise. In addition, anti-corrosion wax is applied to other areas, such as the inside of doors, to further seal the automobile body and prevent moisture damage. This wax contains aluminum flake pigment and is applied using a spray wand.

After painting and finishing, two types of trim are installed - hard and soft. Hard trim, such as instrument panels, steering columns, weather stripping, and body glass, is installed first. The car body is then passed through a water test where, by using phosphorous and a black light, leaks are identified. Soft trim, including seats, door pads, roof panel insulation, carpeting, and upholstery, is then installed. The only VOC emissions resulting from this stage of the process originate from the use of adhesives to attach items, such as seat covers and carpeting.

Next, the automobile body is fitted with the following: gas tank, catalytic converter, muffler, tail pipe, and bumpers. Concurrently, the engine goes through a process known as "dressing," which consists of installing the transmission, coolant hoses, the alternator, and other components. The engine and tires are then attached to the body, completing the assembly process.

The finished vehicle is then rigorously inspected to ensure that no damage has occurred as a result of the final assembly stages. If there is major damage, the entire body part is replaced. However, if the damage is minor, such as a scratch, paint is taken to the end of the line and applied using a hand-operated spray gun. Because the automobile cannot be baked at temperatures as high as in earlier stages of the finishing process, the paint is catalyzed prior to application to allow for faster drying at lower temperatures. Approximately two percent of all automobiles manufactured require this touch-up work. Because the paint used in this step is applied using a hand-operated spray gun, fugitive air emissions are likely to be generated (depending on system design).

Generally, spray and immersion finishing methods are to a certain extent interchangeable, and the application method for various coatings varies from facility to facility. The same variance applies to the number and order of rinsing steps for cleaning, phosphating, and electrodeposition primer operations. Spray rinsing the body prior to immersion rinsing decreases the amount of residues deposited in the bath and allows for greater solvent recovery.

In addition to the above-mentioned uses of solvents as ingredients of coatings, solvents are often used in facility and equipment cleanup operations. Efforts have been made at several facilities to reduce the amount of solvent used for this purpose, thereby reducing fugitive VOC emissions, and to reuse these solvents when preparing batches of coatings used in certain stages of the finishing process.

The expanded use of alternative coating methods, such as electrostatic powder spray, is being researched. Powder coatings are being used instead of solvent-based coatings for some initial coating steps, such as the anti-chip and the primer-surfacer process.

III.A.4. Emerging Industry Trends

Motor vehicles manufactured today are produced more efficiently, brought to market more quickly, and designed to be more environmentally sensitive than the models of the 1980s. As a result, these vehicles are proving to have less of a negative impact on the environment. Automobile manufacturers are striving to meet new air emission standards, and are developing motor vehicles and motor vehicle equipment that meet the demands of the growing market niche for ÒgreenÓ automobiles. Much of the information for this section was adapted from the 1994 publication entitled ÒAutomotive Demand, Markets, and Material Selection ProcessesÓ by David J. Andrea and Brett C. Smith of the University of Michigan.

In order for motor vehicle and motor vehicle equipment manufacturers to remain competitive, it is becoming more important to strike a balance between environmental issues and industrial demands. Approaches such as life cycle assessment (LCA), design for recycling (DFR[a]), and design for disassembly (DFD) encourage the development of products that are more environmentally acceptable. These approaches are in various stages of implementation in the automotive industry. Evidence of their influence can be seen in some of the initiatives currently underway in the automotive industry, some of which are addressed later in this profile.

III.A.4.a. *Life Cycle Assessment*

LCA is an environmental approach that focuses on the environmental costs associated with each stage of the product life cycle (See Exhibit 12). LCA requires the evaluation of environmental effect at every stage of the cycle. The evaluation focuses on such factors the waste streams generated during material acquisition and manufacturing, as well as energy consumption during processing and distribution. Attempts to implement this structured approach have begun, although full LCAs for automobiles have not yet been achieved due to product complexity.

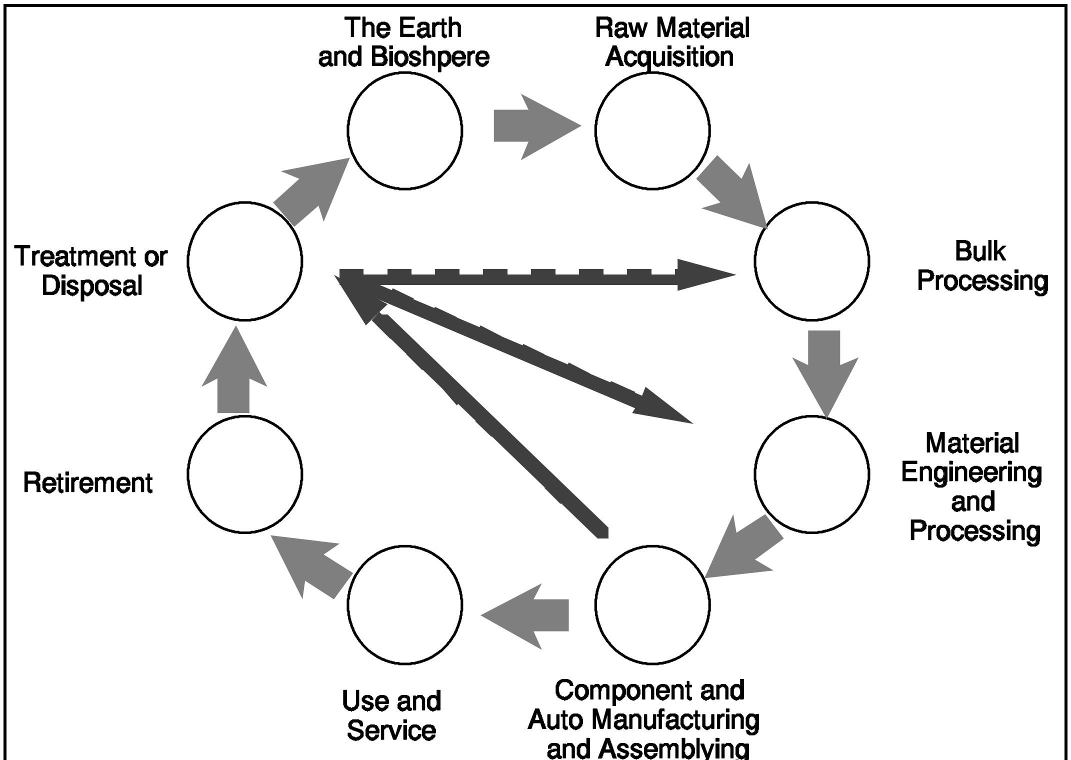
According to General Motors' 1994 Environmental Report, LCA is an important part of the companyÕs commitment to product stewardship. To implement this commitment, GM environmental personnel work closely with vehicle design teams to integrate environmental principles into the earliest possible stages of the product program management process. As part of this process, various statements of work, which specify the health, safety, and facility environmental criteria that must be met before a product can be released to the next development phase, are used to provide a framework for an environmental and health evaluation of GM products. Ford and other automakers are also working to develop LCA technology. LCA promises to be a useful tool and its future applications in the automotive industry should improve overall industry environmental performance.

III.A.4.b. *Recycling*

An important part of LCA is the ÒretirementÓ of a given product. Once a product reaches the retirement stage, it becomes eligible for recycling, another environmental trend.

Autos have been recycled for many years in the U.S., and today approximately 94 percent (or approximately 9 million) of all automobiles scrapped in the U.S. are collected and recycled. This effort results in approximately 11 million tons of recycled steel and 800,000 tons of recycled nonferrous metals, and saves an estimated 85 million barrels of oil that would be used to manufacture new parts. The U.S. boasts one of the most effective and prosperous vehicle recycling industries in the world. At least 75 percent of the material collected from scrap vehicles (steel, aluminum, copper) is recycled for raw material use. According to the Automotive Recyclers Association (ARA), the automotive remanufacturing and recycling industry is responsible for approximately five billion dollars in annual sales.

Exhibit 12
The Product Life Cycle System



Source: Automotive Demand, Markets, and Material Selection Process, Society of Automotive Engineers - Technical Paper Series, International Congress & Exposition, Detroit, Michigan, 1994.

Three operations are primarily responsible for vehicle recycling - automobile scrappage/disassembly, automobile shredders, and materials recycling. There are an estimated 12,000 automobile scrappage/disassembly operations in the United States. Vehicles taken to these businesses are subject to two major dismantling steps: (1) drainage and removal of hazardous and recyclable fluids (oil, auto coolants, CFCs), and (2) removal of parts from the vehicle, which, if undamaged, are then cleaned, tested, inventoried, and sold, and if damaged, are recycled with similar materials. The remaining hulk is then flattened and taken to a shredder.

There are an estimated 200 shredding operations in North America. These operations use large machines to shred the hulk into fist-sized pieces which are then separated by material types: ferrous, nonferrous, and automotive shredder residue (ASR) or Òshredder fluff.Ó

Shredder output is first sorted by magnetic separation to ÒcaptureÓ the ferrous materials, which are then transported to a mill. Nonferrous metals are then hand-sorted from a conveyor belt and sold for use in new products. The remaining material (approximately 25 percent) is sent to landfills. This material is composed primarily of plastics, rubber, glass, dirt, fibers from carpet, seat foam, and undrained fluids. This waste currently constitutes about 1.5 percent of total municipal landfill waste. The amount of waste generated by shredding will be greatly reduced when vehicles are designed using concepts such as DFR and DFD.

III.A.4.c. *Other Initiatives*

Three important trends impacting vehicle development are: the increased use of lighter weight materials such as aluminum, plastic, and the various composites; the use of alternative fuels; and increased use of electric components.

The Federal Corporate Average Fuel Economy (CAFE) Requirements, which mandate average motor-vehicle fuel economy standards for passenger automobiles and light trucks, will push the increased usage of lighter-weight materials by encouraging lower vehicle weight and increased fuel efficiency. Industry experts predict that the use of lighter weight materials will increase 38 percent between 1992 and 2000. A study conducted by the University of Michigan Transportation Research Institute, Office for the Study of Automotive Transportation (OSAT), entitled Delphi VII, states that industry experts expect to see a three percent drop in average weight of a North American produced automobile by 1998 and an eight percent drop by 2003. Light-truck weight is expected to see similar reductions with a five percent decrease by 1998 and a seven percent decrease by 2003.

In order to produce lighter-weight vehicles, new lightweight materials are needed. The use of materials such as aluminum, magnesium, and plastic could potentially increase 15 to 20 percent by 2003. The use of heavier material such as steel and cast iron, which account for the majority of car weight, is expected to fall 9 to 15 percent within the same time frame (See Exhibit 13). Currently, Ford is the largest user of aluminum per vehicle in North America. In 1991, the use of aluminum in Ford vehicles was 15 percent above the industry average. Likewise, Ford researchers and engineers embarked on the ÒSynthesis 1020Ó program, which is part of a $25 million effort to determine the feasibility of a high-volume aluminum intensive vehicle (AIV). Under that initiative, Ford built 40 AIVÕs which now are being fleet-tested. Chrysler is also exploring the use of aluminum in cars and may begin building an aluminum intensive car in 1996, employing 600 to 700 pounds of aluminum per car. The reduction in weight for a midsize vehicle would cut gasoline consumption by one gallon for each 100 miles driven.

Exhibit 13
Material Content Forecast for Passenger Cars

Material Content	**Estimated Current Weight 27.5 mpg***	**Median Responses****		
		1988	**1998**	**2003**
Steel	1709	-1%	-5%	-9%
Cast Iron	430	-5%	-10%	-15%
Aluminum	174	+10%	+15%	+ 20%
Plastics	243	5%	10%	15%
Copper (including electrical)	45	0	0	0

Zinc	37	0	-4%	-4%
Magnesium	7	5%	8%	15%
Glass	88	0	0	0
Ceramics	2	2%	3%	5%
Powdered Metals	25	4%	4%	10%
Rubber -Tires (inc. spare) -All other rubber	 94 39	 0 0	 0 0	 0 0

Source: WardOs Automotive Yearbook, 1992 and various OSAT estimates.

* Miles Per Gallon
** Percent change in material content

In order to satisfy the requirements of the CAA by lowering the emission of hydrocarbons, carbon monoxide, and oxides of nitrogen, the use of alternative fuel sources is being explored. Various alternatives are being explored with different levels of success (See Exhibit 14). Oxygenated fuels, fuels that are blended with either alcohol or ethers, are slowly becoming more common in the United States. Oxygenated fuels are beneficial because they reduce emissions of carbon monoxide without requiring vehicle adjustments. This is particularly true in older cars (pre-1981) which do not have systems which maintain a constant air-fuel mixture. At least two States with severe carbon monoxide problems, Colorado and Arizona, have implemented mandatory oxygenated fuel programs in order to meet ambient air quality standards. Currently, the State of California plans to mandate the sale of electric cars beginning in 1998. Research and development on electric car technology by the U.S. car companies predates the California mandate by several years. The main problem with manufacturing as well as driving electric cars is the battery; a long-lasting battery has not yet been developed.

Exhibit 14
Use of Alternative Fuels Forecast

Alternative Fuels	Estimate 1992	Passenger Cars Median Response	
		1998	2003
Alcohol or Alcohol/gasoline (>10% alcohol; includes flex fuel or variable fuel)	0.5%	1.0%	5.0%
Diesel	1.2%	1.0%	2.0%
Electric	0.0%	0.2%	2.0%
Electric/gasoline hybrid	0.0%	0.0%	1.0%
Natural gas	0.0%	0.5%	2.0%
Propane	0.0%	0.1%	0.5%

Source: UMTRI Research Review, Delphi VII - Forecast and Analysis of the North American Automotive Industry, Information taken from various OSAT estimates.

Electronic components such as anti-lock brakes, electric windows, sun- and moon-roofs have become more prominent in vehicles. This being so, producers of specific motor-vehicle parts and accessories will be replaced or transformed from manufacturers of mechanically engineered products to producers of electronic goods. By the year 2000, the proportionate value of electronic components used in the automotive industry is expected to increase by more than 200 percent from 1987 levels. A study by Volkswagen estimates that by the year 2000, approximately 25 percent of a vehicleÕs manufacturing cost will be attributed to electronics.

III.A.4.d. *Manufacturer Initiatives*

In response to new standards and other environmental concerns, the Big Three have committed substantial resources to researching and developing new technology. One Big Three joint research initiative, under the umbrella of the U.S. Council for Automotive Research (USCAR), is Low Emission Paint Consortium (LEPC), which aims to develop new technologies for low emitting paint processes. In July 1995, the LEPC dedicated a new facility at Wixom, Michigan, to test powder paint and other technologies. In addition to other research initiatives relating to production, USCAR sponsors several that relate to releases from the car. One example is the Low Emissions Technologies Research and Development Partnership. This partnership was formed to explore ways to reduce automotive emissions by improving the performance of catalytic converters and other exhaust related components, and by refining the internal combustion process. The partnership is also researching the feasibility of alternative fuel sources such as ethanol/methanol gasoline mixtures, liquid natural gas (LNG), and liquid petroleum gas.

To respond to perceived future demands for electric cars, The Big Three, together with the U.S. Department of Energy (DOE), formed the U.S. Advanced Battery Consortium. The goal of this consortium is to develop new battery storage technology.

Another Big Three initiative is aimed at developing new materials for vehicles. The U.S. Automotive Materials Partnership will explore the use of materials such as polymer composites, aluminum, plastics, iron, steel, ceramics, and advanced metals. The use of these products in automotive manufacturing is expected to lead to lighter, cleaner, and safer vehicles. Automakers are also exploring the feasibility of developing aluminum vehicles. The Aluminum Association reports that a mid-size sedan using 1,000 pounds of aluminum would be 25 percent lighter and 20 percent more fuel efficient than a car composed entirely of steel. The aluminum content of cars has increased over the years from an average of 78 pounds in 1970 to 191 pounds today.

An additional Big Three initiative - the Vehicle Recycling Partnership (VRP) - is exploring techniques to increase automotive recycling. Although 94 percent of all vehicles are taken to recycling facilities, only 75 percent of a vehicleÕs actual weight is claimed for recycling purposes. One area of particular interest in automotive recycling is plastics. A recent industry study claims that as much as one billion pounds of automotive plastics end up in landfills. New technologies such as Òpolymer renewalÓ recycling are being developed to recycle thermoplastic polyester, nylon, and acetal into first-quality polymers. Ford was the first North American automaker to recycle plastic parts from previously built vehicles. Ford and GM also are making new parts from recycled plastic bumpers. According to AAMA, the automakers are helping to stimulate the market for used materials by incorporating recycled materials into the car. For example, Ford is making: protective seat covers from recycled plastic; splash shields from battery casings; grille opening reinforcements and luggage racks from recycled soda pop bottles; grilles from computer housings and telephones, head lamp housings from plastic water cooler bottles, and on a test basis, brake pedal pads from tires.

Heightened competition has led the Big Three to initiate several jointly funded research products, including the Partnership for a New Generation of Vehicles (PNGV). PNGV is designed to generate technologies that will lead to more environmentally friendly cars. PNGV is joining Federal agencies, under the leadership of the Commerce DepartmentÕs Technology Administration, to initiate the New Technology Initiative. The goal of this initiative, introduced by President Clinton in 1993, is to develop a new generation of vehicles with three times greater fuel efficiency.

III.B. Raw Material Inputs and Pollution Outputs

The many different production processes employed to manufacture a motor vehicle require a vast amount of material input and generate large amounts of waste. The outputs resulting from the various stages of production range from air emissions from foundry operations to spent solvents from surface painting and finishing.

Exhibit 15 highlights the production processes, the material inputs, and the various wastes resulting from these operations. Process waste pollutants are treated or neutralized before discharge.

Exhibit 15
Material Inputs/Pollution Outputs

Process	Material Input	Air Emissions	Process Wastes (Waste Water & Liquids	Other Wastes
Metal Shaping				
Metal Cutting and/or Forming	Cutting oils, degreasing and cleaning solvents, acids, and metals	Solvent wastes (e.g., 1,1,1-trichloroethane, acetone, xylene, toluene, etc.)	Acid/alkaline wastes (e.g., hydrochloric, sulfuric and nitric acids) and waste oils	Metal wastes (e.g., copper, chromium and nickel) and solvent wastes (e.g., 1,1,1-trichloroethane, acetone, xylene, toluene, etc.)
Heat Treating	Acid/alkaline solutions (e.g., hydrochloric and sulfuric acid), cyanide salts, and oils		Acid/alkaline wastes, cyanide wastes, and waste oils	Metal wastes (e.g., copper, chromium, and nickel)
Surface Preparation				
Solvent Cleaning	Acid/alkaline cleaners and solvents	Solvent wastes (e.g., acetone, xylene, toluene, etc.)	Acid/alkaline wastes	Ignitable wastes, solvent wastes, (e.g., 1,1,1-trichloroethane, acetone, xylene, toluene, etc.) and still bottoms
Pickling	Acid/alkaline solutions		Acid/alkaline wastes	Metal wastes
Surface Finishing				
Electroplating	Acid/alkaline solutions, metal bearing and cyanide bearing solutions		Acid/alkaline wastes, cyanide wastes, plating wastes, and wastewaters	Metal wastes, reactive wastes, and solvent wastes

Exhibit 15
Material Inputs/Pollution Outputs (cont'd)

Process	Material Input	Air Emissions	Process Wastes (Waste Water & Liquids	Other Wastes
Surface Finishing (contd)				
Surface Finishing	Solvents	Solvent wastes (e.g., 1,1,1-trichloroethane, acetone, xylene, toluene, etc.)		Metal paint wastes, solvent wastes, ignitable paint wastes, and still bottoms
Facility Cleanup	Solvents	Solvent wastes (e.g., 1,1,1-trichloroethane, acetone, xylene, toluene, etc.)		Solvent wastes and still bottoms

The discussion of pollution outputs from automotive manufacturing follows the same format as the discussion of the manufacturing process: foundry operations; metal fabricating; metal finishing; assembly; painting/coating; and dismantling/shredding.

III.B.1. Foundry Operations

Iron foundries create a number of wastes which may pose environmental concerns. Gas and particulate emissions are a concern throughout the casting process. Dust created during sand preparation, molding, and shakeout is of concern due to the carcinogenic potential of the crystalline silica in the sand. Gases containing lead and cadmium and other particulate matter and sulfur dioxide are also created during foundry operation, especially during the melting of the iron.

The wastewaters generated during foundry operations may also be of an environmental concern. Wastewaters are generated primarily during slag quenching operations (water is sprayed on the slag to both cool it as well as pelletize it) and by the wet scrubbers employed as air pollution control devices connected to furnaces and sand and shakeout operations. Due to the presence of cadmium and lead in iron, these metals may both be present in wastewaters.

Foundry operations also create many waste materials that meet the definition of a RCRA hazardous waste. Of primary concern is the calcium carbide desulfurization slag created during the melting of the iron. This slag readily reacts with water to create acetylene gas, a trait which causes it to be classified as a D003 reactive hazardous waste. Other materials such as wastewater sludges and baghouse dust may also fail the toxicity characteristic for lead and cadmium and would then be classified as D008 and D006 respectively. Foundries may also use solvents for cleaning, which when spent, may be characterized as characteristic (ignitable or toxic) or listed hazardous waste depending upon the formulations used.

III.B.2. Metal Fabricating

Each of the metal shaping processes can result in wastes containing constituents of concern (depending on the metal being used). In general, there are two categories of waste generated in metal shaping operations: scrap metal and metalworking fluids/oils.

Scrap metal may consist of metal removed from the original piece (e.g., steel or aluminum). Quite often, scrap is reintroduced into the process as a feedstock.

In general, metalworking fluids can be petroleum-based, oil-water emulsions, or synthetic emulsions that are applied to either the tool or the metal being tooled to facilitate the shaping operation. Metalworking fluid is used to:

¥ Keep tool and workpiece temperature down and aid lubrication,
¥ Provide a good finish
¥ Wash away chips and metal debris
¥ Inhibit corrosion or surface oxidation.

Metalworking fluids typically become contaminated and spent with extended use and reuse. When disposed, these oils may contain constituents of concern, including metals (cadmium, chromium, and lead), and therefore must be tested to see if they are considered a RCRA hazardous waste. Many fluids may contain chemical additives such as chlorine, sulfur and phosphorus compounds, phenols, cresols, and alkalines. In the past, such oils have commonly been mixed with used cleaning fluids and solvents (including chlorinated solvents). Air emissions may result through volatilization during storage, fugitive losses during use, and direct ventilation of fumes.

Surface preparation operations generate wastes contaminated with solvents and/or metals depending on the type of cleaning operation. Concentrated solvent-bearing wastes and releases may arise from degreasing operations. Degreasing operations may result in solvent-bearing wastewaters, air emissions, and materials in solid form. Solvents may be rinsed into wash waters and/or spilled into floor drains. Although contamination of the wastewater is possible, procedures are in place to prevent such pollution in the first place. Air emissions may result through volatilization during storage, fugitive losses during use, and direct ventilation of fumes. Any solid wastes (e.g., wastewater treatment sludges, still bottoms, cleaning tank residues, machining fluid residues, etc.) generated by the operation may be contaminated with solvents, some of which may meet RCRA hazardous waste listings F001 and F005.

Chemical treatment operations can result in wastes that contain metals of concern. Alkaline, acid, mechanical, and abrasive cleaning methods can generate waste streams such as spent cleaning media, wastewaters, and rinse waters. Such wastes consist primarily of the metal complexes or particles, the cleaning compound, contaminants from the metal surface, and water. In many cases, chemical treatment operations are used in conjunction with organic solvent cleaning systems. As such, many of these wastes may be cross-contaminated with solvents.

The nature of the waste will depend upon the specific cleaning application and manufacturing operation. Wastes from surface preparation operations may contribute to commingled waste streams such as wastewaters discharged to centralized treatment. Further, such operations can result in direct releases such as fugitive emissions and easily segregated wastes such as cleaning tank residues.

III.B.3. Metal Finishing

Surface finishing and related washing operations account for a large volume of wastes associated with automotive metal finishing. Metal plating and related waste account for the largest volumes of metal (e.g., cadmium, chromium, copper, lead, mercury, and nickel) and cyanide-bearing wastes.

Electroplating operations can result in solid and liquid wastestreams that contain constituents of concern. Liquid wastes result from workpiece rinses and process cleanup waters. Most surface finishing (and many surface preparation) operations result in liquid wastestreams. Centralized wastewater treatment systems are common, and can result in solid-phase wastewater treatment sludges. In addition to these wastes, spent process solutions and quench bathes are discarded periodically when the concentrations of contaminants inhibit proper function of the solution or bath. When discarded, process bathes usually consist of solid- and liquid-phase wastes that may contain high concentrations of the constituents of concern, especially cyanide (both free and complex).

Related operations, including all non-painting processes, can contribute wastes including scrap metals, cleaning wastewaters, and other solid materials. The nature of these wastes will depend on the specific process, the nature of the workpiece, and the composition of materials used in the process.

III.B.4. Motor Vehicle Assembly

Due to advances in technology, well designed operating procedures, and the implementation of strategies to limit waste from assembly, little hazardous waste is generated during the actual assembly of an automobile (with the exception of painting/finishing which is discussed in the following section).

The majority of wastes generated during assembly are solid wastes resulting from parts packaging. Parts packaging can be grouped into two categories - returnable and expendable. Returnable packaging (containers) is shipped back to the original suppliers once empty. It includes such items as: metal racks, metal skids, returnable bins, totes, and rigid plastic racks and dunnage. Expendable packaging is used once and recycled, for the most part. Examples include styrofoam peanuts, wood skids, plastic, corrugated boxes, metal barding, and shrink-wrap. Advances in packaging design, changes in purchasing, and the elimination of unneeded materials have greatly reduced the amount of expendable waste generated.

Additional wastes generated from assembly operations may be attributed to general plant operations, cleaning and maintenance, as well as the disposal of faulty equipment and parts.

III. B.5. Motor Vehicle Painting/Finishing

Many of the wastes generated during automotive production are the result of painting and finishing operations. These operations result in air emissions as well as the generation of solid and liquid wastes.

Air emissions, primarily VOCs, result from the painting and finishing application processes (paint storage, mixing, applications, and drying) as well as cleaning operations. These emissions are composed mainly of organic solvents which are used as carriers for the paint. Solvents are also used during cleanup processes to clean spray equipment between color changes, and to clean portions of the spray booth. The solvent utilized during cleaning is generally referred as Òpurge solventÓ and is often composed of a mixture of dimethyl-benzene, 2-Pranone, 4-methyl-2-pentanone, butyl ester acetic acid, light aromatic solvent naphtha, ethyl benzene, hydrotreated heavy naphtha, 2-butanone, toluene, and 1-butanol.

Various solid and liquid wastes may be generated throughout painting operations and are usually the result of the following operations:

¥ Paint application - paint overspray caught by emissions control devices (e.g., paint booth collection systems, ventilation filters, etc.);

¥ Paint drying - ventilated emissions as paint carriers evaporate;

¥ Cleanup operations - cleaning of equipment and paint booth area; and

¥ Disposal - discarding of leftover and unused paint as well as containers used to hold paints, paint materials, and overspray.

Solid and liquid wastes may also contain metals from paint pigments and organic solvents.

III. C. Post Production Motor Vehicle Dismantling/Shredding

Dismantling operations involve both automotive fluids and solids. The fluids, such as engine oil, antifreeze, and air conditioning refrigerant, are recovered to the extent possible, reprocessed for reuse or sent to energy recovery facilities. Many solid parts, such as the radiator and catalytic converter, contain valuable metal materials which are removed for recycling or reuse. In addition, the dismantler will remove and recycle the battery, fuel tank, and tires to reduce shredder processing concerns. The shredder processes the remaining automotive hulk, along with other metallic goods (such as household appliances), into ferrous materials, non-ferrous materials, and shredder residue. The residue is a heterogeneous mix that may include plastics, glass, textiles, metal fines, and dirt. This material is predominantly landfilled.

III. D. Management of Chemicals in Wastestream

The Pollution Prevention Act of 1990 (EPA) requires facilities to report information about the management of TRI chemicals in waste and efforts made to eliminate or reduce those quantities. These data have been collected annually in Section 8 of the TRI reporting Form R beginning with the 1991 reporting year. The data summarized below cover the years 1992-1995 and is meant to provide a basic understanding of the quantities of waste handled by the industry, the methods typically used to manage this waste, and recent trends in these methods. TRI waste management data can be used to assess trends in source reduction within individual industries and facilities, and for specific TRI chemicals. This information could then be used as a tool in identifying opportunities for pollution prevention compliance assistance activities.

While the quantities reported for 1992 and 1993 are estimates of quantities already managed, the quantities reported for 1994 and 1995 are projections only. The EPA requires these projections to encourage facilities to consider future waste generation and source reduction of those quantities as well as movement up the waste management hierarchy. Future-year estimates are not commitments that facilities reporting under TRI are required to meet.

Exhibit 16 shows that the motor vehicle, bodies, parts and accessories industry managed about 333 million pounds of production-related waste (total quantity of TRI chemicals in the waste from routine production operations) in 1993 (column B). Column C reveals that of this production-related waste, 66% was either transferred off-site or released to the environment. Column C is calculated by dividing the total TRI transfers and releases by the total quantity of production-related waste. In other words, about 33% of the industry's TRI wastes were managed on-site through recycling, energy recovery, or treatment as shown in columns D, E and F, respectively. The majority of waste that is released or transferred off-site can be divided into portions that are recycled off-site, recovered for energy off-site, or treated off-site as shown in columns G, H, and I, respectively. The remaining portion of the production-related wastes (25.7%), shown in column J, is either released to the environment through direct discharges to air, land, water, and underground injection, or it is disposed off-site.

From the yearly data presented below it is apparent that the portion of TRI wastes reported as recycled on-site has decreased and the portions treated or managed through energy recovery on-site have increased between 1992 and 1995 (projected).

Exhibit 16
Source Reduction and Recycling Activity for SIC 37

A	B	C	D	E	F	G	H	I	J
	Production Related Waste Volume (10^6lbs.)	% Reported As Released and Transferred	**On-Site**			**Off-Site**			**Remaining Releases and Disposal**
Year			% Recycled	% Energy Recovery	% Treated	% Recycled	% Energy Recovery	% Treated	
1992	333	65%	19.99%	0.26%	12.38%	36.54%	3.99%	2.27%	25.84%
1993	333	66%	18.42%	0.23%	14.75%	34.11%	3.82%	2.97%	25.71%
1994	317	N	14.47%	0.35%	16.54%	34.96%	3.97%	3.36%	26.36%
1995	337	N	15.60%	0.28%	15.81%	36.89%	3.92%	3.21%	24.48%