⟁ EPA

Background Information Document: National Emission Standards for Hazardcus Air Pollutants (NESHAP) for the Friction Materials Manufacturing Industry

Background Information Document

National Emission Standards For Hazardous Air Pollutants (NESHAP) for the Friction Materials Manufacturing Industry

Emission Standards Division

U. S. Environmental Protection Agency
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

September 2001

This report has been reviewed by the Emission Standards Division of the Office of Air Quality Planning and Standards, EPA, and approved for publication. Mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use. Copies of this report are available through the Library Services Office (MD-35), U. S. Environmental Protection Agency, Research Triangle Park, NC 27711. (919) 541-2777, or from National Technical Information Services, 5285 Port Royal Road, Springfield, VA 22161, (703) 487-4650.

Table of Contents

Table of Contents (continued)

Table of Contents (continued)

List of Figures

List of Tables

List of Acronyms and Units of Measure

BID	background information document
Btu/lb	British thermal unit(s) per pound
CAA	Clean Air Act
CFR	Code of Federal Regulations
CO	carbon monoxide
CRF	capital recovery factor
EPA	U.S. Environmental Protection Agency
gal	gallon(s)
HAP	hazardous air pollutant
ICR	information collection request
lb	pound(s)
lb/gal	pound(s) per gallon
MACT	maximum achievable control technology
MMBtu	million Btu
mm Hg	millimeter(s) of mercury
NAICS	North American Industry Classification System
NESHAP	national emission standards for hazardous air pollutants
NO_x	nitrogen oxides
NSPS	new source performance standards
NTI	National Toxics Inventory
OAQPS	Office of Air Quality Planning and Standards
PEC	purchased equipment cost
PM	particulate matter
PM_{10}	PM with an aerodynamic diameter at or below 10 micrometers
ppm	part(s) per million
SBA	Small Business Administration
SIC	Standard Industrial Classification
SO_2	sulfur dioxide
TCE	trichloroethylene
tpy	ton(s) per year
TRI	Toxics Release Inventory
VOC	volatile organic compound

Chapter 1
Introduction

The purpose of this background information document (BID) is to summarize the background information gathered and the analyses performed during the development of the proposed friction materials manufacturing national emission standard for hazardous air pollutants (NESHAP). This chapter presents the statutory basis for the NESHAP, and a discussion of the source category listing. Chapter 2 characterizes the friction materials manufacturing industry, including an industry profile, process description, characterization of organic hazardous air pollutant (HAP) emissions, and a summary of existing State regulations applicable to friction materials manufacturing facilities. Chapter 3 describes organic HAP emission control techniques that are currently being used at friction materials manufacturing facilities and discusses pollution prevention options for reducing air emissions of HAP. Chapter 4 describes the rationale for the determination of maximum achievable control technology (MACT) floors, regulatory options for specific segments of the friction materials manufacturing industry, and compliance assurance monitoring options. Chapter 5 describes the model process units developed to evaluate the effects of the various control options. Chapter 6 presents estimates of primary air impacts, secondary environmental impacts, and energy impacts for existing sources resulting from the control of HAP emissions under the proposed standards. Chapter 7 presents the cost of applying the control options and monitoring required to meet the MACT standards and to ensure continuous compliance.

1.1 STATUTORY BASIS

Section 112 of the Clean Air Act (CAA) requires the U. S. Environmental Protection Agency (EPA) to establish technology-based emission standards for all categories and subcategories of major and area sources emitting one or more of the HAPs listed in §112 (b) of the CAA. These NESHAP must represent the MACT for all major sources. Additional standards may be

developed later under §112 (f) of the CAA to address residual risk that may remain even after application of the technology-based controls. Section 112 (a) of the CAA defines a major source as:

> ". . . any stationary source or group of stationary sources located within a contiguous area and under common control that emits or has the potential to emit considering controls, in the aggregate, 10 tons per year or more of any hazardous air pollutant or 25 tons per year or more of any combination of hazardous air pollutants."

Potential to emit is defined in Part 70 of the Code of Federal Regulations (CFR) as, ". . . the maximum capacity of a stationary source to emit any air pollutant under its physical and operational design." Part 70 of the CFR further explains that, ". . . any physical or operational limitation on the capacity of a source to emit an air pollutant, including air pollution control equipment and restrictions on hours of operation or on the type or amount of material combusted, stored, or processed, shall be treated as part of its design if the limitation is enforceable by the Administrator."

An area source is defined as ". . . any stationary source of hazardous air pollutants that is not a major source." The regulation of area sources is discretionary. If there is a finding of a threat of adverse effects on human health or the environment, then the source category can be added to the list of area sources to be regulated.

The Clean Air Act Amendments of 1990 prescribe an analytical framework that EPA is to apply in developing NESHAP for major sources. A key concept in this framework is the establishment of the MACT floor. Section 112 (d) of the CAA specifies that NESHAP for existing sources are to be no less stringent (but may be more stringent) than, ": . . the average emission limitation achieved by the best-performing 12 percent of the existing sources (for which the Administrator has emissions information) . . ." for categories and subcategories with 30 or more sources. For categories or subcategories with fewer than 30 sources, the MACT floor cannot be less stringent than the average emission limitation achieved by the best-performing 5 sources. The MACT floor

for new sources cannot be less stringent than the level of emission control that is achieved in practice by the best-controlled similar source.

A second key feature of the NESHAP development process is that of determining subcategories. Section 112 (d) of the CAA allows the EPA Administrator to, ". . . distinguish among classes, types, and sizes of sources within a category or subcategory in establishing such standards. . . ." The effect of this provision is that for each category or subcategory for which EPA is developing NESHAP, the resulting standards could be tailored to account for significant differences in classes, types, and sizes of sources. For each of the resulting classifications, a separate MACT floor determination is required.

1.2 SOURCE CATEGORY LISTING

Section 112 of the CAA requires us to list all categories of major HAP emitting sources and to promulgate regulations for their control. An initial list of source categories and accompanying schedules for regulation were published on December 3, 1993 (58 FR 63941).[1] Friction materials manufacturing was not among the initially listed source categories. A subsequent notice published on June 4, 1996 (61 FR 28197) added friction products manufacturing to the list of major source categories scheduled for regulation by November 15, 2000.[2] The listing was based on information obtained in a 1992 survey of the industry from which we concluded that some facilities that manufacture friction products have the potential to be major sources of HAP emissions. Friction products manufacturing includes facilities that manufacture, assemble or rebuild friction products such as brakes, or clutches. Based on additional information obtained during the development of this proposed rule, we have determined that only facilities that manufacture friction materials have the potential to emit HAP at major source levels. As such, this proposed rule will affect only friction materials manufacturers.

1.3 REFERENCES

1.   U. S. Environmental Protection Agency. National Emission Standards for Hazardous Air Pollutants Schedule for the Promulgation of Emission Standards Under Section 112(e) of

the Clean Air Act Amendments of 1990. 58 FR 63941. Washington, DC. U. S. Government Printing Office. December 3, 1993.

2. U. S. Environmental Protection Agency. National Emission Standards for Hazardous Air Pollutants; Revision of Initial List of Categories of Sources and Schedule for Standards Under Sections 112(c) and (e) of the Clean Air Act Amendments of 1990. 61 FR 28197. Washington, DC. U. S. Government Printing Office. June 4, 1996.

Chapter 2
Friction Materials Manufacturing Source Category

Friction materials manufacturing is a subset of friction products manufacturing. This chapter characterizes the friction materials manufacturing industry source category, including facilities, products, manufacturing processes, sources of HAP emissions, emission reduction techniques, and summarizes applicable State regulations. The sources of information presented in this chapter include the literature, industry representatives, site visit reports, information collection requests (ICRs), and State and local air pollution control agencies.

Section 2.1 provides a profile of the friction materials manufacturing industry. Section 2.2 describes the friction materials manufacturing process. Section 2.3 characterizes friction materials manufacturing HAP emission sources. Section 2.4 summarizes the available emission test data. Section 2.5 summarizes existing State regulations that pertain to friction materials manufacturing facilities. Section 2.6 contains a list of references.

2.1 INDUSTRY PROFILE

Broadly speaking, the friction products manufacturing industry includes any facility that manufactures or re-manufactures friction products such as brakes and clutches. A friction product is defined as a device that uses friction to accelerate or decelerate a vehicle or moving element of a machine. Brakes use friction materials to slow, stop, or hold stationary a vehicle or machine part. Clutches use friction materials to transfer kinetic energy from a power source to a transmission to rotate wheels or equipment parts.[1]

Brake friction products can be further subclassified according to design as one of the following: brake pads, as used in light vehicle disc brakes; brake linings, as used generally in light vehicle drum brakes; brake segments, which are strip linings used in medium-sized truck drum brakes; brake blocks, which are brake pads used in heavy duty truck and off-road vehicle drum brakes; and brake discs, as used in aircraft brakes. Brake pads that are manufactured and sold separately for aftermarket use also are referred to as pucks.[1]

Clutches can be classified as wet or dry according to the type of transmission with which they are used. Dry clutches are used with manual or standard vehicle transmissions; vehicles with automatic transmissions use wet clutches, in which kinetic energy is transferred through a viscous fluid. The friction material component of clutches is referred to as the clutch facing.[1]

2.1.1 Data Gathering

In 1997, ICRs were mailed to friction products manufacturing facilities to obtain detailed process and emissions data in order to characterize the industry. These ICRs requested data for the 1996 manufacturing year. Information collection request responses were received from 147 facilities (100 companies) that manufacture friction products in 34 states. These responses are believed to represent all of the friction products manufacturing facilities in the United States. Figure 2-1 presents the geographical distribution of the 147 friction products manufacturing facilities identified in the project database.

In addition, EPA conducted 11 site visits to 10 facilities in 7 states (including visits to 3 of the 4 facilities estimated to be major sources). Telephone calls were made to many of the ICR respondents to clarify and/or complete ICR responses and to gather additional information. The EPA also contacted several State agencies, including Colorado, Georgia, Indiana, North Carolina, Tennessee, and Wisconsin, for permits and emission test data

Industry information collected by the U. S. Census Bureau on the friction products industry is contained in the "Motor Vehicle Brake System Manufacturing 1997 Economic Census Report."[2] However, the data collected covers the manufacture of the entire motor vehicle brake system; friction materials manufacturing statistics are not specified. Additional U. S. Census Bureau
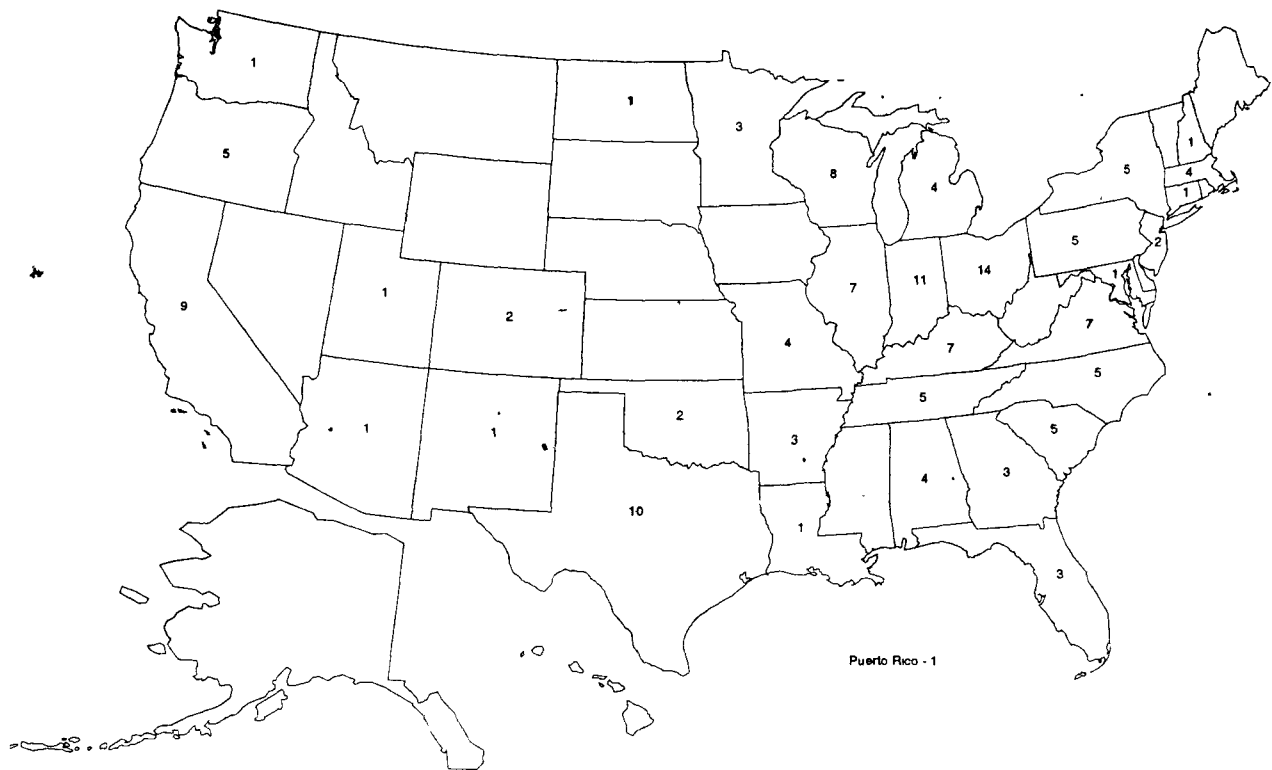
Figure 2-1. Geographic distribution of friction products manufacturing facilities.

information on the transportation industry in general is included in the Statistical Abstract of the United States.[3]

2.1.2 Industry Overview

Based on a review of the IC[P] responses, the 147 friction products manufacturing facilities can be organized into three basic categories: assemblers, rebuilders, and friction materials manufacturers. Of the 147 friction products manufacturers, there are16 friction products assemblers, 78 friction products rebuilders and 53 friction materials manufacturers. Of the 53 friction materials manufacturers, 2 facilities manufacture sintered friction materials, 4 facilities manufacture carbon-based friction materials, and 47 facilities manufacture resin-based friction materials. Table 2-1 lists the manufacturing processes for which data were collected, provides the number of facilities for each process type, and lists the products manufactured with each process. During the review of the available information on this source category, we found that these types of friction products

manufacturing facilities are generally different from each other with respect to types of raw materials, process operations, and emission characteristics.

Table 2-1. Friction Products Manufacturing Processes

Manufacturing process	No. of facilities	Product type(s)
Assemblers[a]	16	Brake shoes; disc pads; clutches
Rebuilders[b]	78	Brake shoes; clutches
Friction Materials Manufacturers		
Sintered	2	Brake discs; clutch facings
Carbon-based	4	Brake discs (aircraft)
Resin-based	47	Disc brake pucks; disc brake pads; brake lining; brake segments; brake block; brake shoes; clutch facings; friction material
Total	147	

[a] Assemblers purchase new friction material and attach it to new steel backing plates or shoes; no new material is manufactured at the facility.
[b] Rebuilders purchase new friction material and attach it to reconditioned brake shoes or clutch plates; no new friction material is manufactured at the facility.

Assemblers purchase new friction material from other manufacturers and attach it to new backing plates or shoes. Rebuilders purchase new friction material from other manufacturers and attach it to reconditioned brake shoes or clutch plates. None of these facilities manufacture friction material and none are major sources of HAP. Consequently, none of these facilities will be regulated under the friction materials manufacturing NESHAP.

Friction materials manufacturers make brake and clutch linings, and in most cases assemble finished products. Friction materials manufacturers can be classified into three classes based on the friction material manufactured: sintered material, carbon-based material, and resin-based material.

Two facilities manufacture sintered friction materials. Both use high-temperature sintering ovens to fuse the non-HAP metal and mineral ingredients into a consolidated product. Neither facility is

believed to be a major source of HAP, and, therefore, neither will be regulated under the friction materials manufacturing NESHAP.

Four facilities manufacture carbon-based friction materials in which carbon is impregnated into a synthetic mesh to create a friction material. Hydrogen cyanide is the only HAP known to be emitted from this process. All four existing facilities have Federally enforceable control requirements that limit hydrogen cyanide emissions to well below the major source threshold of 10 tons per year (tpy). In addition, we do not anticipate that any new carbon-based facilities will be built. As a result, manufacturers of carbon-based friction materials will not be regulated under the friction materials manufacturing NESHAP.

Forty-seven facilities manufacture resin-based friction materials. At these facilities, friction ingredients are mixed with resins which when cured bind the friction ingredients together. In most cases, mixing can be done without the aid of a solvent. However, for some friction materials, solvents are needed to enhance mixing and as a process aid in later stages. Of the 47 facilities that manufacture resin-based friction materials, only four use solvents to mix friction materials. All four are believed to be major sources of HAP due to releases of the solvents used. The HAP-containing solvents include n-hexane, toluene, and trichloroethylene.

Based on our review, we believe that solvent mixing is the only significant HAP emission source associated with friction materials manufacturing. Therefore, the friction materials manufacturing NESHAP establishes emission limitations for HAP emissions only from solvent mixers at new and existing sources that manufacture resin-based friction materials.

2.1.3 Major Sources

The number of major sources in the source category is estimated by calculating total HAP emissions for each facility at production capacity, considering controls already in place. Of the 147 friction products manufacturing facilities for which ICR responses were submitted, 4 were estimated to be potential major sources. The emission estimation methodology is presented in Appendix B. All four of the major sources are resin-based friction materials manufacturers that utilize solvent mixers in the manufacturing process. These four facilities are located in Indiana,

North Carolina, Tennessee, and Wisconsin. The remainder of this chapter will address only the resin-based friction materials manufacturing process and the four facilities estimated to be major sources.

There may be some friction materials manufacturing facilities which are not major for processes included in the friction materials manufacturing source category, but which may be major for surface coating or degreasing operations. These types of operations are subject to other standards and are not regulated under the proposed friction materials manufacturing NESHAP. The specific types of operations not included in the proposed regulation are discussed in Section 2.1.4 below.

2.1.4 Source Types Not Regulated

As described above, assemblers, rebuilders, sintered friction materials manufacturers, carbon-based friction materials manufacturers, and resin-based friction materials manufacturers that do not use solvents as process aid in mixing friction ingredients will not be included in the proposed friction materials manufacturing NESHAP. Additionally, there are other processes that are covered under other standards as described below.

During the manufacture of friction products, a painting process and/or an adhesive application process may be included in the process line. The application of paints and adhesives (coatings), including drying ovens and equipment cleaning, will be covered under the Miscellaneous Metal Parts and Products Surface Coating NESHAP (40 CFR Part 63, Subpart MMMM), or the Plastic Parts Surface Coating NESHAP (40 CFR Part 63, Subpart PPPP). As a result, the proposed friction materials NESHAP will not regulate any surface coating processes. Many facilities also perform metal preparation processes that include degreasing operations. Degreasing equipment that uses halogenated solvents will be covered under the Halogenated Solvents Cleaning NESHAP (40 CFR Part 63, Subpart T) and, therefore, will not be regulated under the proposed friction materials NESHAP.

In recent years, some friction products manufacturing facilities have changed their product formulations to remove some of the more hazardous components, such as lead and asbestos. Based on the responses to the ICR, only three facilities reported currently using asbestos in their product

formulations; none of these three facilities are estimated to be major sources. The asbestos contents reported range from 43 to 75 percent, with an average of 60 percent. Asbestos emissions from the use of asbestos-containing materials are covered under the Asbestos NESHAP (40 CFR Part 61, Subpart M) and, therefore, are not included in the proposed friction materials manufacturing NESHAP.

2.1.5 SIC and NAICS Codes

Friction materials manufacturing is covered by several Standard Industrial Classification (SIC) codes and North American Industry Classification System (NAICS) codes. Friction materials manufacturing is typically classified under SIC 3714, Motor Vehicle Parts and Accessories, Brake and Brake Systems, Including Assemblies and NAICS 33634, Motor Vehicle Brake System Manufacturing. Some facilities manufacture other products in addition to friction materials, and may have reported the SIC code for the product which makes up the majority of their annual production. A summary of SIC codes reported in the ICR responses for the four major facilities, and their respective NAICS codes, is presented in Table 2-2.

2.1.6 Small Businesses

Of the four major sources, one was determined to be a small business, based on SIC codes reported in the ICRs and on the Small Business Association's (SBA) small business size regulations. The SBA small business cutoffs for the SICs reported by the four major sources are presented in Table 2-3. Small business cutoffs for the SICs reported were either 500 or 750 employees, with most cutoffs being 500 employees.[4]

Table 2-2. Distribution of SIC Codes Reported in ICR Responses for Major Sources in the
Friction Materials Manufacturing Source Category

SIC code	SIC definition	Number of facilities[a]	NAICS code	NAICS definition[b]
3292	Asbestos Products (Asbestos Brake Linings and Pads)	1	33634	Motor Vehicle Brake System Manufacturing (pt)
3299	Nonmetallic Mineral Products, N.E.C. (Other Nonmetallic Mineral Products)	1	327999	All Other Miscellaneous Nonmetallic Mineral Product Manufacturing (pt)
3499	Fabricated Metal Products, N.E.C. (Other Metal Products)	1	332999	All Other Miscellaneous Fabricated Metal Product Manufacturing (pt)
3568	Mechanical Power Transmission Equipment, N.E.C.	1	333613	Mechanical Power Transmission Equipment Manufacturing
3714	Motor Vehicle Parts and Accessories (Brakes and Brake Systems, Including Assemblies)	1	33634	Motor Vehicle Brake System Manufacturing (pt)
Not reported[c]		1		

[a] Total is greater than four as some facilities reported two SIC codes.
[b] If more than one definition was available for a specific SIC or NAICS Code, the most appropriate definition was chosen.
[c] Facilities not reporting an SIC code were assigned SIC 3714 for determining small business status.

Table 2-3. Small Business Association Cutoffs for SIC Codes
Reported by Major Sources

SIC code	Small business size cutoff, no. of employees
3292	750
3299	500
3499	500
3568	500
3714	750

2.1.7 Markets

The resin-based friction materials produced using solvent as a process aid are used by numerous market segments, including railroad, automotive, and industrial. Table 2-4 summarizes the distribution of market segments for products manufactured by the four major source friction materials manufacturing facilities. Table 2-5 lists the product types produced by the four major facilities. Table 2-6 summarizes the 1996 production and production capacity data reported in the ICR responses for the four major facilities.

Table 2-4. Distribution of Product Market Segments
for Major Sources

Product market	Number of facilities[a]
Automotive	2
Railroad	1
Industrial	1
Other	1

[a] Total is greater than four because one facility manufactures products for more than one market segment.

Table 2-5. Distribution of Product Type for Major Sources

Product type	Number of facilities[a]
Brake lining	1
Brake shoe	1
Brake pad	1
Brake puck	1
Friction material	1
Industrial friction	1

[a] Total is greater than four because one facility manufactures more than one product type.

Table 2-6. Reported 1996 Production and Capacity for Major Sources[a]

Range (tpy)	Number of facilities	
	1996 production	Capacity
100 to 500	2	0
501 to 1,000	1	1
1,001 to 10,000	0	2
10,001 to 20,000	1	0
20,001 to 40,000	0	1

[a] Includes production of resin-based products only.

2.2 RESIN-BASED FRICTION MATERIALS MANUFACTURING PROCESS

Resin-based friction materials are used to make a variety of products. Figures 2-2 and 2-3 present simplified process flow diagrams for the manufacture of brake shoes and linings, and disc pads and pucks, respectively. These products are manufactured primarily for the automotive industry, but are also produced for industrial and railroad applications.

All four of the major sources reported both their actual annual production and annual production capacity in their ICR responses. Total 1996 annual production of resin-based products where solvent is used at these four facilities is approximately 13,000 tpy. Total 1996 annual production capacity for these products at the four facilities is approximately 39,000 tpy. In general, the industry is operating well below its capacity for these products, with an overall production utilization of approximately 33 percent.

The principal operations included in the manufacture of resin-based friction materials can be classified into four general areas: (1) raw material preparation; (2) forming; (3) curing; and (4) assembling and finishing. These four areas, and the specific equipment types (emission units) found in each area, are described in the following sections.[5,6,7]

2-10

```
  ┌─────────────────┐        ┌─────────────────┐
  │ Non-solvent mixer │      │  Solvent mixer   │
  │                 │        │   (optional)     │
  └─────────────────┘        └─────────────────┘
            │                         │
            └───────────┬─────────────┘
                        ▼
                ┌─────────────────┐
                │    Forming      │
                │  (roll machine) │
                └─────────────────┘
                        │
                        ▼
  ┌─────────────────┐   ┌──────────────────────┐
  │ Shoe preparation│   │       Curing         │
  │  (degreasing,   │   │ (curing oven, post-bake │
  │    painting)    │   │        oven)         │
  └─────────────────┘   └──────────────────────┘
            │                         │
   ┌────────┴──────────┬──────────────┴─────────┐
   ▼                                            ▼
┌──────────────────┐              ┌──────────────────┐
│   Assembling     │              │    Finishing     │
│ (adhesive        │              │  (grinding,      │
│  application,    │              │   drilling,      │
│  bonding oven,   │              │   packaging)     │
│  riveter)        │              │                  │
└──────────────────┘              └──────────────────┘
         │                                  ⇩
         ▼                         Finished Product:
┌──────────────────┐                 Strip Lining
│    Finishing     │
│  (grinding,      │
│   packaging)     │
└──────────────────┘
         ⇩
 Finished Product:
    Brake Shoe
```
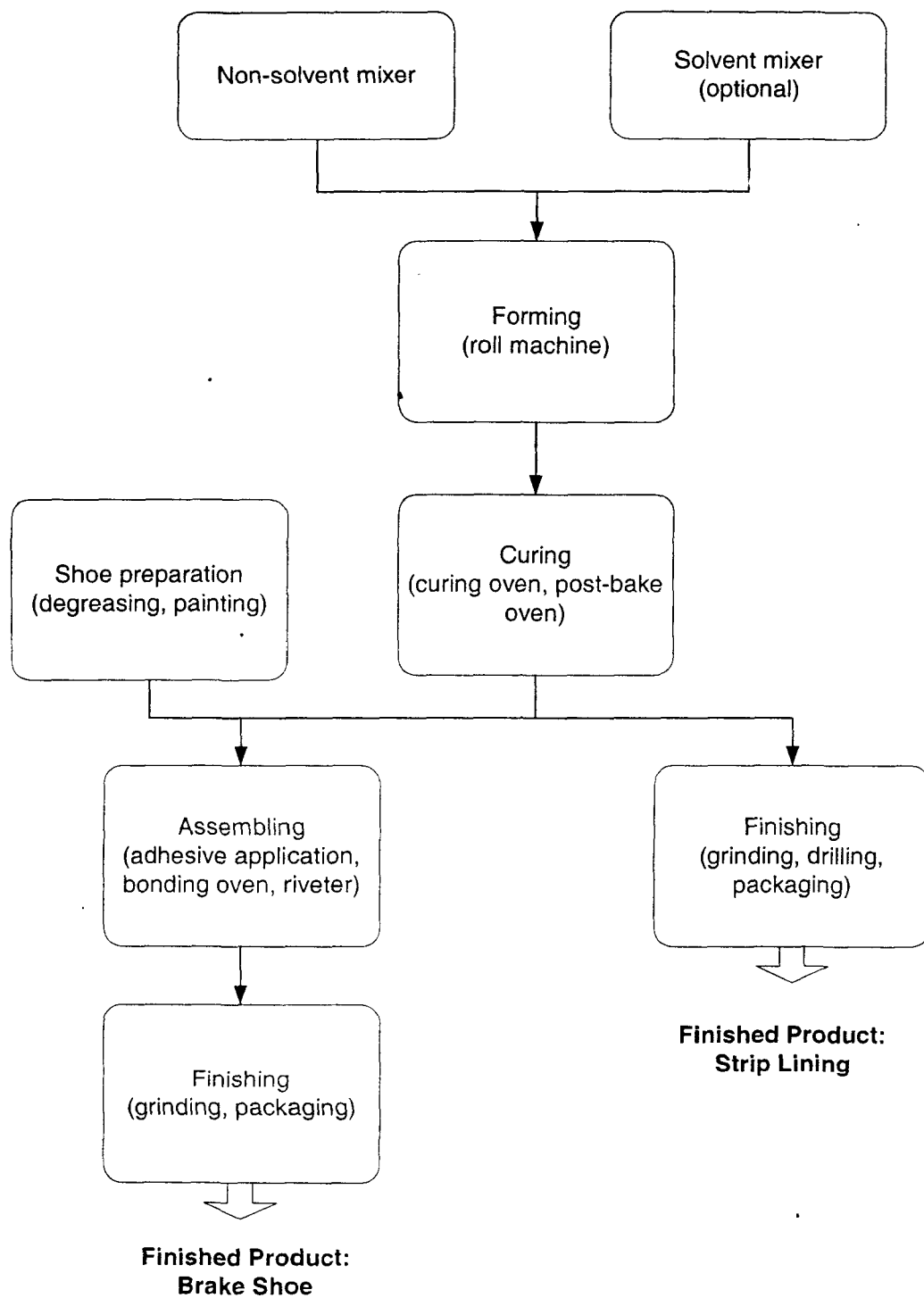
Figure 2-2. Simplified process flow diagram for the manufacture of brake shoes and strip lining.
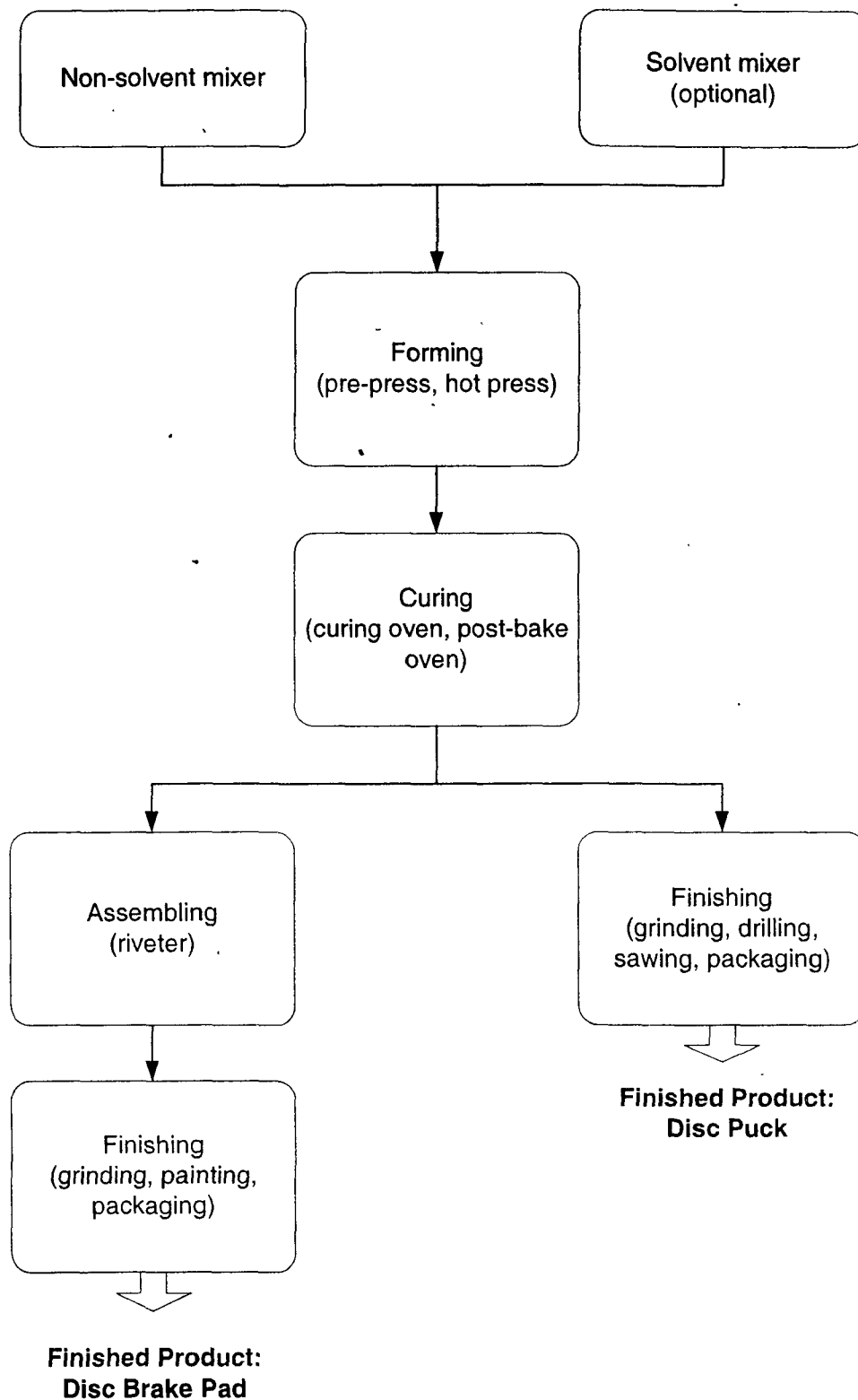
Figure 2-3. Simplified process flow diagram for the manufacture of disc brake pads and pucks.

2.2.1 Raw Material Preparation

The equipment in the raw material preparation area accomplishes the blending of individual ingredients (reinforcement material, property modifiers, resins, solvents, and other additives) in the proportions necessary to manufacture a friction product with the desired specifications. Process units in the raw material preparation area include mixers, granulators, and dryers.

Mixing is accomplished in discreet batches. Double-arm mixers are the most common type of mixer used. A typical batch includes between 300 and 1,000 pounds (lb) of friction ingredients, and takes between 20 minutes and 1 hour to mix. When solvents are used in the preparation of friction materials, the solvents are typically added as a process aid to obtain a homogenous mix of material. After mixing, most of the solvent is extracted from the friction material. However, some solvent is allowed to remain in the friction mix as a process aid for further process operations. Solvent mixers are typically batch mixers operated at slightly elevated temperatures. Typically, the reinforcement material, property modifiers, resin (if any), and any other additives are loaded into the mixer, and then the solvent is added. Some solvent mixers are completely enclosed, having lids that seal. With this type of mixer, the solvent is pumped into the mixer after the other ingredients have been added and the lid has been closed and sealed. After mixing, the solvent is removed under vacuum and recovered in a solvent recovery system. The recovered solvent may be reused in future batches of friction material mix. Other solvent mixers have covers that do not seal; with this type of mixer the solvent is not recovered.

Batches of mixed friction material may then be processed through a granulator to obtain a uniform particle size in the friction material. A granulator extrudes the material through a 0.25 to 0.5 inch die, and then cuts the extruded material into 0.5 to 1 inch lengths. Uniform particle size is important in obtaining the proper distribution of materials and optimum curing characteristics.

In some cases, friction material is dried after mixing, but before the forming step. Material dryers use indirect heat to remove most of the remaining solvent from the mix. Natural gas or steam is used to heat the dryer to around 150°F. Fumes from the dryer may be vented through a stack to the atmosphere, or may be released inside the manufacturing building as fugitive emissions.

2.2.2 Forming

The blended and prepared friction material is then transferred from the raw material preparation area to the forming area, where the material is formed into shapes. Forming equipment includes extruders, roll machines, and hot presses.

Extruders are used to form tapes and pellets of friction material. Pellets are formed by forcing the moist friction material through perforations in a metal die and cutting the continuously formed strands to a predetermined length. Tapes are formed by forcing the friction material through a metal die with an appropriately-shaped slot in a heated extruder head.

Roll machines are used to form flat, pliable tapes, similar to those produced by an extruder, and are also used to produce wider sheets of friction material. The moist friction material is metered between a series of rollers which form a continuous strip of friction material with a preset width and thickness.

Hot presses are used to form disc brake pucks, integrally-molded disc brake pads, brake segments, and brake blocks. Hot presses apply heat and pressure over time to consolidate the friction mix into a solid product. Premeasured quantities of friction mix are poured into each press cavity. As heat and pressure are applied, the material is partially cured. For some IM pads, the friction material is simultaneously attached to the metal backing plate during hot pressing; in this way they are formed, partially cured, and assembled in one step. Hot presses may be single- or multi-opening. Most hot presses are electrically- or steam-heated. Press temperatures range from 285° to 450°F, with an average operating temperature of 315°F. Press cycle times range from 0.2 to 240 minutes, with an average press time of about 20 minutes. Both press temperature and cycle time vary, depending on product size and composition.

2.2.3 Curing

After the friction shapes are formed, they must be cured. Curing equipment includes curing ovens and post bake ovens. Hot presses used to form friction material also begin the curing process;

2-14

however, a post bake or curing oven is used to ensure that the friction material is fully cured. Where hot presses are not used to form the friction material, uncured friction material from the forming process is cured in batch or continuous curing ovens. Oven cycle times vary from 1 to 46 hours, with an average cycle time of 13 hours. Oven temperatures ramp up and then down over the cycle. Oven temperatures range from 180° to 500°F, with an average temperature of 370°F. Oven cycle times and temperatures vary with product size and composition.

2.2.4 Assembling and Finishing

Once the friction material is formed and cured, it is finished and assembled with some type of metal backing. Friction material to be sold to assembly plants or to rebuilders is sold as-is, and is not assembled with the metal backing. Finishing operations bring the friction product to final specifications. These operations include machining, painting, and edge coding. Assembly operations include steel preparation (i.e., degreasing), adhesive application, oven bonding, riveting, and attachment of hardware (e.g., mounting brackets, wear sensors, and noise suppressors).

2.3 CHARACTERIZATION OF HAP EMISSIONS FROM RESIN-BASED FRICTION MATERIALS MANUFACTURING EMISSION UNITS

The nature and quantity of HAP emissions from the manufacturing of friction materials is driven almost entirely by whether HAP containing solvents are used in mixing. The primary HAP emitted from the major source friction materials manufacturing facilities are HAP solvents from mixing operations. Currently, these include n-hexane, toluene, and trichloroethylene. The main sources of these HAP emissions are the solvent mixers. Other potential sources of HAP solvent emissions include granulators, dryers, extruders, roll machines, hot presses, and ovens.

Baseline emissions are defined as actual HAP emissions from facilities in the absence of additional regulation. Baseline emissions are estimated by calculating total HAP emissions for each facility at actual production levels, considering controls already in place. The HAP solvent emission estimates were developed using a mass balance approach and control technology efficiencies. The emissions estimates for resin components (phenol and formaldehyde) are based

on the available emission test data.[8] Table 2-7 presents the potential and baseline organic HAP

emissions from the four major source friction materials manufacturing facilities.

Table 2-7. Potential and Baseline Annual HAP Emissions
from Friction Materials Manufacturing Major Sources

HAP compound	Potential emissions, tpy	Baseline emissions, tpy
Phenol	5.7	2.0
Formaldehyde	1.4	0.5
Toluene	222.0	62.5
Trichloroethylene	192.1	18.4
n-Hexane	2,644.2	556.4
Total HAP	3,065.5	639.9

Emissions from mixers can occur as solvent is added to the mixer, during the mixing cycle, and as

fugitive emissions when the mixed material is transferred from the mixer to the next process

operation. The type and quantity of organic HAP emissions from solvent mixers varies depending

on the type of solvent used, the amount of solvent used per batch, the configuration of the mixer,

and the presence or absence of a solvent recovery system. The three HAP solvents used at

solvent-based friction materials manufacturing facilities are n-hexane, toluene, and

trichloroethylene. Three of the seven solvent mixers are equipped with solvent recovery systems

designed to minimize HAP emissions and to reclaim solvent for reuse. For these mixers, the

solvent is removed from the mixed material by vacuum extraction and collected in either a

condenser (two mixers) or a carbon adsorber (one mixer). The reclaimed solvent is reused in the

process by the two facilities with condensers, and sold by the facility with the carbon adsorber.

Residual solvent that is not recovered or is emitted at the solvent mixer can be emitted in

subsequent processes as the friction material is processed through extruders, roll machines,

granulators, dryers, hot presses, and ovens. The potential for emissions from these downstream

processes is proportional to the quantity of residual solvent retained in the friction material after

mixing.

Small amounts of phenol and formaldehyde (HAP components of phenolic resins) are emitted from hot presses and curing ovens. At the four major HAP sources, phenol and formaldehyde emissions account for less than 1 percent of the total HAP emitted. None of the existing hot presses or curing ovens at the four major sources are equipped with HAP emission controls. Available test data indicate that the phenol and formaldehyde emissions are on the order of 5 parts per million (ppm) or less, which is below the level which can effectively be controlled by add-on controls.[8]

2.4 EMISSION TEST DATA

Minimal emission test data were received with the ICR responses. Additional test reports and summary emission data were received from States and from follow-up calls to individual facilities. Eight complete emission test reports and six partial or summary reports were received. These reports include emissions data for mixers, hot presses, and curing ovens. The pollutants tested include n-hexane, trichloroethylene, toluene, phenol, formaldehyde, and total hydrocarbons. A summary of the available emission test data is presented in a separate memorandum.[8]

2.5 EXISTING STATE REGULATIONS

As mentioned previously, there are several emission units at friction materials manufacturing facilities that are covered under other Federal emission standards; specifically, degreasing operations, coating operations, and asbestos operations. Many States have regulations applying to these operations. However, because these emission units are not regulated under the proposed friction materials manufacturing NESHAP, these State regulations are not summarized in this report. The only State regulations that have been found to be applicable to the friction materials manufacturing sources covered under this standard are general manufacturing volatile organic compound (VOC), particulate matter (PM), and combustion source regulations.

In addition to general VOC regulations, many States have their own air toxics programs that may apply to friction materials manufacturing facilities. These regulations typically regulate a large number of chemical compounds. Many States have their own list of air toxics, many of which are also designated as organic HAP under the Clean Air Act. These air toxics regulations typically specify allowable fenceline concentrations for the individual air toxics. If a facility's annual emissions of a regulated compound exceed a specified level, the State may require a facility to

perform dispersion modeling to determine whether the allowable concentration is exceeded at any point beyond the fenceline. The decision to require modeling depends on several factors, including the toxicity of the pollutant, its status as a VOC or organic HAP, the attainment status of the location, and other considerations. If emissions exceed the allowable concentration, the facility must reduce emissions.

One facility has a State operating permit with requirements specific to the solvent recovery system controlling emissions from the solvent mixer at the facility. For product batches that are mixed onsite at the facility, the State operating permit for this facility requires that the facility collect at least 85 percent (by weight) of the solvent that is added to those batches, averaged over any week. The permit further requires that the facility calculate and record a unique batch identification number for each batch mixed, the weight of solvent added to each batch, the weight of solvent recovered for each batch, and the weekly average solvent collection efficiency for the recovery system. Solvent recovery records from this facility show that a 7-day block average of 85 percent solvent recovery has been consistently achieved.[9]

2.6 REFERENCES

1. Kirk-Othmer Encyclopedia of Chemical Technology. Kroschwitz, J. I. (Ed.). New York, John Wiley & Sons. 1985.

2. U. S. Census Bureau. Motor Vehicle Brake System Manufacturing 1997 Economic Census Report.

3. U. S. Census Bureau. Statistical Abstract of the United States: The National Data Book.

4. U. S. Small Business Administration. Small Business Size Standards. October 2000.

5. Memorandum from Midwest Research Institute, to Zapata, S., EPA/ESD. Site Visit Report–Plant A.

6. Memorandum from Midwest Research Institute, to Cavender, K., EPA/ESD. Site Visit Report–Plant B.

7. Memorandum from Midwest Research Institute, to Zapata, S., EPA/ESD. Site Visit Report–Plant C.

8. Memorandum from Abraczinskas, M., Bullock, D., Holloway, T., and Turner, M., Midwest Research Institute, to Cavender, K., EPA/ESD. August 3, 2001. Summary of Emission Test Data.

9. Air Pollution Control Construction and Operation Permits for Plant A.

Chapter 3
Emission Control Techniques

This chapter discusses organic HAP emission control techniques that are currently being used in the friction materials manufacturing industry to control emissions from solvent mixers. There are two general approaches to reducing organic HAP emissions resulting from solvent mixers: add-on control devices and pollution prevention.

The first approach to limiting organic HAP emissions from solvent mixers utilizes capture systems and add-on control devices to remove the HAP from the air stream. Recovery devices are used to collect organic HAP (typically solvents) for reuse in the process; consequently, they are not emitted to the atmosphere. Organic HAP in an exhaust gas stream can be collected through condensation, or by adsorption of the contaminants onto a porous bed. Both condensers and carbon adsorbers are used to recover HAP solvents from solvent mixers. Design, factors affecting performance, control efficiency, and monitoring of condensers and carbon adsorbers are described in sections 3.1 and 3.2, respectively.

An alternative approach to limiting organic HAP emissions, focusing on pollution prevention, is highly dependent on the specific product being manufactured and its applications. Generally, the idea is to substitute currently used materials with low-HAP or HAP-free materials (solvents, resins, property modifiers, etc.). Section 3.3 provides a discussion of pollution prevention opportunities in the friction materials manufacturing industry.

3.1 CONDENSERS

Condensers are used to separate one or more volatile components of a vapor mixture from the
remaining vapors through saturation followed by a phase change. The phase change from gas to
liquid can be achieved in two ways: (1) by increasing the system pressure at a given temperature,
or (2) by lowering the temperature at a constant pressure.[1-3] Because condensers typically reduce
the temperature of the gas stream with a coolant, this section addresses the latter method. A
schematic diagram of a typical condenser is provided in Figure 3-1.
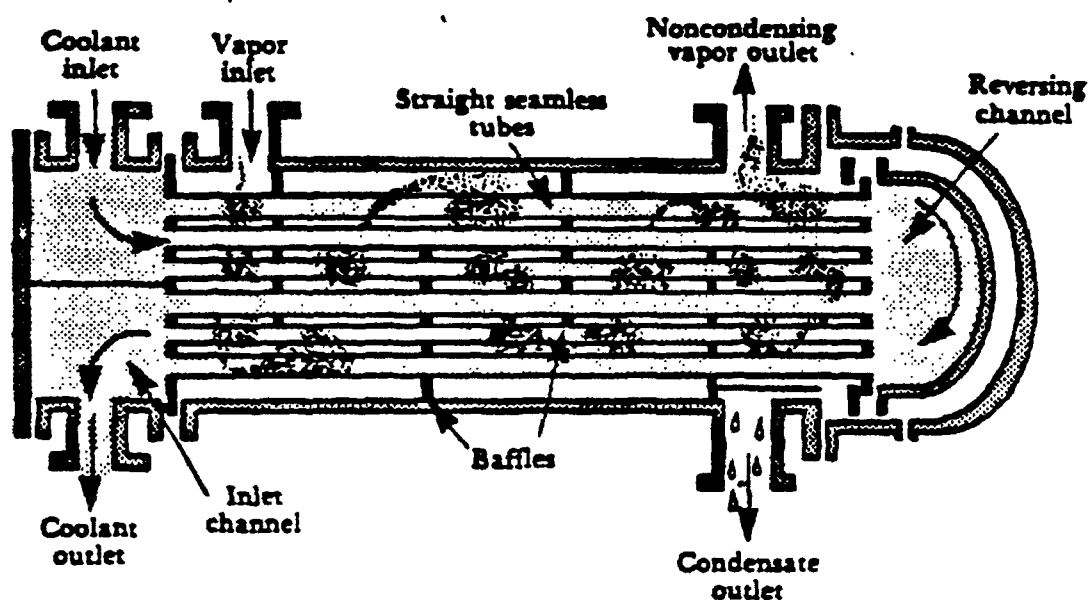
Figure 3-1. Typical shell-and-tube condenser.[3]

Condensers can generally be classified as either surface condensers or contact condensers.
Surface condensers are usually shell-and-tube heat exchangers. The coolant typically flows
through the tubes and the vapors condense on the shell outside the tubes. The condensed vapors
form a film on the cool tubes and drain by gravity to a collection tank for storage or disposal. No
secondary pollutants are generated from the operation of surface condensers because the coolant
flows through a closed system.[1-3] Based on the responses to ICRs, the condensers in place at
friction materials manufacturing facilities are surface condensers.

Contact condenser designs are similar to spray towers. In contrast to surface condensers where the coolant does not contact either the vapors or the condensate, in contact condensers, the vapor mixture is cooled by spraying a cool liquid directly into the gas stream.[1-3]

Condensation occurs when the partial pressure of the condensible pollutant in the waste gas stream is equal to its vapor pressure as a pure substance at the operating temperature of the condenser. The waste gas stream is cooled by transfer of its heat to a refrigerant or coolant; the waste gas becomes saturated with one or more of its pollutants at the dew point or saturation temperature, and as the gas continues to cool, the pollutants condense. The dew point temperature can be predicted from the temperature-vapor pressure curve for the pollutant and its mole fraction in the waste gas stream. The temperature required to achieve a given removal efficiency or outlet concentration depends on the outlet vapor pressure of the pollutant at vapor-liquid equilibrium. When the partial pressure is known, the condensation temperature can be determined (using temperature-vapor pressure relationship, such as Antoine's equation).[1,3]

3.1.1 Factors Affecting Performance

The design and operation of a condenser are affected significantly by the number and nature of the components present in the emission stream. For example, condenser efficiency is sensitive to the inlet HAP concentration. In most HAP control applications, the emission stream will contain large quantities of noncondensible and small quantities of condensible compounds. To separate the condensible component from the gas stream at a fixed pressure, the temperature of the gas stream must be reduced. The more volatile a compound (i.e., the lower the normal boiling point), the larger the amount that can remain as vapor at a given temperature; hence the lower the temperature required for saturation (condensation).[2]

The coolant used in a condenser depends upon the saturation temperature needed to condense the pollutants of interest in the gas stream. Chilled water can be used for condensation temperatures that are below 7°C (45°F), brines for below -34°C (-29°F), and chlorofluorocarbons for condensation temperatures below -34°C (-29°F). Temperatures as low as -62°C (-80°F) may be necessary to condense some streams. When such low temperatures must be achieved to reach

the dew point for a particular pollutant, other components of the waste gas stream, such as water, can solidify and foul the heat transfer surface.[1,3]

Table 3-1 summarizes the condenser operating parameters provided in the ICR responses.

Table 3-1. Condenser Operating Parameters Reported in ICR Responses

Condenser type	Coolant	Inlet gas temperature, °C (°F)	Outlet gas temperature, °C (°F)
Non Contact	freon	40 (100)	10 (50)
Non Contact	water	65 (150)	15 (60)
Vertical	water	90 (190)	25 (80)
n/a	refrigerant	n/a	n/a
Shell and Tube	water	90 (190)	50 (120)
Shell and Tube	water	n/a	65 (150)
Shell and Tube	water	n/a	65 (150)
Surface (Indirect)	glycol	90 (190)	15 (60)

n/a = not available

3.1.2 Control Efficiency

Condensers generally achieve removal efficiencies ranging from 50 to 95 percent. The removal efficiency of condenser systems designed to control exhaust streams containing air/organic HAP mixtures depends primarily on the following parameters:

- Inlet and outlet waste gas temperature;
- Volumetric flow rate of the waste gas stream;
- Inlet and outlet coolant temperature;
- Concentrations of the organic HAP in the exhaust stream;
- Absolute pressure of the vent stream; and
- Properties of the organic HAP in the vent stream (dew points, heats of condensation, heat capacities, and vapor pressures).[1,3]

The performance of two existing condensers installed as solvent recovery devices on solvent mixers at friction materials manufacturing facilities was evaluated. For the first condenser, only anecdotal information on recovery efficiency was available. However, reliable data documenting recovery efficiency is available for the second condenser. Solvent recovery records from this facility show that a 7-day block average of 85 percent solvent recovery has been consistently achieved.

3.1.3 Current Monitoring Practices

The primary indicators of the performance of condensers are the condenser outlet VOC concentration, condenser outlet temperature, and coolant inlet temperature. Other parameters that indicate condenser performance include coolant outlet temperature, exhaust gas flow rate, pressure drop across condenser, coolant flow rate, pressure drop across coolant recirculation system, and condensate collection rate. Table 3-2 lists these indicators and briefly describes the relationship of the indicator to condenser performance. A summary of ICR responses indicating the existing monitoring procedures for condensers at friction materials manufacturing facilities is presented in Table 3-3. Generally, the existing parameters monitored include outlet gas temperature, outlet coolant temperature, and system pressure drop.

Table 3-2. Summary of Performance Indicators for Condensers

Parameters	Performance indication	Comments
Primary indicators of performance		
Outlet VOC concentration	Direct measure of outlet concentration.	Best indicator of condenser performance, can be monitored continuously or periodically.
Outlet temperature	Indicates if gas is being cooled to/below dewpoint of target compounds; indicator of level of condensation.	Too high indicates condensation to the level expected wil not occur; decrease in outlet temperature may indicate plugging or fouling problems.
Coolant inlet temperature	Indicates if condenser is operating as designed	If inlet gas temperature and flow rate do not vary, is comparable to outlet gas temperature as indicator of condenser performance; increase in coolant inlet temperature indicates lower organic compound removal rate.

Table 3-2. (continued)

Parameters	Performance indication	Comments
Other performance indicators		
Coolant outlet temperature	If coolant inlet temperature and are flow rates also are measured, indicates level of heat transfer from inlet exhaust stream.	By itself, would be less reliable indicator of performance than other parameters listed above; increase would indicate decrease in organic compound removal rate.
Exhaust gas flow rate	·Determines residence time within condenser.	Increase in flow rate could indicate a decrease in condenser performance.
Pressure drop across condenser	Indicator of plugging or fouling within condenser.	Increase in pressure drop indicates obstruction in condenser and likely decrease in condenser performance; fouling decreases heat transfer rate.
Coolant flow rate	Affects heat transfer rate.	Decrease indicates decrease in condenser performance; parameter is of limited use without coolant temperature data.
Pressure drop across coolant recirculation system	Indicates plugging and/or fouling of condenser coolant tubes.	Comparable to monitoring coolant flow rate (see above).
Condensate collection rate	Organic compound removal rate.	Useful indicator of condenser performance only if process gas stream characteristics do not vary.
Periodic inspection	Fouling of tubes, corrosion.	Fouling decreases heat transfer.

Table 3-3. Condenser Monitoring Procedures Reported in ICR Responses

Parameters monitored	Monitoring frequency	Type of device used	Recordkeeping procedures	Operation and maintenance	
				Equipment	Control device
Different pressures	Daily	Pressure gauge	Recorded manually	As needed	Visual inspection of structure, daily
Temperature	Daily	Built in gauge	Recorded manually	As needed	Visual inspection of cooling and filter chamber, weekly
Vacuum pressure	Continuous	Pressure gauge	Manually recorded per batch	Check per batch	Visual inspection
Temperature	Continuous	Temperature gauge	Manually recorded per batch	Check per batch	Visual inspection
Water & gas outlet temperature	Daily	Dial thermometers	Maintain log of water temperature		Clean condensers as required

3.2 CARBON ADSORBERS

Carbon adsorbers are used for both air pollution control and solvent recovery. The carbon adsorption process used to control organic HAP and VOC emissions from waste gas streams can be subdivided into two sequential processes. The first process involves the adsorption cycle, in which the waste gas stream is passed through the adsorbent bed for contaminant removal. The second process involves regeneration of the adsorbent bed, in which contaminants are removed using a small volume of steam or hot air and recovered using condensation, so that the adsorbent (carbon) can be reused for contaminant removal.

Adsorption is the capture and retention of a contaminant (adsorbate) from the gas phase by an adsorbing solid (adsorbent). The four types of adsorbents most typically used are activated carbon, aluminum oxides, silica gels, and molecular sieves. Activated carbon is the most widely used adsorbent for air pollution control and is the only type of adsorbent discussed in this section.[4]

The two main mechanisms of adsorption are physical adsorption and chemisorption. Physical adsorption (otherwise known as van der Waals adsorption) uses a weak bonding of the adsorbate molecules to the adsorbent. The van der Waals forces within the bond are similar to the forces that attract molecules in a liquid and are easily overcome by the application of heat or the reduction of pressure. Chemisorption uses chemical bonding by inducing a reaction between the adsorbate and the adsorbent.[5]

There are three basic types of adsorption systems, which can be categorized by the manner in which the adsorbent bed is maintained or handled during the adsorption and regeneration cycles. These three types of systems are: (1) fixed or stationary bed, (2) moving bed, and (3) fluidized bed. The stationary bed design is the most common and is the only design described in this section.

A stationary-bed, regenerable carbon adsorption system is depicted in Figure 3-2. The components of the carbon adsorption system include a fan (to convey the waste gas into the carbon beds); at least two stationary-bed carbon adsorption beds; a stack for the treated waste gas outlet; a steam valve for introducing desorbing steam; a condenser for the steam/contaminant desorbed stream; and a decanter for separating the organic HAP condensate and water.
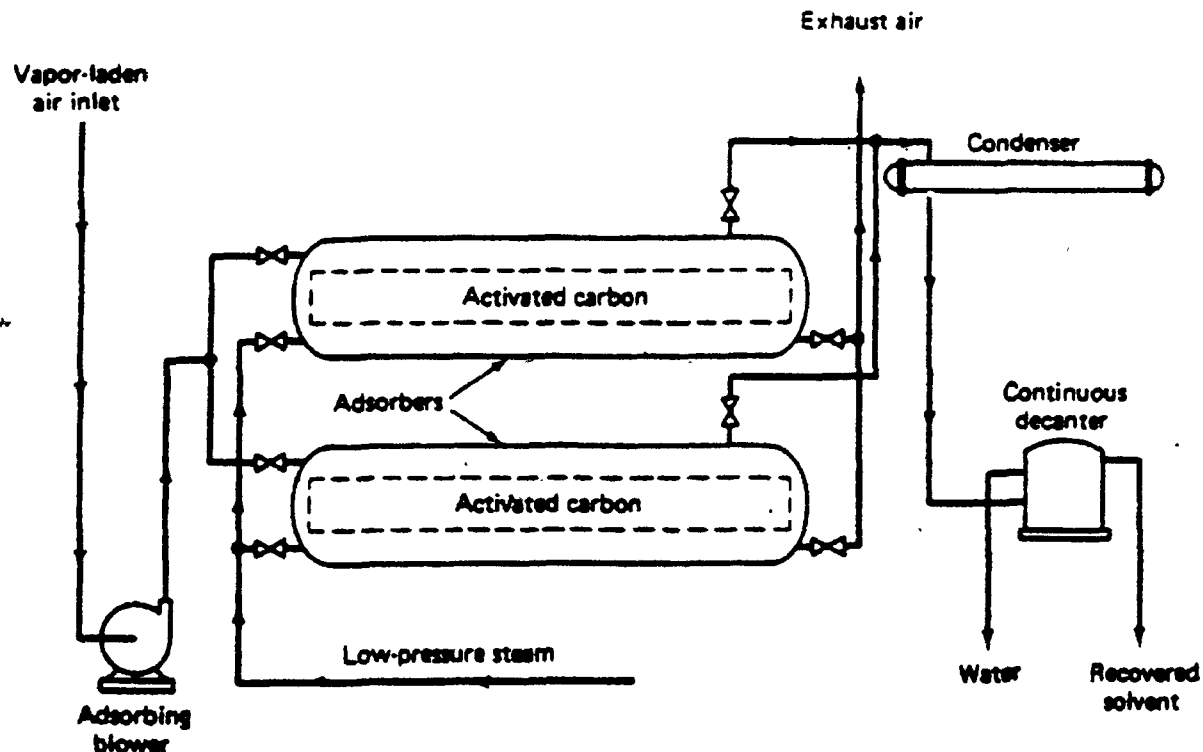
Figure 3-2. Typical stationary-bed, regenerable carbon adsorption system.[1]

In a typical dual stationary-bed system, the vapor is collected from various sources, transported through a particulate filter and into one of two carbon adsorption beds. As the carbon adsorber operates, three zones form within the bed: the saturated zone, mass transfer zone, and fresh zone. In the saturated zone, which is located at the entrance to the bed, the carbon has already adsorbed its working capacity of VOC; no additional mass transfer can occur in this zone. The mass transfer zone is where VOC is removed from the gas stream. The carbon in this zone is at various degrees of saturation, but is still capable of adsorbing VOC. The fresh zone is the region of the bed that has not encountered VOC-laden air since the last regeneration. This zone has a full working capacity available for adsorption of additional VOC.

As the carbon bed operates, the mass transfer zone moves through the bed in the direction of flow toward the bed outlet. Breakthrough occurs when the mass transfer zone first reaches the bed

3-8

outlet. At this point, a sharp increase in the outlet VOC concentration occurs. The available adsorption time (the time before breakthrough occurs) depends on the amount of carbon in the bed, the working capacity of the bed, and the VOC concentration and mass flow rate of the gas stream. Once the breakthrough point is reached, the carbon bed must be regenerated. When this occurs, the flow of VOC-laden air is redirected to the second bed, while the first bed undergoes a regeneration cycle.

Regeneration is the process of desorbing (that is, reversing the adsorption process and separating the contaminants from the carbon), and is accomplished by increasing the temperature and/or reducing the system pressure. The most common method of regeneration is steam stripping. Low-pressure, superheated steam is introduced into the carbon bed. The steam desorbs and carries the VOC through a condenser, then through a decanter and/or distillation column for separation of the VOC from the steam condensate.

Another regeneration method is the use of hot, inert gas or hot air. With either steam or hot air regeneration, the desorbing agent flows through the bed in the direction opposite to the waste stream, allowing the exit end of the carbon to remain contaminant-free. The regenerated carbon bed is then ready to be put back on-line when the second bed reaches breakthrough.[1,3,4]

3.2.1 Factors Affecting Performance

Several factors affect the amount of material that can be adsorbed onto the carbon bed. These factors include type and concentration of contaminants in the waste gas, system temperature, system pressure, humidity of waste gas, and residence time.[6]

The type and concentration of contaminants in the waste stream are major factors in the adsorption capacity of the carbon. In general, adsorption capacity increases with a compound's molecular weight or boiling point, provided all other parameters remain constant. There is also a relationship between concentration and the carbon adsorption capacity. As concentration decreases, so does the carbon capacity. However, the capacity does not decrease proportionately with the concentration decrease.[6]

Increases in operating temperature decrease adsorption efficiency. At higher temperatures, the vapor pressures of the contaminants increase, reversing the mass transfer gradient. Contaminants would then be more likely to return to the gas phase than to stay on the carbon. At lower temperatures, the vapor pressures are lower, so the carbon will likely retain the contaminants.[7]

Increases in the system pressure improve the effectiveness of adsorption. Increases in the gas phase pressure promote more effective and rapid mass transfer of the contaminants from the gas phase to the carbon. Therefore, the probability that the contaminants will be captured is increased.[4]

Although water vapor is not preferentially adsorbed over the contaminants, increases in the relative humidity or moisture content of the gas phase generally reduce adsorption efficiency. However, the effect of humidity in the gas phase is insignificant for VOC concentrations greater than 1,000 parts per million (ppm) and during the initial startup of the adsorption cycle (when the carbon is drier). In some instances moisture content in the gas phase can be beneficial. For instance, when high concentrations of contaminants with high heats of adsorption are present, the temperature of the carbon bed may rise considerably during adsorption due to the exothermic nature of the process. The presence of water may minimize the temperature rise.[6]

Adsorption efficiency may also be reduced if contaminants do not have enough contact (residence) time with the active sites of the carbon to allow mass transfer to occur. Contaminants especially need this time if many molecules (high-concentration streams) are competing for the same sites. Residence time of the contaminants with the active sites can be increased by using larger carbon beds, but then the pressure drop across the system increases, resulting in increased operating costs.[4]

3.2.2 Control Efficiency

Carbon adsorption recovery efficiencies of 95 percent and greater have been demonstrated to be achievable in well-designed and maintained units.[2] The performance of the carbon adsorption unit is negatively affected by elevated temperature, low pressure, and high humidity, as previously

discussed. One carbon adsorber is in use on a solvent mixer and halogenated solvent degreaser at a major friction materials manufacturing facility. The adsorber system has demonstrated a VOC capture efficiency of 94 percent and a VOC removal efficiency of 99.8 percent, which yields a VOC control efficiency of 93.8 percent for the solvent mixing and degreasing operations.[8] However, this system was not operating under representative conditions during the test, and these non-representative data were not sufficiently reliable to use in establishing the level of the standard. Additionally, the overall control efficiency does not equate to solvent recovery because it does not account for the residual solvent remaining in the mixed material.

3.2.3 Current Monitoring Practices

The primary indicators of the performance of carbon adsorbers are the adsorber outlet VOC concentration, regeneration cycle timing, and integrated steam flow. Other indicators of adsorber performance include bed operating temperature, inlet gas temperature, gas flow rate, inlet VOC concentration, pressure drop, and inlet gas moisture content. Table 3-4 lists these indicators and briefly describes the relationship of the indicator to adsorber performance. The only monitoring practice reported in the ICR responses was taking semi-annual samples of the carbon for bed breakthrough and carbon quality.

Table 3-4. Summary of Performance Indicators for Carbon Adsorbers

Parameters	Performance indication	Comments
Primary indicators of performance		
Outlet VOC concentration	Direct measure of outlet concentration.	Best indicator of adsorber performance; can be monitored continuously or periodically.
Regeneration cycle timing	Key factor in determining adsorptive capacity of bed.	If regeneration cycles are too infrequent, VOC emissions may be excessive; if regeneration times are too short, the adsorption capacity of the bed is reduced.
Integrated steam flow	Determines extent to which bed is desorbed (regenerated).	Decreases in steam flow result in a shorter time period to reach breakthrough.
Other performance indicators		
Bed operating temperature	Affects adsorptive capacity of bed.	Adsorptive capacity decreases with increasing temperature.

Table 3-4. (continued)

Parameters	Performance indication	Comments
Inlet gas temperature	Indicator of bed operating temperature (see above).	Not as useful as bed operating temperature as an indicator of performance, but is an alternative to monitoring bed operating temperature.
Gas flow rate	Adsorption capacity of bed.	Increases in flow rate result in a shorter time period to reach breakthrough.
Inlet VOC concentration	System is operating within design limits.	Increases in VOC concentrations may require adjustments to regeneration cycle timing.
Pressure drop across adsorber	Indicator of fouling or channeling within bed.	Increase in pressure drop can indicate fouling of bed; decrease in pressure drop can indicate channeling.
Inlet gas moisture content	Adsorptive capacity of bed.	High moisture content can result in reduced adsorptive capacity of bed; applies to inlet VOC concentrations less than ~1,000 ppm.

3.3 POLLUTION PREVENTION TECHNIQUES

Pollution prevention alternatives for reducing air emissions associated with friction materials manufacturing can vary widely. The pollution prevention practices involving friction material formulations are influenced by the specific product being manufactured, and the product performance requirements that must be met. Therefore, specific pollution prevention techniques will vary with different products and applications.

Generally, replacing HAP-containing organic process solvents and resins with non-HAP materials has been demonstrated in several products and applications. A specific reformulation technique that may have been employed at one facility to reduce air emissions, however, may not work for another facility. Techniques involving the reuse of scrap materials, reject products, and baghouse catches have also been demonstrated as pollution prevention practices.

3.4 REFERENCES

1. Air Pollution Engineering Manual. Buonicore, A. J. and Davis, W. T. (Eds.). New York, Van Nostrand Reinhold Company. 1992.

2. U. S. Environmental Protection Agency. Handbook: Control Technologies for Hazardous Air Pollutants. EPA 625/6-91/014. Cincinnati, OH. July 1991.

3. U. S. Environmental Protection Agency. APTI Course 415, Control of Gaseous Emissions, Student Manual. EPA 450/2-81-005. Research Triangle Park, NC. December 1981.

4. Bethea, R. M. Air Pollution Control Technology. New York, Van Nostrand Reinhold Company. 1978.

5. Cooper, C. D. and Alley, F. C. Air Pollution Control: A Design Approach. Prospect Heights, IL, Waveland Press, Inc. 1994.

6. Calgon Corporation. Introduction to Vapor Phase Adsorption Using Granular Activated Carbon.

7. Prudent Practices for Disposal of Chemicals from Laboratories. Washington, D.C., National Academy Press. 1983.

8. Emission Test Report for Plant C.

Chapter 4
MACT Floor and Regulatory Options

This chapter describes the CAA requirements for MACT standards, the methodology and conclusions of the MACT floor analyses for the friction materials manufacturing source category, regulatory options considered, and monitoring options identified for the emission units and HAP to be regulated.

4.1 CLEAN AIR ACT REQUIREMENTS

The amended CAA contains requirements for the development of NESHAP for sources of HAP emissions. The statute requires the standards to reflect the maximum degree of reduction in emissions of HAP that is achievable for new and existing sources. This control level is referred to as MACT. The amended CAA also provides guidance on determining the least stringent level of control allowed for a MACT standard; this level is termed the "MACT floor."

The approach to selecting the MACT floor depends on the number of major and synthetic area sources in each source category. Section 112 (d)(3) of the CAA specifies that NESHAP for existing sources are to be no less stringent (but may be more stringent) than, ". . . the average emission limitation achieved by the best-performing 12 percent of the existing sources (for which the Administrator has emissions information). . . ." We have interpreted the "average" emission limitation as the median of the best-performing 12 percent, or the 94th percentile. In categories or subcategories with fewer than 30 major and synthetic area sources, the MACT floor is to be based on the average emission limitation achieved by the best-performing five sources. We have interpreted the "average" emission limitation as either the mean or median emission limitation of

those best-performing five sources. The MACT floor for new sources corresponds to the level of emission control that is achieved in practice by the best controlled similar source.

4.2 MACT DETERMINATIONS

For NESHAP developed to date, we have used several different approaches to determine the MACT floor and beyond-the-floor options for individual source categories depending on the type, quality, and applicability of available data. These approaches are based on: (1) emissions test data that characterize actual HAP emissions from presently controlled sources included in the source category; (2) existing federally-enforceable emission limitations specified in air regulations and facility air permits applicable to the individual sources comprising the source category; and (3) application of a specific type of control technology for air emissions currently being used by sources in the source category or by sources with similar pollutant stream characteristics. The available emission test data and the existing State regulations and permit data are inadequate for establishing the MACT floor for the friction materials manufacturing industry; therefore, the MACT floor will be technology-based.

4.2.1 Performance of Solvent Recovery Systems on Solvent Mixers

As reported previously, we surveyed the entire friction materials manufacturing industry and determined that four facilities with solvent mixers emit HAP in excess of the major source levels. Combined, these four facilities (Plants A, B, C, and D) operate a total of seven solvent mixers, of which three are equipped with air pollution controls (solvent recovery systems), and four have no control. Table 4-1 lists the control technologies in place on the various emission sources at the four major source facilities in the friction materials manufacturing industry. The following paragraphs briefly describe the solvent mixers in place at each of the four facilities and the performance of the solvent recovery systems.

Table 4-1. Existing Control Technologies for Potential Sources of Organic HAP Emissions at the Four Major Source Facilities in the Friction Materials Manufacturing Industry

Emission unit	Total number	No control[a]		Carbon adsorber		Condenser	
		No.	%	No.	%	No.	%
Extruder	6	6	100				
Granulator	3	3	100				
Hot press	104	104	100				
Material dryer	16	16	100				
Mixer (solvent)	7	4	57	1	14	2	29
Oven	42	42	100				
Roll machine	4	4	100				

[a] Includes emission units with fabric filters; fabric filters are expected to provide no control for organic HAP emissions.

Plant A has one solvent mixer that uses toluene as the solvent.[1] According to information on air releases reported by the facility to the 1997 Toxics Release Inventory (TRI), air emissions of toluene are on the order of 45 tpy.[2] After mixing, solvent is drawn out of the mixer under a strong vacuum.[1] Data collected by facility personnel indicate that typically more than 95 percent of the solvent is removed from the mixed material, with less than 5 percent remaining in the mix.[1] The evacuated solvent vapors are then condensed in a non-contact, glycol-chilled condenser which cools the vapors to 32°F.[1] Liquid condensate is collected and recycled to the process, and uncondensed vapor is exhausted to the atmosphere through a stack.[1]

Plant A has a State operating permit which requires that the facility collect at least 85 percent (by weight) of the solvent that is added to the mixer, averaged over a calender week.[1] The percent solvent recovery is determined for each individual mix batch by weighing the amount of solvent loaded into the mixer, and weighing the amount of solvent recovered by the condenser.[1] Plant A began collecting solvent recovery data for each batch in January 1999. We reviewed the solvent recovery records from January 1999 through October 1999 and found that the 85 percent solvent recovery limit has been consistently achieved on a weekly, or 7-day block average, basis.[3]

Plant B has four solvent mixers that use n-hexane as the solvent.[4] Again, based on self-reported emissions data to TRI for 1998, Plant B emits approximately 450 tpy of n-hexane.[5] Three of the four mixers have no air pollution controls.[4] All of the solvent added to these mixers is emitted to the atmosphere. The fourth mixer has a solvent recovery system similar to the one described for Plant A.[4] Solvent is drawn out of the mixed material by vacuum.[4,6] The solvent vapors are then collected by a non-contact, Freon-cooled condenser, which cools the solvent vapor to 60°F.[4] Once per quarter, Plant B performs a solvent mass balance for one batch to evaluate the performance of the solvent recovery system.[7] The amount of solvent added to the mixer is measured using a calibrated flow meter, and the amount of solvent recovered by the condenser is weighed.[8] The results of these measurements indicate that approximately 70 percent of the solvent is recovered by the solvent recovery system on average.[4] Using these data and the overall system efficiency, facility personnel have determined that approximately 90 percent of the solvent is removed from the mix by the solvent recovery system, and that the condenser removes approximately 80 percent of the solvent vapors.[4]

Plant C has one solvent mixer that uses trichloroethylene as the solvent.[9] Based on the self-reported emissions data to TRI for 1998, Plant C emits approximately 30 tpy of trichloroethylene.[10] As with the other two controlled mixers, solvent is removed from the mixer under vacuum.[9] No data are available on how much of the solvent is removed from the mixed friction material by the vacuum system. The solvent vapors are combined with the emissions from a solvent degreaser, and the commingled vapors are collected in a carbon adsorber.[9] The adsorbed solvent is recovered weekly by steam stripping the adsorber bed, and the recovered solvent is sold. Performance data based on a single inlet/outlet emissions test conducted in 1996 indicate that the subject adsorber is capable of achieving 94 percent control.[11] It should be noted that control efficiency does not equate to solvent recovery because it does not account for the residual solvent content remaining in the mixed material. If one assumes that the residual solvent content is similar to that achieved at Plant A and Plant B (i.e., between 5 and 10 percent), then the corresponding percent of solvent recovered would be on the order of 85 to 90 percent.

Plant D has one solvent mixer that uses toluene as the solvent.[12] Based on the self-reported emissions data to TRI for 1998, Plant D emits about 40 tpy of toluene.[13] Plant D has no air pollution controls on its mixer, and 100 percent of the solvent used is emitted to the atmosphere.[12]

4.2.2 Selection of MACT

We have determined that the MACT floor for existing mixers is a solvent recovery system with a 70 percent solvent recovery efficiency, and the MACT floor for new mixers is a solvent recovery system with a 85 percent solvent recovery efficiency. We have also determined that it is both technically and economically feasible for existing mixers to achieve better than the MACT floor level of control. Therefore, we are establishing MACT for both new and existing solvent mixers at 85 percent solvent recovery efficiency. Table 4-2 summarizes the MACT floor and MACT determinations for the sources at the four major source facilities in the friction materials manufacturing industry. The following paragraphs describe how we determined the MACT floors, and our rationale for going beyond the MACT floor for existing mixers.

Table 4-2. Summary of MACT Determinations

Emission unit	MACT floor control technology	MACT floor for existing sources	MACT for existing sources	MACT floor for new sources
Extruder	No control	No control	No control	No control
Granulator	No control	No control	No control	No control
Hot press	No control	No control	No control	No control
Material dryer	No control	No control	No control	No control
Mixer (solvent)	Solvent recovery	70% control	85% control	85% control
Oven	No control	No control	No control	No control
Roll machine	No control	No control	No control	No control

Because there are only seven solvent mixers (fewer than 30 sources), the MACT floor for existing solvent mixers is based on the best-performing five sources. The available information does not allow for a floor calculation based on actual emissions data or State limits. However, ranking the sources by the estimated performance of the control technology applied allows for a floor determination based on the median of the best-performing five sources, i.e., the third best-performing source.

Each of the three mixers with control is equipped with a solvent recovery system comprised of two components: a vacuum system to remove the solvent from the mixed material, and a control device that recovers the solvent from the exhaust. The overall performance of these systems is determined by the performances of the individual components, i.e., the efficiency of the vacuum system at removing solvent from the mixed material, and the efficiency of the control device in removing the solvent vapors from the vacuum exhaust.

Both Plant A and Plant B use a condenser to recover the solvent vapors. Based on the available data, Plant A's recovery system performs better than the recovery system used at Plant B. Plant A's vacuum system removes 95 percent of the toluene from the mixer, and the condenser removes 90 percent of the solvent vapor, resulting in an overall solvent recovery efficiency of 85 percent. Plant B's vacuum system is estimated to remove 90 percent of the n-hexane from the mixer, and the condenser removes 80 percent of the n-hexane vapors from the vacuum exhaust, resulting in an overall solvent recovery efficiency of 70 percent.

Plant C uses a carbon adsorber to recover the trichloroethylene solvent vapors contained in the vacuum exhaust coming from the mixer. The 94 percent control efficiency estimated for the carbon adsorber is the highest of the three control devices applied. However, as stated previously, we have no information from which to assess the effectiveness of the vacuum system at removing the solvent from the mixed material. Without this information, we cannot determine the overall solvent recovery efficiency achieved by the vacuum systems and carbon adsorbers together. Therefore, for the purpose of determining the MACT floor, we have assumed that the recovery system at Plant C is comparable to that of the system at Plant A, and we have assigned it an 85 percent solvent recovery efficiency.

Given the above, the ranking of the five best sources for purposes of the floor determination is as follows: 85 percent for Plant A and Plant C, 70 percent for Plant B, and 0 percent recovery for any two of the remaining mixers. The third best-performing source and, thus, the MACT floor for existing solvent mixers is the mixer at Plant B with 70 percent solvent recovery. The MACT floor for new mixers is based on the best-performing solvent recovery system. We have determined that

Plant A has the best-performing solvent recovery system, and we have set the MACT floor for new mixers at an 85 percent solvent recovery efficiency.

Next, we evaluated options that would be more stringent than the floor. Clearly, requiring existing mixers to meet an 85 percent solvent recovery efficiency is an option for existing mixers. To evaluate technical feasibility of this option, we examined whether a better-designed and operated solvent recovery system could achieve an 85 percent solvent recovery efficiency on Plant B's solvent mixing operation. Plant B was selected because it had the lowest performing solvent recovery system of the three controlled mixers. We looked at the volatility of the three different solvents used at the existing solvent mixers to determine if the volatility of the solvents could limit the vacuum system efficiency, such that, for certain solvents, an 85 percent solvent recovery efficiency could not be achieved. Vacuum systems remove solvent from the mixed material by evaporation at low pressure. Consequently, the higher the volatility of the solvent, the more easily it can be removed by a vacuum system. Of the three solvents used, n-hexane is the most volatile, while toluene is the least volatile. Based on the available data, Plant A's vacuum system efficiency of 95 percent is the best of the existing systems. Because Plant A also uses the least volatile solvent, it is clear that a vacuum system efficiency of 95 percent can be achieved for all three of the solvents used at the existing facilities.

We then evaluated the condenser used at Plant B, the poorer performer of the sources with condensers, to determine if improvements to condenser efficiency are possible. The key parameter that determines condenser performance for a given solvent is the outlet temperature of the condenser. The lower the outlet temperature of the condenser, the more solvent will be condensed, and the higher the condenser efficiency will be. For Plant B, the condenser outlet temperature is 60°F. This compares to an outlet temperature of 32°F at Plant A. Condenser outlet temperatures of 32°F can be obtained with either a glycol-cooled condenser, or a Freon-cooled condenser. The vapor pressure of n-hexane, the solvent used at Plant B, is estimated to be approximately 100 millimeters of mercury (mm Hg) at 60°F. At 32°F, the vapor pressure of n-hexane is estimated to be approximately 50 mm Hg. This indicates that the penetration (the amount of solvent that is not condensed) would be halved by lowering the condenser outlet temperature at Plant B from 60°F to 32°F. Because the current condenser is estimated to be 80 percent efficient,

we would predict that a condenser with a 32°F outlet temperature would achieve 90 percent efficiency on this gas stream. If Plant B were to install both an improved vacuum system and an improved condenser, we predict the overall solvent recovery would be 85 percent (0.95 x 0.90 x 100 percent = 85 percent). Based on the above analysis, we believe that it is technically feasible to achieve 85 percent solvent recovery on each of the existing solvent mixers used at friction manufacturing facilities.

We also believe that it is economically feasible to achieve 85 percent solvent recovery on each of the existing solvent mixers. The incremental costs to install and operate a solvent recovery system that achieves 85 percent over that of a system that would achieve 70 percent are minimal. Furthermore, because the recovered solvent can be reused in the process, the costs of solvent purchases will be greatly reduced, which we believe would more than offset the costs of installing and operating the solvent recovery system.

We also evaluated and rejected an option that would prohibit the use of HAP solvents altogether. The HAP solvent usage has declined significantly as friction material manufacturers develop formulations and processes that either use non-HAP solvents or need no solvents in the mixing process (i.e., dry mixing). Personnel at Plant B and Plant C are actively working to identify alternatives to the HAP solvents they currently use. Plant B uses a dry mixer to mix many of the formulations it currently makes, but they must use n-hexane to mix those formulations where the dry mixing process cannot meet the performance characteristics needed. They have also investigated several non-HAP solvents, but they have not yet identified an acceptable alternative to n-hexane. Plant C uses non-HAP solvents to mix many of the friction materials they manufacture, but still have a number of formulations that require the use of trichloroethylene to achieve the necessary characteristics. While it may be possible in the future to eliminate the use of HAP solvents from all friction materials manufacturing, we believe it is not currently feasible to eliminate HAP solvents from all friction materials manufacturing.

4.2.3 Selection of the Standard

The CAA requires us to set numerical emission limitations if feasible, and it prohibits use of operational standards, unless we can demonstrate that the setting and enforcement of an emission

limitation is infeasible. Consequently, we have selected a format for the standard that expresses the goal of 85 percent solvent recovery as an emission limit based on the amount of solvent loaded into the mixer and the amount recovered. Specifically, the proposed standard would limit the HAP solvent emissions to the atmosphere to no more than 15 percent of that loaded into the solvent mixer.

We also evaluated several averaging times to determine an appropriate averaging time for the standard. We determined that long averaging times (such as a 30-day or annual average) would not be appropriate because they would allow for long periods of under-performance by the solvent recovery system. In addition, one deviation from a 30-day or annual average would put the facility at risk of being determined to be out of compliance for the entire period. We determined that requiring compliance on a per-batch basis (i.e. no averaging) would also be inappropriate because it would not accommodate normal variability in the residual solvent requirements for different product mixes. The use of a 7-day block average provides time to detect and correct problems (e.g., individual mix batches not achieving the emission limitation) without the risk of the longer averaging periods. A 7-day block average is also consistent with the existing State operating permit requirements for Plant A.

4.3 MONITORING OPTIONS

The applicable monitoring approach for any operation or facility depends on the control technology used to meet the applicable emission limit. For processes with control devices, often called add-on control devices, monitoring approaches will include continuous emission monitoring systems and operating parameter monitoring devices, used in combination with regular maintenance and corrective action as indicated. For other processes, improved recordkeeping and repc..ting of pollution control activities may be sufficient.

The general approach to selecting monitoring options begins with identifying the emission units and pollutants that are likely to be regulated. The emission units likely to be regulated under the current regulatory approach for the friction materials manufacturing NESHAP are solvent mixers. The pollutants to be regulated from these emission units are organic HAP, including n-hexane, trichloroethylene, and toluene.

Continuous monitoring of the regulated pollutants or surrogate pollutants is not recommended as a means of ensuring continuous compliance with the HAP solvent recovery emission standard. Neither of these monitoring options provides a means to measure, directly or indirectly, the solvent recovery efficiency.

Continuous monitoring of selected control device operating parameters allows for real-time measurements of parameters that generally are reliable indicators of control device performance. The costs of monitoring control device operating parameters are reasonable. The parameter used most often as an indicator of condenser performance is outlet gas temperature. For carbon adsorbers, the parameters typically monitored include regeneration cycle frequency and steam flow. The drawback to this option is that it does not provide adequate information to ensure compliance with the solvent recovery standard, considering variations in the quantity of solvent added to batches of different product mixes, variations in the amount of solvent remaining in different products, and variations in the amount of solvent collected by the system.

For solvent recovery systems (e.g., carbon adsorbers and condensers), monitoring of solvent usage and solvent recovered for each batch allows for measurement of actual solvent recovery efficiency. The costs of monitoring these parameters are reasonable. For the proposed standard, this would include monitoring the quantity of solvent introduced into the solvent mixer and the quantity of solvent recovered by the solvent recovery system.

4.4 REFERENCES

1. Memorandum from Bullock, D., Midwest Research Institute, to Cavender, K., ESD/MG. Site Visit Report–Plant A.

2. U. S. Environmental Protection Agency. Toxics Release Inventory for Reporting Year 1997 for Plant A.

3. Air Pollution Control Construction and Operation Permits for Plant A.

4. Memorandum from Bullock, D. and Turner, M., Midwest Research Institute, to Zapata, S., ESD/MICG. Site Visit Report–Plant B.

5. U. S. Environmental Protection Agency. Toxics Release Inventory for Reporting Year 1998 for Plant B.

6. Memorandum from Schmitt, D., Bullock, D., and Abraczinskas, M., Midwest Research Institute, to Cavender, K., ESD/MG. Site Visit Report–Plant B.

7. Telecon. Bullock, D. and Abraczinskas, M., Midwest Research Institute, with representative of Plant B. Solvent recovery process at Plant B.

8. Information from Plant B to Abraczinskas, M., Midwest Research Institute. Solvent recovery process at Plant B.

9. Memorandum from Schmitt, D. and Turner, M., Midwest Research Institute, to Zapata, S., ESD/MICG. Site Visit Report–Plant C.

10. U. S. Environmental Protection Agency. Toxics Release Inventory for Reporting Year 1998 for Plant C.

11. Emission test report for Plant C.

12. Completed information collection request for Plant D.

13. U. S. Environmental Protection Agency. Toxics Release Inventory for Reporting Year 1998 for Plant D.

Chapter 5
Model Process Unit

This chapter describes the development of the model process unit for solvent mixers in the friction materials manufacturing industry. The model process unit is designed to be representative of solvent mixers found at friction materials manufacturing facilities and is used by EPA to estimate industry-wide environmental and energy impacts, and costs of control options. These impacts and costs are presented in Chapters 6 and 7, respectively.

Most of the information used in developing the model process unit comes from site visit reports for three of the four facilities.[1-3] This information has been supplemented by information from other sources, including emission test reports and discussions with industry representatives.[4-7]

5.1 GENERAL APPROACH

The model process unit exhaust stream parameters that are required for the cost analysis include the exhaust gas volumetric flow rate, exhaust gas temperature, and pollutant concentration in the exhaust gas stream. Generally, multiple sizes of models are developed (e.g., small, medium, and large) to represent the process units. The small population of solvent mixers in the friction materials manufacturing industry and the limited data available do not support developing multiple models for solvent mixers. Therefore, one solvent mixer model was developed. Also, because of the limited available data, a simple approach was taken in choosing the model process unit exhaust stream parameters. For parameters where only a single data point was available (e.g., pollutant concentration in the exhaust stream), the single data point was used for the model process unit. For parameters where multiple data points were available (e.g., exhaust gas flow rate and exhaust gas temperature), the arithmetic average of the data points (rounded to two significant figures) was used to represent the model process unit parameters.

A model process unit was developed only for solvent mixers; no other models were developed because no other emission units will be regulated under the proposed standard for friction materials manufacturing. The model solvent mixer is characterized by the stack gas parameters mentioned above, and VOC concentration. The VOC concentration is used as a surrogate for the organic HAP concentration because actual HAP concentration data are not available. Section 5.2 describes the development of the model solvent mixer. Chapter 2 describes solvent mixers in more detail.

5.2 SOLVENT MIXERS

There are seven solvent mixers in operation at the four friction materials manufacturing facilities estimated to be major sources. Of these four facilities, one facility operates four solvent mixers, and the other three facilities operate a single solvent mixer each. The HAPs emitted from solvent mixers include n-hexane, toluene, and trichloroethylene. Based on available data, a given facility uses only one of these three solvents. Therefore, emissions from any single solvent mixer would include only one of the above compounds.

The controlled solvent mixers for which data are available are controlled by dedicated solvent recovery systems (i.e., one solvent recovery system for one mixer). The solvent mixers that represent the MACT floor and beyond-the-floor are each characterized as having a closed-vent system with a low-volume, high-concentration exhaust stream ducted to a condenser. It is assumed that the four existing uncontrolled solvent mixers will be enclosed in order to vent emissions to a condenser. The solvent mixer model process unit has been developed to reflect this application.

Table 5-1 presents the limited available data for closed-vent solvent mixer exhaust parameters. Because inlet concentration data were available for only one of the solvents used, Antoine's equation was used to calculate the inlet concentrations for the three solvents at the model temperature, assuming a saturated stream.[8] As a check of the reasonableness of assuming a saturated stream, Antoine's equation was also used to calculate the inlet concentration for the one facility where an inlet value was available. Using the actual temperature of that stream, the calculated inlet concentration is within approximately 10 percent of the actual value.

Table 5-1. Exhaust Stream Characteristics for Closed-Vent Solvent Mixer Systems

Facility	Flow rate (dscfm)	Exhaust stream temperature (°F)	VOC concentration (ppm)
Plant A	50	145	--
Plant B	39	110	456,206
Average:	45	128	456,206

Table 5-2 presents a summary of the model process unit exhaust parameters for closed-vent solvent mixers based on the data in Table 5-1 and the calculated inlet concentrations for each solvent.

Table 5-2. Model Process Unit Exhaust Parameters for Closed-Vent Solvent Mixer Systems

Parameter	Model Process Unit Value
Flow rate (dscfm)	45
Exhaust stream temperature (°F)	130
Calculated volume fraction of solvent in the exhaust stream at saturation:[a]	
n-hexane	0.62
trichloroethylene	0.33
toluene	0.15

[a] Volume fractions are for exhaust streams containing only one of the listed compounds. Based on available data. a given mixer uses only one of the three listed solvents.

5.2 REFERENCES

1. Memorandum from Bullock, D., Midwest Research Institute, to Cavender, K., ESD/MG. Site Visit Report–Plant A.

2. Memorandum from Bullock, D. and Turner, M., Midwest Research Institute, to Zapata, S., ESD/MICG. Site Visit Report–Plant B.

3. Memorandum from Schmitt, D. and Turner, M., Midwest Research Institute, to Zapata, S., ESD/MICG. Site Visit Report– Plant C.

4. Telecon. Bullock, D. and Abraczinskas, M., Midwest Research Institute, with representative of Plant A. Solvent mixer and condenser system.

5. Telecon. Bullock, D. and Abraczinskas, M., Midwest Research Institute, with representative of Plant A. Solvent mixer condenser system and mixing process.

6. Telecon. Bullock, D. and Abraczinskas, M., Midwest Research Institute, with representative of Plant B. Solvent mixer and recovery system.

7. Telecon. Abraczinskas, M., Midwest Research Institute, with representative of Plant C. Solvent mixing process.

8. Memorandum from Randall, D., Midwest Research Institute, to project file. Volume Fraction of Solvents. October 19, 2000.

Chapter 6
Environmental and Energy Impacts

This chapter presents the environmental and energy impacts associated with controlling HAP emissions from solvent mixers in the friction materials manufacturing source category. Environmental impacts include primary and secondary air pollution impacts, water impacts, and solid waste impacts, while energy impacts include electricity requirements. Environmental and energy impacts were estimated for the control technique (solvent recovery system) likely to be used to control emissions to the MACT floor and beyond-the-floor control levels for solvent mixers.

Four friction materials manufacturing facilities were included in the MACT floor and beyond-the-floor analyses. The potential and baseline HAP emissions and characterization of HAP emission sources are provided in Chapter 2. The MACT floor and beyond-the-floor control options for existing and new solvent mixers are provided in Chapter 4. The development of the model process unit is described in Chapter 5. The emission estimation approach is described in Appendix B.

This chapter contains seven sections. Section 6.1 discusses the basis for the environmental and energy impacts analysis. Section 6.2 discusses the primary air pollution impacts. Section 6.3 discusses the secondary air pollution impacts. Section 6.4 discusses the water pollution impacts. Section 6.5 discusses the solid waste disposal impacts. Section 6.6 discusses the energy impacts. Section 6.7 provides a list of references.

6.1 BASIS FOR IMPACTS ANALYSIS

This environmental and energy impacts analysis assumes that solvent mixers will be retrofitted with condensers to control HAP emissions. This assumption is based on control techniques demonstrated by friction materials manufacturing facilities. For the purposes of this analysis, it is assumed that the four existing uncontrolled solvent mixers will be retrofitted with condensers in order to meet the MACT floor and beyond-the-floor levels. It is also assumed that one existing solvent mixer currently controlled to the MACT floor level of 70 percent will have to install a more efficient condenser to meet the beyond-the-floor level of 85 percent. This analysis also assumes that multiple solvent mixers will not share a condenser.

Data on the number of motor vehicles in use and locomotives and railcars in use were used to project the change in the demand for friction materials over the next 5 years (i.e., from 2001 to 2006).[1] Based on the available data, an 8 percent increase in motor vehicles, locomotives, and railcars in use is expected over the next 5 years. This increase is believed to be indicative of a similar increase in the demand for friction materials. The annual growth rate in friction materials sales over the next 5 years is estimated to be approximately 14 percent.[1] The number of new solvent mixers is assumed to correlate to the increase in friction materials production and sales. Because the overall average production capacity utilization for the friction materials manufacturing industry is approximately 50 percent, the current industry capacity is more than sufficient to meet the increased demand. Therefore, it is projected that no new solvent mixers will be installed.

6.2 PRIMARY AIR POLLUTION IMPACTS

Primary air pollution impacts consist of the reduction of n-hexane and toluene emissions relative to the baseline level directly attributable to the implementation of the control options. (No reduction in trichloroethylene [TCE] emissions is expected at the MACT floor or beyond the floor because the facility using this solvent is already in compliance with the beyond-the-floor control option.) The MACT floor control option is estimated to reduce HAP emissions from existing friction materials manufacturing facilities by approximately 200 tpy, or 31 percent, from a baseline HAP emission level of approximately 640 tpy. The beyond-the-floor control option is estimated to reduce HAP emissions by approximately 310 tpy, or 49 percent, relative to the baseline level. A

summary of the primary air impacts associated with implementation of the MACT floor and beyond-the-floor control options is shown in Table 6-1.

Table 6-1. Nationwide Primary Air Impacts for Existing Friction Materials Manufacturing Facilities

Control level	Pollutant	Emissions, tpy[a]		Emission reduction, tpy	Percent reduction
		Baseline	Post-MACT		
MACT floor	n-Hexane	560	380	170	31%
	Toluene	63	36	27	56%
	TCE	18	18	0	0%
	Total HAP	640	440	200	31%
Beyond the floor	n-Hexane	560	280	280	50%
	Toluene	63	30	33	68%
	TCE	18	18	0	0%
	Total HAP	640	330	310	49%

[a]   The baseline emissions are based on emissions from the four facilities estimated to be major sources and equipped with HAP solvent mixers.

6.3 SECONDARY AIR POLLUTION IMPACTS

Secondary air pollution impacts consist of any adverse or beneficial air impacts other than the primary air impacts described in Section 6.2. The secondary impacts are impacts that result from the operation of any new or additional add-on control devices (e.g., condensers).

Secondary air impacts consist of: (1) byproducts generated from the fuel combustion necessary to generate the electricity required to operate the control devices, and (2) VOC emissions reduced due to the implementation of the control options. The estimated electricity requirements are described in Section 6.6. The electricity is assumed to be generated at coal-fired utility plants built since 1978. These plants are subject to the new source performance standards (NSPS) in subpart Da of 40 CFR part 60. These NSPS emission limits were used to estimate secondary emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), and PM with an aerodynamic diameter at or below 10 micrometers (PM_{10}) from coal combustion.

Because carbon monoxide (CO) emissions are not covered by the NSPS, the CO emission factor for bituminous/subbituminous coal combustion from the AP-42 was used to estimate the CO secondary emissions. The CO secondary emissions were estimated assuming an average heating value of 14,000 British thermal units per pound (Btu/lb) of bituminous/subbituminous coal.

A summary of the estimated secondary air impacts is presented in Table 6-2. It is estimated that the MACT floor control option will increase byproduct emissions from fuel combustion from utility plants by less than 0.3 tpy, while the beyond-the-floor control option will increase byproduct emissions by less than 0.5 tpy.

Table 6-2. Nationwide Secondary Air and Energy Impacts for
Existing Friction Materials Manufacturing Facilities

Control level	Model	Increased emissions, tpy[a]				Increased electricity, MMBtu/yr
		SO_2	NO_X	PM_{10}	CO	
MACT floor	Solvent mixers (n-hexane)	0.17	0.069	0.0041	0.0025	280
	Solvent mixers (toluene)	0.018	0.0074	0.0004	0.0003	30
	Solvent mixer (TCE)	0	0	0	0	0
	Total	0.18	0.076	0.0046	0.0027	300
Beyond the floor	Solvent mixers (n-hexane)	0.29	0.12	0.0073	0.0044	490
	Solvent mixers (toluene)	0.024	0.0099	0.0006	0.0004	39
	Solvent mixer (TCE)	0	0	0	0	0
	Total	0.32	0.13	0.0079	0.0047	530

[a] The SO_2, NO_X, and PM_{10} emissions were estimated using the NSPS emission limits of 1.2 lb SO_2, 0.5 lb NO_X, and 0.03 lb PM_{10} per MMBtu fuel input for coal-fired utility plants. The CO emissions were estimated using the AP-42 emission factor of 0.5 lb CO/ton of coal for bituminous and subbituminous coal combustion.

In addition to the generation of byproduct emissions from fuel combustion, secondary air impacts also include the reduction of VOC emissions from the implementation of the control options. The VOC compounds are precursors to tropospheric ozone formation. Emissions of VOC will be reduced by approximately 200 tpy at the MACT floor and 310 tpy beyond the floor. These VOC

emission reductions are identical to the primary organic HAP emission reductions because the organic HAP reduced by the control options are also classified as VOC.

6.4 WATER POLLUTION IMPACTS

Friction materials manufacturing facilities impacted at the MACT floor or beyond the floor are expected to install condensers with glycol rather than chilled water as the cooling medium. Therefore, no water pollution impacts are expected with the implementation of either the MACT floor or beyond-the-floor option.

6.5 SOLID WASTE DISPOSAL IMPACTS

Friction materials manufacturing facilities impacted at the MACT floor or beyond the floor are expected to install condensers to comply with the control options. Because condensers do not generate solid waste, no solid waste disposal impacts are expected with the implementation of either the MACT floor or beyond-the-floor option.

6.6 ENERGY IMPACTS

Energy impacts consist of the electricity required to operate the control devices (condensers) used to comply with the control options. As noted in section 6.3, electricity is assumed to be generated in coal-fired boilers at utility plants. The amount of fuel energy required to generate the electricity was estimated using a heating value of 14,000 Btu/lb of coal and a utility plant efficiency of 35 percent. The electricity requirements were estimated by dividing the electricity costs for each of the control devices by the unit cost for electricity ($0.06 per kilowatt-hour [kWh]) used in the cost analyses, converting to million British thermal units (MMBtu), and multiplying by the number of impacted units for each model process unit. Table 6-2 presents the annual electricity impacts associated with operating the control devices. The overall energy demand (i.e., electricity) is expected to increase by approximately 300 MMBtu/yr nationwide at the MACT floor and 530 MMBtu/yr beyond the floor.

6.7 REFERENCES

1.   Memorandum from Bullock, D., Midwest Research Institute, to project file. May 17, 2001. New Source Projections for the Friction Materials NESHAP.

Chapter 7
Cost of Controls

This chapter presents the estimated costs associated with controlling HAP emissions from solvent mixers in the friction materials manufacturing source category. Costs were estimated for the control technique likely to be used to control emissions to the MACT floor and beyond-the-floor control levels for solvent mixers, as well as for testing, monitoring, reporting, and recordkeeping requirements.

Four friction materials manufacturing facilities were included in the MACT floor and beyond-the-floor analyses. The MACT floor and beyond-the-floor control options for existing and new solvent mixers are provided in Chapter 4. The development of the model process unit is described in Chapter 5. In addition, estimates of baseline emissions and emission reductions achieved under the MACT floor and beyond-the-floor control options are provided in Chapter 6.

This chapter contains eight sections. Section 7.1 discusses the basis for the control cost analysis. Section 7.2 discusses the estimated control device costs. Section 7.3 discusses the costs associated with initial compliance (performance tests and compliance demonstrations). Section 7.4 discusses the estimated monitoring costs. Section 7.5 discusses the estimated repc ting and recordkeeping costs. Section 7.6 discusses the cost effectiveness of the MACT floor and beyond-the-floor control options. Section 7.7 discusses the estimated number of new sources. Section 7.8 discusses the estimated cost impacts on small businesses. Section 7.9 provides a list of references.

7.1 BASIS FOR CONTROL COST ANALYSIS

The controlled solvent mixers for which data are available are controlled by dedicated solvent recovery systems (e.g., one condenser or carbon adsorber per mixer). The solvent mixers that represent MACT floor and beyond-the-floor control are enclosed (i.e., sealed and under vacuum) and have low-volume, high-concentration exhaust streams controlled with a condenser. In order to meet the MACT floor and beyond-the-floor control levels, it is assumed that the four uncontrolled solvent mixers will be enclosed in order to vent emissions to a comparable solvent recovery system (e.g., a condenser). The solvent mixer model process unit has been developed to reflect this application. It is also assumed that one existing solvent mixer currently controlled to the MACT floor level of 70 percent will have to install a more efficient condenser to meet the beyond-the-floor level of 85 percent.

A condenser is the likely choice for the low-volume, high-concentration exhaust stream represented by the model. For applications having a high-volume, low-concentration exhaust stream (i.e., solvent mixers that are not enclosed), a carbon adsorber may be a viable option.

The control cost algorithm for the condenser is based on the control cost algorithm developed by EPA's Office of Air Quality Planning and Standards (OAQPS).[1] The assumptions and data used in the algorithm were generated following guidelines in the OAQPS Control Cost Manual. The refrigeration unit size (tons of cooling) is based on an energy balance around the unit when the process is venting and the inlet stream contains its maximum HAP load. Costs were developed for single-stage refrigeration units using the approach in the OAQPS Control Cost Manual.

The purchased equipment cost (PEC) for the refrigeration system is equal to the total equipment cost plus 18 percent for instrumentation, sales tax, and freight. The installation cost for the refrigeration system includes both direct and indirect installation costs. The direct installation cost for the refrigeration system is equal to the PEC for the system plus 43 percent for foundations and supports, handling and erection, electrical installation, piping installation, insulation for ductwork, and painting. The indirect installation cost for the refrigeration system is equal to the PEC for the system plus 31 percent for engineering, construction and field expenses, contractor fees, start-up, performance test, and contingencies.

The total capital cost is equal to the sum of the PEC for the refrigeration system, direct and indirect installation costs of the refrigeration system. In estimating the total capital cost for control device equipment, the equipment costs were based on data from various years and were scaled to represent costs in December 2000 dollars.

The total annual cost for the condenser consists of direct annual costs, indirect annual costs, and recovery credits. Direct annual costs are costs for labor, maintenance materials, and electricity. Indirect annual costs are costs for overhead, administrative charges, property taxes, insurance, and capital recovery. Recovery credits are credits for the value of the recovered solvent and represent the savings due to reduced solvent purchases. The unit costs and other factors used to estimate these costs and credits are given in Table 7-1.

Table 7-1. Assumptions for Annual Cost Calculations

Direct annual costs	
Operator labor wage rate	$19.72 per hour, based on December 2000 wage rate for Manufacturing: Transportation Equipment (Monthly Labor Review, Bureau of Labor Statistics)
Maintenance labor wage rate	$21.69 per hour, based on 110 percent of operator labor wage rate
Supervisor labor cost	15 percent of operator labor cost
Maintenance materials cost	100 percent of maintenance labor cost
Maintenance labor requirements	0.5 hour per 8-hour operation
Electricity unit cost	$0.06 per kWh
Indirect annual costs	
Overhead	60 percent of all labor and maintenance material costs
Administrative changes, property taxes, and insurance	4 percent of total capital cost
Capital recovery (condenser)	Capital recovery factor (CRF) times the total capital cost. The CRF is 0.1098, based on a 15-year equipment life and 7 percent interest rate.
Recovery credits	
n-Hexane	$0.26 per lb
Toluene	$0.28 per lb

Electricity requirements for the refrigeration unit were estimated using the tabulated data in the OAQPS Control Cost Manual. Linear regression was used to develop an equation for electricity requirements per ton of cooling as a function of the condenser temperature. The mechanical efficiency of the compressor was estimated to be 85 percent. Electricity requirements for pumps and blowers were considered to be negligible relative to the requirements for the refrigeration unit.

7.2 CONTROL DEVICE COSTS

Table 7-2 presents a summary of the estimated capital and annual control costs for condensers installed on individual solvent mixers. Annual costs are presented without recovery credits. Separate costs are presented for systems recovering toluene and n-hexane and for the MACT floor and beyond-the-floor control requirements. Total facility control costs were estimated assuming that separate recovery systems will be installed for each solvent mixer.

Table 7-2. Control Costs for Condensers Installed on Individual Solvent Mixers

Control level	Solvent used	Capital cost, $	Annual cost, $/year[a]
MACT floor[b]	n-Hexane	$39,000	$19,000
	Toluene	$28,000	$16,000
Beyond the floor[c]	n-Hexane	$50,000	$21,000
	Toluene	$37,000	$18,000

[a] Annual costs do not include solvent recovery credits.
[b] Condenser costs were estimated at 74 percent efficiency to achieve MACT floor level of 70 percent recovery.
[c] Condenser costs were estimated at 90 percent efficiency to achieve beyond-the-floor level of 85 percent recovery.

The total capital control costs for the industry are estimated to be approximately $150,000 at the MACT floor and $240,000 beyond the floor. The total annual control costs for the industry, without recovery credits, are estimated to be approximately $72,000 at the MACT floor and $100,000 beyond the floor. The total annual control costs for the industry, including recovery credits, are estimated to be net credits of approximately $33,000 at the MACT floor and $62,000 beyond the floor.[2]

7.3 INITIAL COMPLIANCE COSTS

No performance testing would be required under the NESHAP for friction materials manufacturing. Therefore, there are no costs associated with performance testing. However, an initial compliance demonstration would be required under the friction materials manufacturing NESHAP. The initial compliance demonstration would consist of monitoring and recording the weight of HAP solvent delivered into each solvent mixer and recovered from each mix batch over the first 7 consecutive days after the compliance date. Because this is also a monitoring activity, the costs associated with the initial compliance demonstration are included in the monitoring costs presented in the following section.

7.4 MONITORING COSTS

The friction materials manufacturing NESHAP would include requirements for monitoring and recording the weight of HAP solvent delivered into solvent mixers and recovered from each mix batch. Capital costs include costs for an industrial floor scale system to weigh the solvent loaded into and recovered from the mixer, digital meter, installation, taxes, and freight. The total capital cost for a scale system is estimated to be approximately $2,100.[3] Annual costs include costs for operating and maintenance labor, maintenance materials and supplies, taxes, insurance, administrative charges, and capital recovery. The total annual cost for a scale system is estimated to be approximately $3,700.[3] Facility monitoring costs were estimated assuming that separate scale systems will be installed and operated for each solvent mixer. Total capital monitoring costs for the industry are estimated to be approximately $13,000 and total annual monitoring costs are estimated to be approximately $22,000, both at the MACT floor and beyond the floor.[2]

7.5 REPORTING AND RECORDKEEPING COSTS

The proposed friction materials manufacturing NESHAP includes requirements for reporting and recordkeeping. Capital reporting and recordkeeping costs include costs for file cabinets for storing records. The total capital cost for the industry is estimated to be $940.[2] Annual reporting and recordkeeping costs include labor costs for reporting and recordkeeping, annualized capital costs for the file cabinets, and operation and maintenance costs for photocopying and postage associated with the reporting requirements. The total annual cost for the industry is estimated to be

approximately $80,000.[2] These costs do not include costs associated with monitoring, which are discussed in the previous section.

7.6 COST EFFECTIVENESS

The cost effectiveness of the MACT floor and beyond-the-floor control options for friction materials manufacturing is estimated as the total annual cost of the control option (control cost, monitoring cost, and reporting and recordkeeping cost) divided by the amount (tpy) of HAP recovered, which yields a cost per ton of HAP recovered. Table 7-3 presents the total HAP emission reduction, total·annual costs, and the associated cost effectiveness. The cost effectiveness of controlling HAP solvent emissions from existing solvent mixers at major sources, without recovery credits, is estimated to be approximately $890/ton at the MACT floor and $660/ton beyond the floor. The cost effectiveness of controlling HAP solvent emissions from existing solvent mixers at major sources, including recovery credits, is estimated to be approximately $360/ton at the MACT floor and $140/ton beyond the floor.

Table 7-3. Nationwide Cost-effectiveness for Existing
Friction Materials Manufacturing Facilities

| Control level | Nationwide annual cost, $/yr | | Emission reduction from baseline, tpy | Cost effectiveness, $/ton | |
	Without credits	With credits		Without credits	With credits
MACT floor	$180,000	$72,000	200	$890	$360
Beyond the floor	$210,000	$43,000	310	$660	$140
Incremental	$29,000	($29,000)	110	$260	($260)

The incremental cost effectiveness of going from the MACT floor to beyond the floor for friction materials manufacturing is estimated as the difference in the annual cost of the control options divided by the difference in the number of tons of HAP recovered, which yields an incremental cost per ton of HAP recovered. Table 7-3 presents the incremental HAP emission reduction, incremental total annual cost, and the associated incremental cost effectiveness. The incremental cost effectiveness of going from the MACT floor to beyond the floor is estimated to be approximately $260/ton, without recovery credits, and a net credit of approximately $260/ton, with recovery credits.

7.7 NEW SOURCES

Data on the number of motor vehicles in use and locomotives and railcars in use were used to project the change in the demand for friction materials over the next 5 years (i.e., from 2001 to 2006).[3] Based on the available data, an 8 percent increase in motor vehicles, locomotives, and railcars in use is expected over the next 5 years. This increase is believed to be indicative of a similar increase in the demand for friction materials. The annual growth rate in friction materials sales over the next 5 years is estimated to be approximately 14 percent.[3] The number of new solvent mixers is assumed to correlate to the increase in friction materials production and sales. Because the overall average production capacity utilization for the friction materials industry is approximately 50 percent, the current industry capacity is more than sufficient to meet the increased demand. Therefore, it is projected that no new solvent mixers will be installed. Consequently, there are no costs associated with new solvent mixers.

7.8 SMALL BUSINESSES

One small business is included in the population of facilities used for evaluating and determining the MACT floor and beyond-the-floor control levels. This facility is estimated to be a major source of HAP emissions and will have to meet the requirements of the friction materials manufacturing NESHAP. This facility already has a solvent recovery system (condenser) in place that can meet both the MACT floor and beyond-the-floor control levels. In addition, this facility has the necessary monitoring equipment in place. The total annual cost for this facility is estimated to be approximately $21,000, which is comprised entirely of reporting and recordkeeping costs.

7.9 REFERENCES

1.   U. S. Environmental Protection Agency. OAQPS Control Cost Manual. Fifth Edition. EPA/453/B-96-001. February 1996. Chapter 8. Refrigerated Condensers.

2.   Memorandum from Bullock, D., Hanks, K., and Holloway, T., Midwest Research Institute, to project file. July 24, 2001. Facility-Specific Costs for the Friction Materials Manufacturing Industry.

3.   Memorandum from Hanks, K., Midwest Research Institute, to project file. May 17, 2001. Monitoring Costs for the Friction Materials Manufacturing NESHAP.

4. Memorandum from Bullock, D., Midwest Research Institute, to project file. May 17, 2001. New Source Projections for the Friction Materials Manufacturing NESHAP.

Appendix A
Evolution of the Standard

This appendix summarizes the background information gathered and the analyses performed during the development of the friction materials manufacturing standard. In developing the standard, the following technical data were acquired from the friction materials manufacturing industry: (1) equipment design and operating parameters, (2) types and quantities of HAP emitted, (3) emission reduction techniques, and (4) the effectiveness of these control techniques in reducing HAP emissions. The bulk of the information was gathered from the following sources:

1. Technical literature;

2. Industry representatives;

3. Site visit reports;

4. ICRs;

5. State and local air pollution control agencies; and

4. Emission test reports.

Significant events relating to the evolution of the friction materials manufacturing standard are listed in Table A-1.

Table A-1. Evolution of the Standard

Date	Event
4/1/97	Draft memo summarizing existing friction products information submitted to EPA
4/3/97	Site visit to Stone Heavy Vehicle Specialists, Inc., Raleigh, North Carolina
4/24/97	Site visit to Quality Automotive Co., Tappahannock, Virginia
4/25/97	Site visit to VAAPCO, Inc., Millers Tavern, Virginia
5/1/97	Site visit to The Hastings Co., King, North Carolina
6/11/97	Final site visit reports for Stone Heavy Vehicle Specialists, Inc., Raleigh, North Carolina and The Hastings Co., King, North Carolina

Date	Event
6/24/97	Meeting with representatives of the friction products industry to discuss the friction products MACT standards development project, including draft ICR
8/27/97	Draft memo comparing generic ICR questionnaire with friction products ICR questionnaire submitted to EPA
9/4/97	Final site visit report for VAAPCO, Inc., Millers Tavern, Virginia
9/23/97	Site visit to Performance Friction Corp., Clover, South Carolina
11/7/97	ICR questionnaires mailed out to friction products industry (responses due 60 days after mailout)
12/12/97	First site visit to Railroad Friction Products Corp., Laurinburg, North Carolina
1/2/98	Final site visit report for Performance Friction Corp., Clover, South Carolina
1/16/98	Data base created to tabulate information in the ICR responses; responses (ICRs, delay/extension letters, not applicable letters) received for over 50 percent of mailouts by deadline; updated docket index submitted to EPA
2/27/98	Memo describing current plans for emission testing at friction products facilities submitted to EPA
3/12/98	Updated docket index submitted to EPA
5/7/98	Updated docket index submitted to EPA
5/11/98	Final site visit report for Quality Automotive Co., Tappahannock, Virginia
6/18/98	Updated docket index submitted to EPA
7/22/98	·Site visit to BF Goodrich Aerospace, Pueblo, Colorado
7/30/98	Updated docket index submitted to EPA
8/4/98	Site visit to Federal-Mogul, Smithville, Tennessee
8/25/98	Final site visit report for first trip to Railroad Friction Products Corp., Laurinburg, North Carolina
8/27/98	All expected ICR responses/clarifications (97 percent) received; updated docket index submitted to EPA
10/8/98	Updated docket index submitted to EPA
10/21/98	Site visit to Raybestos Products Co., Crawfordsville, Indiana
12/11/98	Data entry of ICR responses complete (about 90 percent of available data sets); poor ICR responses (about 10 percent) not entered
12/11/98 ·	Updated docket index submitted to EPA
1/19/99	Final site visit report for Raybestos Products Co., Crawfordsville, Indiana
2/8/99	Friction products National Toxics Inventory (NTI) template submitted to EPA

Date	Event
7/8/99	Updated friction products NTI template submitted to EPA
3/14/00	Second site visit to Railroad Friction Products Corp., Laurinburg, North Carolina
3/8/00	Draft BID Chapter 1 (Introduction) submitted to EPA
3/17/00	Draft outline of BID submitted to EPA
4/5/00	Draft BID Chapter 2 (Industry Profile) submitted to EPA
4/13/00	Meeting with EPA to review MACT floors
4/19/00	Final site visit report for BF Goodrich Aerospace, Pueblo, Colorado
4/26/00	Draft BID Chapter 3 (Emission Control Techniques) submitted to EPA
5/31/00	Draft BID Chapter 4 (MACT Floors and Regulatory Options) submitted to EPA
6/13/00	Meeting with EPA to review model process units; draft Appendix B to BID (Emission Estimation Methodology) submitted to EPA
6/30/00	Draft BID Chapter 5 (Model Process Units) submitted to EPA
7/13/00	Meeting with EPA to discuss economics-related issues for friction products MACT standard
8/17/00	Drafts of BID Chapters 6 (Environmental and Energy Impacts) and 7 (Cost of Controls) submitted to EPA
10/26/00	Draft proposal regulation submitted to EPA
11/9/00	Site visit to Thermoset, Inc., Jackson, Wisconsin
11/14/00	Non-CBI test report summary submitted to EPA for review by facilities
11/16/00	Meeting with representatives of the friction products industry to update the industry on the status of the friction products MACT standards development project
12/22/00	Draft proposal preamble submitted to EPA
1/16/01	Draft new source projections memo submitted to EPA; draft monitoring costs memo submitted to EPA
2/6/01	Draft memo transmitting facility-specific cost estimates submitted to EPA/ISEG; draft OMB 83-I and supporting statement submitted to EPA
3/27/01	Final site visit report for Thermoset, Inc., Jackson, Wisconsin
4/17/01	Final site visit report for second trip to Railroad Friction Products Corp., Laurinburg, North Carolina
4/27/01	Final site visit report for Federal-Mogul, Smithville, Tennessee
5/8/01	Final facility-specific cost estimates submitted to EPA
5/10/01	Final OMB 83-I and supporting statement submitted to EPA
6/11/01	Revised draft BID Chapters 1-7 and Appendices A and B submitted to EPA

Date	Event
8/3/01	Final draft BID submitted to EPA

Appendix B
Emission Estimation Methodology

This appendix presents the methodologies used in estimating HAP emissions from facilities in the friction materials manufacturing industry. The methodologies for estimating uncontrolled and controlled emissions are presented, as well as the methodologies for estimating emissions associated with the MACT floor and beyond-the-floor options. The emissions estimates are presented in Tables B-1 through B-4 below. Emissions were estimated for the four friction materials manufacturing facilities (Plants A, B, C, and D) with resin-based processes that are major sources of HAP emissions. Sections B.1 through B.4 present the emission estimation methodologies for these four facilities. Section B.5 provides a list of references.

B.1 Plant A

B.1.1 Baseline and Uncontrolled Emissions

Uncontrolled emissions from Plant A were determined based on the annual consumption of toluene solvent. assuming that the quantity of solvent consumed is equal to the quantity of solvent emitted. According to the ICR response for Plant A, the annual consumption of toluene solvent for 1997 was expected to be 13,085 gal, and the HAP content of the solvent is 100 percent; this is equivalent to an annual consumption of 46.98 tpy for toluene, based on a reported density of 7.18 lb/gal.[5] Therefore, the total uncontrolled emissions for Plant A were estimated to be 46.98 tpy.

Using the equipment ratios from Plant B as a model (80.5 percent from solvent mixer, 10.5 percent from extruder, 7.2 percent from granulator, 1.6 percent from dryers, and 0.2 percent from hot presses), 80.5 percent of the uncontrolled emissions at Plant A were assumed to be from the solvent mixer, and 10.5 percent were assumed to be from the extruder. Emissions from the oven

were assumed to be equivalent to the remainder of the emissions (9.0 percent). Therefore, the uncontrolled emissions for the solvent mixer were estimated to be 0.805 * 46.98 tpy = 37.82 tpy, while the uncontrolled emissions for the rest of the solvent mixer line (extruder and oven) were estimated to be 0.195 * 46.98 tpy = 9.16 tpy.

Baseline emissions for the solvent mixer were estimated based on the effectiveness of the vacuum system used to capture and collect the toluene solvent and the control efficiency of the condenser used to recover the toluene solvent. Based on the available data, Plant A's vacuum system captures 95 percent of the toluene from the solvent mixer, and the condenser recovers 90 percent of the captured solvent vapor, resulting in an overall solvent recovery of 85 percent, which the facility has consistently achieved.[6] Therefore, baseline emissions for the solvent mixer were estimated to be 0.15 * 37.82 tpy = 5.67 tpy. Because the rest of the solvent mixer line (extruder and oven) is uncontrolled, the emissions from these pieces of equipment would remain unchanged (9.16 tpy).

B.1.2 MACT Floor and Beyond-the-Floor Emissions

The MACT floor and beyond-the-floor emissions for Plant A would be identical to baseline emissions because the solvent mixer at this facility already achieves 85 percent solvent recovery. Therefore, this solvent mixer is not impacted at the MACT floor and beyond-the-floor.

B.2 Plant B

B.2.1 Baseline and Uncontrolled Emissions

Baseline emissions from Plant B were determined based on the quantity of hexane solvent purchased, assuming that the quantity of solvent purchased is equal to the quantity of solvent emitted. According to the response to the ICR for Plant B, the annual purchase of hexane solvent for 1997 was expected to be 317,914 gallons (gal), and the n-hexane content of the solvent purchased was 62.3 percent.[1] Using a reported density of 5.619 pounds per gallon (lb/gal) for n-hexane, this is equivalent to baseline emissions of 556.45 tpy of n-hexane for Plant B.[1]

Table B-1. Facility-Specific Uncontrolled HAP Emissions

Facility	Solvent used	Control device	No. solvent mixers	Uncontrolled HAP emissions, tpy[a]						
				Facility	Mixer	Extruder	Granulator	Dryer	Press	Oven
Plant A	Toluene	Condenser	1	46.98	37.82	4.93	--	--	--	4.23
Plant B	n-Hexane	Condenser	1[b]	570.74	459.45	59.93	41.09	9.13	1.14	0.00
	n-Hexane	None	3[c]	307.32	247.39	32.27	22.13	4.92	0.61	0.00
Total Plant B			4	878.06	706.84	92.20	63.22	14.05	1.76	0.00
Plant C	TCE	Carbon adsorber	1	58.39	47.00	--	--	--	7.07	4.32
Plant D	Toluene	None	1	47.70	38.40	7.68	--	1.38	0.24	0.00
Total nationwide			7	1,031.13						

[a] Uncontrolled emissions for each piece of equipment were apportioned based on the ratios provided by Plant B.
[b] At Plant B, estimated 65 percent of total annual uncontrolled emissions are through the Sigma mixer line.
[c] At Plant B, estimated 35 percent of total annual uncontrolled emissions are through the Ross mixers (3) line.

Table B-2. Facility-Specific Baseline HAP Emissions

Facility	Solvent used	Control device	Baseline percent recovery	No. solvent mixers	Baseline HAP emissions, tpy						
					Facility	Mixer	Extruder	Granulator	Dryer	Press	Oven
Plant A	Toluene	Condenser	85%	1	14.83	5.67	4.93	--	--	--	4.23
Plant B	n-Hexane	Condenser	70%	1	249.13	137.83	59.93	41.09	9.13	1.14	0.00
	n-Hexane	None	0%	3	307.32	247.39	32.27	22.13	4.92	0.61	0.00
Total Plant B				4	556.45	385.23	92.20	63.22	14.05	1.76	0.00
Plant C[a]	TCE	Carbon adsorber	85%	1	18.44	7.05	--	--	--	7.07	4.32
Plant D	Toluene	None	0%	1	47.70	38.40	7.68	--	1.38	0.24	0.00

Table B-3. Facility-Specific MACT Floor HAP Emissions (MACT Floor Level of Control = 70 Percent)

Facility	Solvent used	Control device	Baseline percent recovery	No. solvent mixers	MACT floor HAP emissions, tpy						
					Facility	Mixer	Extruder	Granulator	Dryer	Press	Oven
Plant A	Toluene	Condenser	85%	1	14.83	5.67	4.93	--	--	--	4.23
Plant B	n-Hexane	Condenser	70%	1	249.13	137.83	59.93	41.09	9.13	1.14	0.00
	n-Hexane	None	0%	3	134.15	74.22	32.27	22.13	4.92	0.61	0.00
Total Plant B				4	383.27	212.05	92.20	63.22	14.05	1.76	0.00
Plant C[a]	TCE	Carbon adsorber	85%	1	18.44	7.05	--	--	--	7.07	4.32
Plant D	Toluene	None	0%	1	20.82	11.52	7.68	--	1.38	0.24	0.00
Total nationwide				7	437.37						

[a] At Plant C, estimated 85 percent control at solvent mixer; control efficiency is 94 percent; capture efficiency unknown, assumed to be 90 percent.

Table B-4. Facility-Specific Beyond-the-Floor HAP Emissions (Beyond-the-Floor Level of Control = 85 Percent)

Facility	Solvent used	Control device	Baseline percent recovery	No. solvent mixers	Beyond-the-floor HAP emissions, tpy						
					Facility	Mixer	Extruder	Granulator	Dryer	Press	Oven
Plant A	Toluene	Condenser	85%	1	14.83	5.67	4.93	--	--	--	4.23
Plant B	n-Hexane	Condenser	70%	1	180.21	68.92	59.93	41.09	9.13	1.14	0.00
	n-Hexane	None	0%	3	97.04	37.11	32.27	22.13	4.92	0.61	0.00
Total Plant B				4	277.25	106.03	92.20	63.22	14.05	1.76	0.00
Plant C[a]	TCE	Carbon adsorber	85%	1	18.44	7.05	--	--	--	7.07	4.32
Plant D	Toluene	None	0%	1	15.06	5.76	7.68	--	1.38	0.24	0.00
Total nationwide				7	325.58						

[a] At Plant C, estimated 85 percent control at solvent mixer; control efficiency is 94 percent; capture efficiency unknown, assumed to be 90 percent.

The uncontrolled emissions for Plant B were back-calculated from the baseline emissions using information provided by the facility on equipment ratios for their production lines and on their solvent recovery system. Of the uncontrolled emissions, 35 percent of the emissions are estimated to be emitted from the Ross mixers line and 65 percent from the Sigma mixer line.[1] For each mixer line, 80.5 percent of emissions are estimated to be emitted from the mixer itself and 19.5 percent of the emissions are estimated to be emitted from the rest of the line (10.5 percent from extruder, 7.2 percent from granulator, 1.6 percent from dryers, and 0.2 percent from hot presses).[1]

Based on information from the facility, the Sigma mixer is equipped with a solvent recovery system, the rest of the Sigma mixer line (extruder, granulator, dryers, and hot presses) is uncontrolled, and the Ross mixers line is also uncontrolled.[1] The solvent is drawn out of the mixed material from the Sigma mixer by vacuum.[2] The facility estimates that the residual solvent content is 10 percent, which means that 90 percent of the solvent is captured from the mixture.[1] The solvent vapors are collected by a non-contact Freon-cooled condenser, which cools the solvent vapor to 60°F.[1] According to the facility, the condenser is 80 percent efficient in recovering the captured solvent.[2] The total solvent recovery is estimated at 70 percent recovery on average. These data were based on informal mass balance measurements performed by the facility personnel for facility purposes. Using this facility information, the total uncontrolled emissions were estimated using the following equation:

Baseline emissions (556.45 tpy) = (0.35 * x) + [(0.65 * 0.805 * 0.30 * x) + (0.65 * 0.195 * x)], where x is total uncontrolled emissions. Solving for x, total uncontrolled emissions = 878.06 tpy.

The uncontrolled emissions were broken out for the Sigma mixer line using the following equations:

Uncontrolled emissions (Sigma mixer) = (0.65 * 0.805 * 878.06 tpy) = 459.45 tpy.
Uncontrolled emissions (extruder, granulator, dryers, and hot presses) = (0.65 * 0.195 * 878.06 tpy) = 111.29 tpy.

The uncontrolled emissions were broken out for the Ross mixers line using the following equations:

Uncontrolled emissions (Ross mixers) = (0.35 * 0.805 * 878.06 tpy) = 247.39 tpy.
Uncontrolled emissions (extruder, granulator, dryers, and hot presses) = (0.35 * 0.195 * 878.06 tpy) = 59.93 tpy.

B-5

Based on 70 percent solvent recovery, the baseline (controlled) emissions for the Sigma mixer were estimated to be 0.3 * 459.45 tpy = 137.83 tpy. The baseline emissions for the Ross mixers line and the rest of the Sigma mixer line (extruder, granulator, dryers, and hot presses) are the same as the uncontrolled emissions because there is no solvent recovery for these equipment.

B.2.2 MACT Floor and Beyond-the-Floor Emissions

To comply with the MACT floor option (70 percent solvent recovery for solvent mixers), Plant B is expected to equip its uncontrolled Ross mixers with a solvent recovery system (condenser) capable of achieving 70 percent solvent recovery (including capture and collection). Therefore, the emissions associated with the MACT floor option for Plant B were estimated based on a 70 percent reduction in uncontrolled emissions for the Ross mixers (0.3 * 247.39 tpy = 74.22 tpy). The emissions for the rest of the Ross mixers line and the entire Sigma mixer line would remain at baseline levels.

To comply with the beyond-the-floor option (85 percent solvent recovery for solvent mixers), Plant B is expected to equip its Sigma mixer and Ross mixers with solvent recovery systems (condensers) capable of achieving 85 percent solvent recovery (including capture and collection). Therefore, the emissions associated with the beyond-the-floor option for Plant B were estimated based on an 85 percent reduction in uncontrolled emissions for the Sigma mixer and Ross mixers (0.15 * 459.45 tpy + 0.15 * 247.39 tpy = 106.03 tpy). The emissions for the rest of the Sigma mixer line and Ross mixers line would remain at baseline levels.

B.3 Plant C

B.3.1 Baseline and Uncontrolled Emissions

Uncontrolled emissions from Plant C were determined based on the annual consumption of trichloroethylene solvent, assuming that the quantity of solvent consumed is equal to the quantity of solvent emitted. According to the ICR response for Plant C, the annual consumption of trichloroethylene solvent for 1997 was expected to be 9,660 gal, and the HAP content of the solvent is 100 percent; this is equivalent to an annual consumption of 58.39 tpy for

trichloroethylene, based on a reported density of 12.09 lb/gal.[3] Therefore, the total uncontrolled emissions for Plant C were estimated to be 58.39 tpy.

Using the equipment ratios from Plant B as a model (80.5 percent from solvent mixer, 10.5 percent from extruder, 7.2 percent from granulator, 1.6 percent from dryers, and 0.2 percent from hot presses), 80.5 percent of the uncontrolled emissions at Plant C were assumed to be from the solvent mixer. Emissions from the hot press were assumed to be equivalent to the total emissions from the extruder and dryer (10.5 percent + 1.6 percent = 12.1 percent) because of the press' relative position in the process and because it is heated. Emissions from the oven were assumed to be equivalent to the remainder of the emissions (7.4 percent). Therefore, the uncontrolled emissions for the solvent mixer were estimated to be 0.805 * 58.39 tpy = 47.00 tpy, while the uncontrolled emissions for the rest of the solvent mixer line (hot press and oven) were estimated to be 0.195 * 58.39 tpy = 11.39 tpy.

Baseline emissions for the solvent mixer were estimated based on the effectiveness of the vacuum system used to capture and collect the trichloroethylene solvent and the control efficiency of the carbon adsorber used to recover the trichloroethylene solvent. Based on information from Plant C, the control efficiency of the carbon adsorber is 94 percent.[4] No data are available on the effectiveness of the vacuum system at removing the trichloroethylene solvent from the mixed material. However, if the residual solvent content is similar to those at Plant B and Plant A (i.e., between 5 and 10 percent), the overall solvent recovery for the solvent mixer would be between 85 and 90 percent. To be conservative, a solvent recovery of 85 percent was assumed. Therefore, baseline emissions for the solvent mixer were estimated to be 0.15 * 47.00 tpy = 7.05 tpy. Because the rest of the solvent mixer line (hot press and oven) is uncontrolled, the emissions from these pieces of equipment would remain unchanged (11.39 tpy).

B.3.2 MACT Floor and Beyond-the-Floor Emissions

The MACT floor and beyond-the-floor emissions for Plant C would be identical to baseline emissions because the solvent mixer at this facility is assumed to already achieve 85 percent

solvent recovery. Therefore, this solvent mixer is not impacted at the MACT floor and beyond-the-floor.

B.4 Plant D

B.4.1 Baseline and Uncontrolled Emissions

Uncontrolled emissions from Plant D were determined based on the annual consumption of toluene solvent, assuming that the quantity of solvent consumed is equal to the quantity of solvent emitted. According to the ICR response for Plant D, the annual consumption of toluene solvent for 1997 was expected to be 13,069 gallons, and the HAP content of the solvent is 100 percent; this is equivalent to an annual consumption of 47.70 tpy for toluene, based on a reported density of 7.3 lb/gal for toluene.[7] Therefore, the uncontrolled emissions for Plant D were estimated to be 47.70 tpy.

Using the equipment ratios from Plant B as a model (80.5 percent from solvent mixer, 10.5 percent from extruder, 7.2 percent from granulator, 1.6 percent from dryers, and 0.2 percent from hot presses), 80.5 percent of the emissions at Plant D were assumed to be from the solvent mixer. Because Plant D has no granulator, ratios were used to apportion the granulator emissions to the extruder (16.1 percent), dryer (2.9 percent), and hot press (0.5 percent). Therefore, the uncontrolled emissions for the solvent mixer were estimated to be 0.805 * 47.70 tpy = 38.40 tpy, while the uncontrolled emissions for the rest of the solvent mixer line (extruder, dryer, and hot press) were estimated to be 0.195 * 47.70 tpy = 9.30 tpy.

B.4.2 MACT Floor and Beyond-the-Floor Emissions

To comply with the MACT floor option (70 percent solvent recovery for solvent mixers), Plant D is expected to equip its uncontrolled solvent mixer with a solvent recovery system (condenser) capable of achieving 70 percent solvent recovery (including capture and collection). Therefore, the emissions associated with the MACT floor option for Plant D were estimated based on a 70 percent reduction in uncontrolled emissions for the solvent mixer (0.3 * 38.40 tpy = 11.52 tpy). The emissions for the rest of the solvent mixer line would remain at baseline levels (9.30 tpy).

To comply with the beyond-the-floor option (85 percent solvent recovery for solvent mixers), Plant D is expected to equip its uncontrolled solvent mixer with a solvent recovery system (condenser) capable of achieving 85 percent solvent recovery (including capture and collection). Therefore, the emissions associated with the beyond-the-floor option for Plant D were estimated based on an 85 percent reduction in uncontrolled emissions for the solvent mixer (0.15 * 38.40 tpy = 5.76 tpy). The emissions for the rest of the solvent mixer line would remain at baseline levels (9.30 tpy).

B.5 References

1. Completed information collection request for Plant A.

2. Memorandum from Bullock, D., Midwest Research Institute, to Cavender, K., EPA/ESD. Site Visit Report Plant–A.

3. Completed information collection request for Plant B.

4. Memorandum from Schmitt, D., Bullock, D., and Abraczinskas, M., Midwest Research Institute, to Cavender, K., EPA/ESD. Site Visit Report–Plant B.

5. Completed information collection request for Plant C.

6. Memorandum from Abraczinskas, M., Bullock, D., Holloway, T., and Turner, M., Midwest Research Institute, to Cavender, K., EPA/ESD. August 3, 2001. Summary of Emission Test Data.

7. Completed information collection request for Plant D.

TECHNICAL REPORT DATA

1. REPORT NO. EPA-453/R-01-008	2.	3. RECIPIENT'S ACCESSION NO.

4. TITLE AND SUBTITLE National Emission Standards for Hazardous Air Pollutants (NESHAP) for the Friction Materials Manufacturing Industry-- Background Information Document	5. REPORT DATE August 2001
	6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS Midwest Research Institute 5520 Dillard Road, Suite 100 Cary, NC 27511	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO. 68-D6-0012

12 SPONSORING AGENCY NAME AND ADDRESS Office of Air Quality Planning and Standards U. S. Environmental Protection Agency Research Triangle Park, NC 27711	13 TYPE OF REPORT AND PERIOD COVERED Final (1997-2001)
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT
National emission standards for hazardous air pollutants (NESHAP) for friction materials manufacturing facilities are being proposed under the authority of Section 112(d) of the Clean Air Act as amended in 1990. These standards would reduce air toxics from all major source friction materials manufacturing facilities (defined as those sources that emit or have the potential to emit 10 tpy or greater of individual HAPs, or 25 tpy or greater of any combination of HAPs). This document contains background information and environmental and cost impact assessments of the emission control options considered in developing the proposed standards.

17.	KEY WORDS AND DOCUMENT ANALYSIS	
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c COSATI Field/Group
n-Hexane Solvent mixer Solvent recovery Toluene Trichloroethylene	Air pollution control Friction materials manufacturing Hazardous air pollutants MACT NESHAP	

18. DISTRIBUTION STATEMENT Release Unlimited	19. SECURITY CLASS (Report) Unclassified	21. NO. OF PAGES
	20. SECURITY CLASS (Page) Unclassified	22. PRICE