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Polymer Manufacturing Industry - Background Information for Proposed Standards

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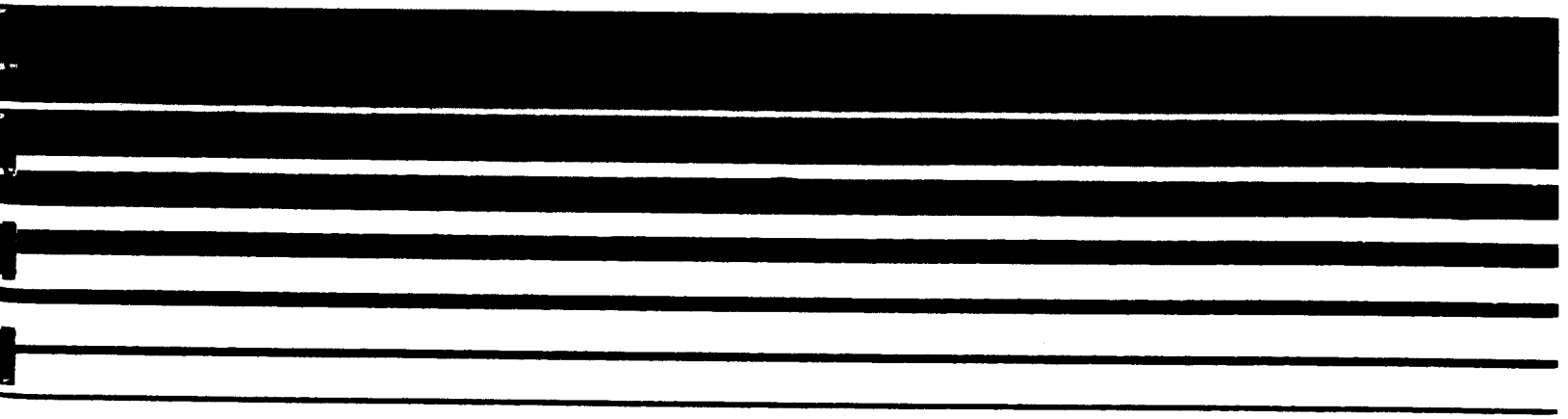
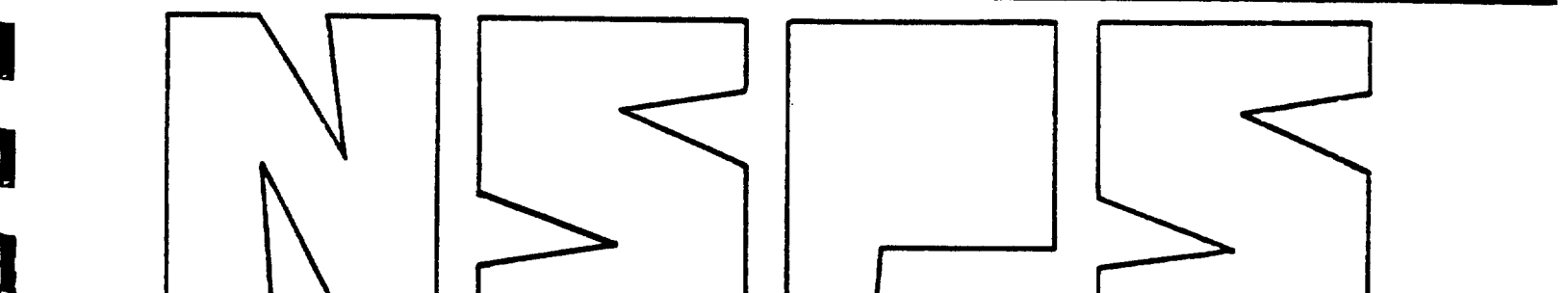
Preliminary Draft





numerous sectors of the economy. Forms include shapes for structural housings or parts, films, sheets, surface coatings, adhesive liquids, foams, fibers, and filaments. Many types of manufacturing processes are used to shape resin into these forms. The various kinds of shaping techniques used include blow molding, tubular film blowing, calendaring, injection molding, rotational molding, casting, coating, extrusion, foaming, and elongation to orient fibers. These shaping operations are noted, but not elaborated on in this document. (This document discusses the manufacturing of the above selected polymers but does not include the fabrication of polymer products.)

These products are used in every sector of the economy with particularly large applications in the construction, transportation, clothing, consumer goods, and electrical industries. Generally, end-use functions include structural components in equipment or appliances, insulation, film for packaging wrap, and fiber for lines or clothing.

Each major polymer or resin product has its own properties, forms, and end-use sectors. The important end-uses of each polymer chosen for NSPS development are summarized below.

3.1.1.1 End-Uses of Polypropylene. Polypropylenes, which are made by many different processes, are lightweight, water- and chemical-resistant plastics, somewhat rigid, but easy to process. They are thermoplastic and belong to the olefins family. Polypropylene products can be formed in many ways, including molding, extrusion, rotational molding, powder coating, thermoforming, foam molding, and fiber orientation.

Molded applications include bottles for syrups and foods, caps, auto parts, appliance parts, toys, housewares, and furniture components. Polypropylene fibers and filaments are used in carpets, rugs, carpet backing, woven bags, and cordage. Film uses include packaging for cigarettes, records, toys, and housewares. Extrusions include pipes, profiles, wire and cable coatings, and corrugated packing sheets.[2]

Products formed by injection molding consume about 41 percent of the polypropylene produced domestically. The second most utilized form, fibers and filaments, accounts for 31 percent of the total production. Other forms account for the remaining 28 percent.[3] The major sectors using polypropylenes are consumer/institutional (19 percent), furniture/furnishings (18 percent), packaging (16 percent),

transportation (12 percent), and electrical/electronics (7 percent). Other uses account for the remaining 28 percent.[3]

3.1.1.2 End-Uses of Polyethylenes: Low Density and High Density. Polyethylenes are the largest volume plastics produced, both domestically and internationally. These thermoplastic polymers are valued for their structural strength, water and chemical resistance, and easy processing characteristics.

There is nearly an infinite variety of polyethylenes that differ in melting point, clarity, and density. They are generally divided into two broad categories, low and high density, both of which are flexible, although high density polyethylene (HDPE) is more rigid. Within the last few years, a new class of LDPE has appeared - linear low density polyethylene (LLDPE). LLDPE combines the linear molecular structure of HDPE with the physical and optical properties of conventional LDPE, and its overall properties are superior to those of conventional LDPE.[4] Polyethylenes are often extruded into film, sheets, pipe, or profiles, injection molded, blow molded, rotationally molded, foamed, or formed in other ways.[5]

3.1.1.2.1 Low density polyethylene (LDPE). Conventional LDPE is used primarily in packaging. Specific applications include packaging film and wrap, trash bags, garment bags, and molded forms (toys, housewares, containers, and others).[5] End-uses are found in many segments of the economy, including the packaging industry (62 percent), consumer/institutional industries (11 percent), electrical/electronics industries (7 percent), and other sectors (21 percent).[6]

Like conventional LDPE, LLDPE is suitable for many end-uses. Specific applications may include housewares, lids, closures, blow molded parts (e.g., toys, bottles, and drums), wire and cable insulation, extruded pipe and tubing, and industrial and consumer films (e.g., food packaging, trash bags, and garment bags).[7]

3.1.1.2.2 High density polyethylene (HDPE). The primary application for HDPE is the manufacture of blow molded bottles for bleaches, liquid detergents, milk, and other fluids. Other blow molded forms for which HDPE is used include automotive gas tanks, drums, and carboys. HDPE is

material recovery, polymer extrusion and pelletizing, and product cooling drying and storage. The process descriptions in this section are representative of most of the polymerization processes used to manufacture the products of the source categories chosen for NSPS development.

The remainder of this section presents information on the polymers and resins listed below, including their production processes and the process emissions associated with each process.

1. Polypropylene - continuous, liquid phase slurry process
2. Polypropylene - gas phase process
3. LDPE - high-pressure process
4. LDPE - low-pressure process
5. HDPE - liquid phase slurry process
6. HDPE - liquid phase solution process
7. HDPE - gas phase process
8. Polystyrene - batch process
9. Polystyrene - continuous process
10. Expandable Polystyrene - post-impregnation suspension process
11. Expandable Polystyrene - in-situ suspension process
12. PET - Dimethyl terephthalate (DMT) process
13. PET - Terephthalic acid (TPA) process

Fugitive emissions, which originate from equipment components common to all of the processes, are treated in the same manner for the entire industry and are discussed separately in Section 3.3.

3.2.1 Polypropylene

Polypropylene is a high molecular weight, crystalline polymer of propylene. With a density of 0.902 to 0.904 g/cm^3, it is one of the lightest commercial thermoplastics. The general formula for polypropylene is:

$$\ldots - CH_2 - \underset{CH_3}{CH} - CH_2 - \underset{CH_3}{CH} - CH_2 - \underset{CH_3}{CH} - CH_2 - \ldots$$

Polypropylene can be stereospecific, which means that each repeating methyl group of the polymer chain can be attached to its neighboring groups in two different geometrical arrangements. Depending on the geometrical arrangement of the methyl groups, the polymer exists in the following three forms: (1) isotactic - with all methyl groups aligned

on the same side of the chain as shown above, (2) syndiotactic - with methyl groups alternating, and (3) atactic - all other forms in which the methyl groups are randomly aligned on either side of the chain. Both isotactic and syndiotactic forms, because of their regular structure, are highly crystalline, whereas the atactic form has little crystallinity. Only the isotactic polypropylene is of commercial interest. Atactic resin, an undesirable byproduct of all polypropylene processes, represents about 7 percent of the total product.[11]

Polypropylene is produced by either a liquid phase or a gas phase process. Two basic types of liquid phase process are employed - slurry and solution. The slurry process is the predominant liquid phase process,[12] and can be a batch or continuous process. Batch polymerization is applicable particularly when low volume specialty resins are to be produced. The continuous, liquid phase slurry process and the gas phase process are described in this section.

3.2.1.1 Polypropylene Continuous, Liquid Phase Slurry Process. Polypropylene resins are produced through coordination polymerization using a heterogeneous Ziegler-Natta type catalyst system, which is typically a combination of titanium chlorides and aluminum alkyls.[12] In conventional liquid phase processes, the catalyst provides a relatively low polymer yield on the order of 500 to 1,000 units per unit of catalyst.[13] In addition, a significant amount of catalyst or its residue remains in the reaction product and must be removed. More recently, some slurry processes have used high yield catalysts with improved activity. These catalysts are known to provide a relatively high polymer yield on the order of 5,000 to 7,000 units per unit of catalyst.[13] In these processes, the catalyst is present in such small quantities that it can remain in the product, eliminating the need for the additional process equipment required for catalyst removal and recovery. The elimination of this process operation results in lower VOC emissions.

3.2.1.1.1 Process description. Both conventional and high yield catalyst continuous slurry processes are represented in Figure 3-2. (The identification numbers used for process equipment in this section and the identification letters used for VOC emission streams in the following section refer to this figure.) Liquid phase slurry processes

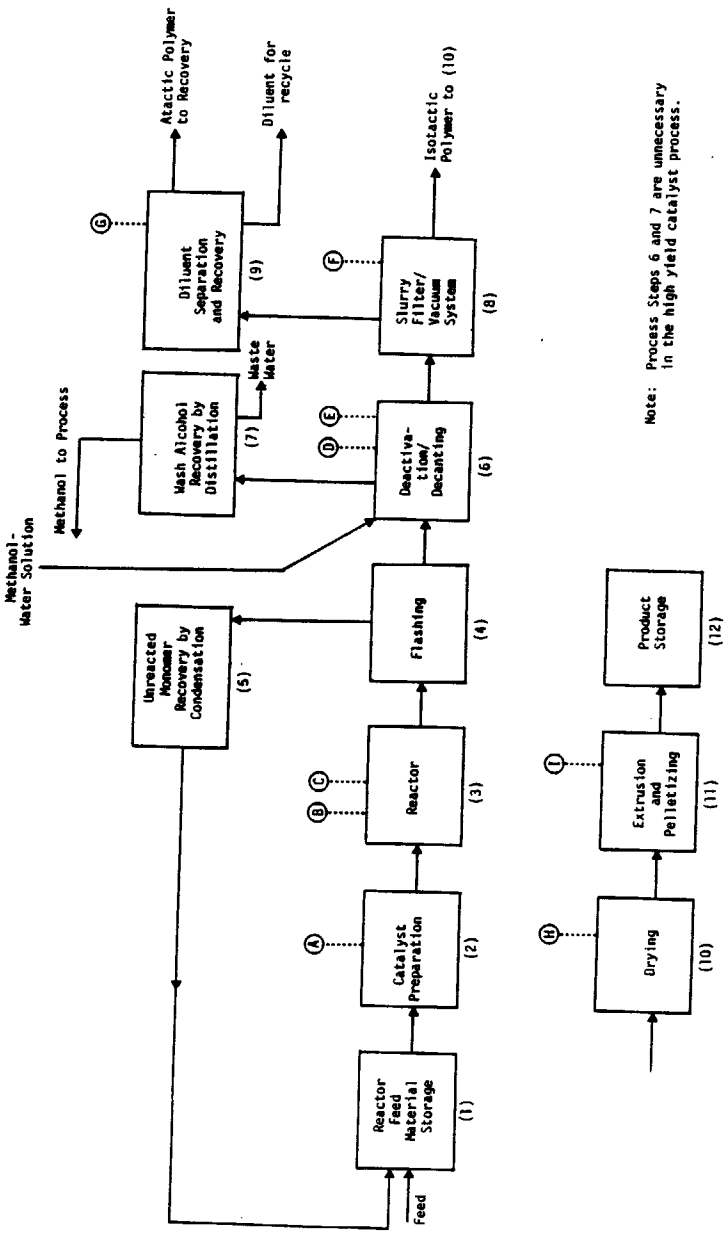


Figure 3-2. Simplified Process Block Diagram for the Polypropylene Continuous, Liquid Phase Slurry Process

may use either liquid propylene or a different organic compound as a diluent in which the polymer forms a slurry. The only difference between the conventional and high yield processes is that process steps 6 and 7 are unnecessary in the high yield process.

Reactor feed material (1) consists mainly of liquid propylene (the monomer), comonomer ethylene (if a copolymer product is desired), a process diluent (which acts as a heat transfer agent), a polymer suspension medium, and a heterogeneous Ziegler-Natta type catalyst. Hexane is used often as a process diluent, although some processes use mixtures of other aliphatic hydrocarbons. The catalyst (2) sometimes is manufactured on-site. The catalyst solution is prepared by mixing the catalyst with the process diluent. Propylene is charged to the polymerization reactor while the catalyst solution and process diluent are metered in separately. Hydrogen is also introduced into the reactor for molecular weight control. Spent diluent from the catalyst preparation operation is sent to the diluent recovery section for reuse.

Polymerization is carried out in either of two types of reactors (3), a continuously stirred, jacketed vessel or a loop reactor. Most conventional slurry processes employ jacketed, continuous, stirred-tank reactors. The pipe or loop reactor is more prevalent in high yield catalyst plants. Operating pressures of 2,070 to 2,760 kPa (300 to 400 psig) are common, but they can be as high as 4,140 kPa (600 psig) when higher operating temperatures are used.[14] Reaction is carried out at temperatures of about 60°C (140°F) for approximately 8 hours.[15] A portion of the reaction effluent, which consists of polymer, monomer, and diluent, is drawn continuously from the reactor to a flash tank (4) in which the unreacted propylene and propane (an impurity in the monomer) are vaporized, and subsequently condensed by compression and cooling (5).

If the catalyst residues must be removed from the product polymer, the residual slurry from the flash tank is fed to the deactivation/decanting section (6) for washing with a methanol-water solution. Some processes use isopropyl alcohol instead of methanol to deactivate the catalyst. The washing with alcohol decomposes the catalyst, dissolves the residues, and results in two phases - a lighter diluent/crude product phase and a heavier methanol-water phase. The crude methanol from this latter phase is refined in a distillation column (7) and leaves the column in the

overhead for recycle to the process. The column bottoms containing catalyst metals are sent to the plant wastewater treatment facility.

The crude product slurry, containing isotactic polymer and atactic polymer-diluent (hexane) solution, is decanted from the methanol-water phase and fed to a slurry vacuum/filter system (8) where isotactic polymer solids are separated from the atactic polymer, which is dissolved in the diluent by vacuum filtration. (Alternatively, a centrifuge may be used in place of the slurry vacuum/filter system.) The atactic-diluent solution is then introduced into a diluent purification unit (9) containing a stripping column in which the diluent is evaporated, condensed, and purified, after which it is dried for recycle. The atactic solids may then be recovered or burned in an incinerator. Liquid and gaseous waste streams from the diluent separation and purification unit may be burned in the same incinerator with the atactic waste.

The isotactic product from the slurry filter goes through a product dryer (10), extruder and pelletizer (11), and then is sent to storage (12). The type of polymer dryer used varies with the facility, but the fluidized bed dryer with a hot nitrogen or air purge is the most common.

Except for the high yield catalyst process, the variations in the various processes are minor and have little effect on VOC emissions. The high yield slurry process, however, does not require catalyst removal. The absence of deactivation/decanting and alcohol recovery processes eliminates several major VOC emission sources. The units that would not be required by the high yield process are identified in Figure 3-2.

3.2.1.1.2 Emissions from the polypropylene continuous, liquid phase slurry process. The characteristics of vent streams from this process are shown in Table 3-6. Each vent stream is identified (circled letter) in Figure 3-2. The total process VOC emission rate for a conventional slurry process is approximately 37 kg VOC/Mg product. The high yield process requires neither a decanter nor a neutralizer. Therefore, the high yield process would not have emissions from these sources and the emission rate would be about 23.8 kg VOC/Mg product. The emission streams are continuous, or nearly so, and consist mainly of propylene, ethylene, propane, and a small amount of the diluent used by the process, usually hexane. The temperatures of the vent streams vary from ambient to 104°C (220°F), and the pressure is about atmospheric.

Table 3-6. CHARACTERISTICS OF VENT STREAMS FROM THE POLYPROPYLENE CONTINUOUS LIQUID PHASE SLURRY PROCESS[a]

Process Section[b]	Stream[c]	Name	Nature	Emission rate, kg VOC/Mg product	Temperature, °C	Pressure, psig	Composition[d,e]
RMP	A	Catalyst preparation	Continuous	0.07	29	0	$C_{10}HC$, IPA
PR	B	Reactor vents	Continuous	4.07	54	0	C_3HC, $C_{10}HC$
PR	C	Emergency Reactor Vents	Intermittent	0.38	66	-	C_2-C_6, N_2, H_2[f]
MR	D	Decanter vents	Continuous	11.49	38	0	C_3HC, $C_{10}HC$, IPA
MR	E	Neutralizer vents	Continuous	1.82	32-71	0	C_3HC, C_4HC, $C_{10}HC$, IPA
MR	F	Slurry vacuum/filter system vent	Continuous	7.93	32	0	$C_{10}HC$, IPA
MR	G	Diluent separation and recovery	Continuous	8.72	104	0	$C_{10}HC$, IPA
PF	H	Dryer vents	Continuous	0 to 0.68	85-104	0	Air and small amount of VOC
PF	I	Extrusion/pelletizing vent	Continuous	2.0			25% HC
		Total Emission Rate		37.1h			

[a]Source of information: Industry correspondence.

[b]RMP= raw materials preparation; PR = polymerization reaction; MR = material recovery; PF = product finishing.

[c]See Figure 2-1 for stream identification.

[d]Streams are diluted in 10 to 30 percent nitrogen.

[e]C_3HC - Propylene or any other hydrocarbon compound with three carbon atoms such as propane.

C_4HC - Butylene or any other hydrocarbon compound with four carbon atoms.

$C_{10}HC$ - A mixture of aliphatic hydrocarbons with 10-12 carbon atoms.

IPA - Isopropyl alcohol.

[f]Approximately 80 percent by weight C_2 - C_6; 10 percent by weight N_2; and 10 percent by weight H_2.

[g]The range reflects the fluidized bed dryer emission at different operating pressures. Other types of dryers may have even higher emissions.

[h]Including upper end to the range of emissions from dryer vents.

The vent from the catalyst preparation section, Stream A, releases diluent continuously. Reactor vent Stream B is continuous and releases monomer and diluent. Reactor vent Stream C is an intermittent stream that occurs during emergency dumps of the reactor. This stream is typically controlled by a flare.

The combined total of the decanter and neutralizer vents, Streams D and E, is usually the largest VOC emission source in the process. The constituents are methanol or isopropyl alcohol (if used), C_3 hydrocarbons, and diluent. Newer, high yield catalyst processes do not require these process steps. The absence of these vents significantly reduces the overall VOC emission rates for the high yield process.

The slurry vacuum/filter system vent, Stream F, is one of the largest VOC emission streams, venting process diluent and alcohol that has remained in the polymer. It is common to both the conventional and high yield slurry processes and releases at atmospheric pressure.

The vacuum jet exhaust, Stream G, from the by-product and diluent recovery section, can be the second largest VOC emission stream in the entire process. The diluent recovery section, which consists of an evaporator, an extractor, and distillation units, is common to both the conventional and high yield processes. It emits process diluents and traces of alcohol.

The vents from the product drying section, Stream H, emit diluent, methanol, and propane diluted in large quantities of air at a relatively high temperature, 104°C (220°F), and near atmospheric pressure.

Emissions are also released from the extrusion/pelletizing section vent, Stream I. Significant quantities of hydrocarbon still remain in the polypropylene powder as it exits the dryer and enters the extruder feed chute. At this point, the powder is in equilibrium with a vapor that can contain up to 25 percent hydrocarbon by weight. As a result of heating and compression in the extruder, there is some VOC loss through the extruder/pelletizer section and further losses from the powder/pellet transfer system downstream from the product dryer since the transfer medium acts as a stripping gas.

The stream properties and VOC concentrations of these process vents can vary depending on process conditions. The variation generally depends on the grade or type of product being manufactured, process

variables such as temperature, pressure, catalyst concentration, or catalyst activity, and the amount of hydrogen used for molecular weight control.

3.2.1.2 Polypropylene Gas Phase Process. The gas phase process for producing polypropylene is relatively new and currently is being used in only one plant. Processing steps are less complicated than in the traditional continuous liquid phase slurry process. The gas phase process is similar to the high yield liquid phase slurry process in that there is no need for catalyst removal. The product processing techniques, however, are different due to the gas phase reaction. The uncontrolled continuous VOC emission rate from the gas phase and the high yield liquid phase slurry processes are comparable. These two newer processes are expected to predominate in future polypropylene capacity because of their simplicity, lower capital cost, and high yield.

3.2.1.2.1 Process description. Figure 3-3 shows a simplified flow diagram of the gas phase process. (The identification numbers used for process equipment in this section and the identification letters used for VOC emission streams in the following section refer to this figure.) In the gas phase process, catalysts and hexane are premixed in the catalyst mix drum (1) from which they are fed to the gas phase reactor (2). Propylene monomer (3) is introduced into the gas phase reactor by a separate line.

The product, which is in a powder form containing contaminants of propylene and finely divided catalyst, is transferred from the gas phase reactor to a fluidized bed catalyst deactivator (4). The gaseous components containing unreacted propylene from the reactor are recovered and purified in a material recovery operation (5) and then recycled back to the reactor. The recycle system contains bag filters, an entrained gas scrubber, a recycle scrubber, and a recycle gas compressor. The gas stream from the fluidized bed catalyst deactivator passes through a bag filter system (6) to recover product. A nitrogen purge gas stream from the bag filters is then fed to a scrubber (7). The purge gas from the HCl scrubber is sent to a flare for combustion.

Polymer product from the fluidized bed deactivator and the bag filter system (6) is sent through the product finishing steps of extrusion, pellet blending, and storage (8).

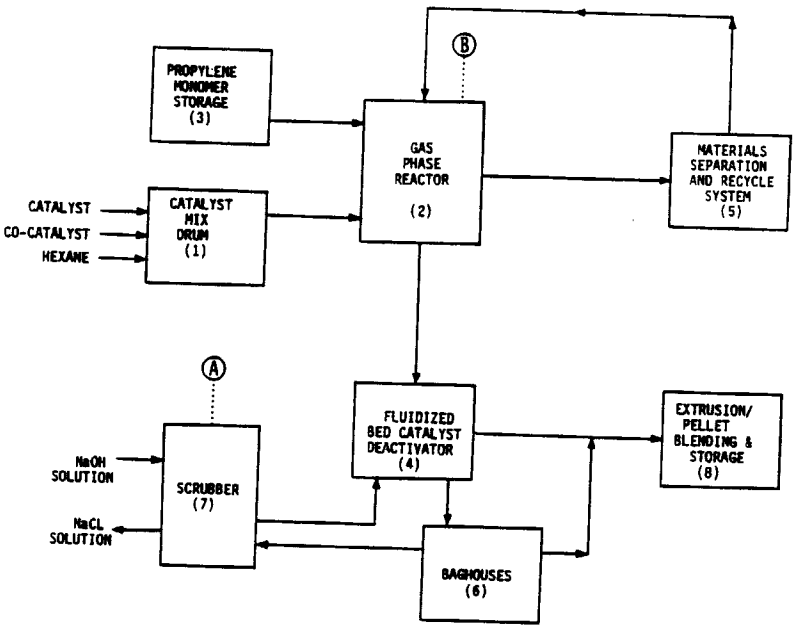
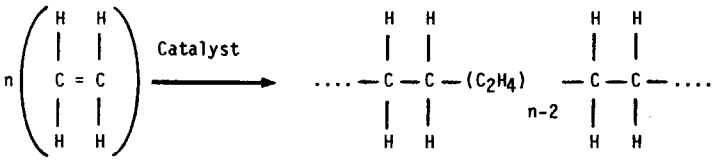


Figure 3-3. Simplified Process Block Diagram for the Polypropylene Gas Phase Process

3.2.1.2.2 Emissions from the polypropylene gas phase process. Two VOC offgas streams from the process, the scrubber vent, which is a continuous stream (A), and the reactor blowdown vent, which is an intermittent stream (B), are currently controlled by a flare system according to one industry source. The uncontrolled VOC emission rate for the entire process, based on the average expected flow rate from these two streams, is 36.5 kg VOC/Mg product. The VOC emissions consist primarily of propylene, propane, and hexane. Table 3-7 summarizes the emission characteristics of this process.

3.2.2 Low Density Polyethylene (LDPE)

Ethylene polymerizes in the presence of a suitable catalyst in the following manner.



Conventional LDPE resins have a high degree of branching with densities that range from 0.910 to 0.935 g/cm^3 and are produced in either an autoclave or tubular reactor.

LDPE resins may also be produced commercially at low pressures in both gas phase fluidized bed reactors and liquid phase solution process reactors. The low pressure process yields a much more linear structure. Linear LDPE can be made in the gas phase with melt indices and densities over the full commercial range. Both processes are described below.

3.2.2.1 LDPE High-Pressure Process. The high-pressure process is currently used more widely than the low-pressure process. However, due to the more favorable economics of the low-pressure process, few, if any, high-pressure plants are likely to be built in the future.[16] The high-pressure process is a free radical process utilizing pressures of several thousand atmospheres to polymerize ethylene and copolymers of ethylene, and nonolefinic comonomers such as vinyl acetate.[17] High-pressure processes, however, are not capable of polymerizing propylene or higher olefins to their corresponding polyolefin.[18] Free radical catalysts, or initiators, are usually used and are predominantly oxygen and peroxides. The product grade can be changed by varying the throughput rate of the

Table 3-7. CHARACTERISTICS OF VENT STREAMS FROM THE POLYPROPYLENE GAS PHASE PROCESS[a]

Process Section[b]	Stream[c]	Name	Nature	Emission rate, kg VOC/Mg product	Temperature, °C	Pressure, psig	Composition
HR	A	Scrubber vent	Continuous	25	38	75	Propylene, Propane, Hexane
PR	B	Reactor blow-down vent	Intermittent	11.5	38	75	Hydrogen, Propylene, Propane, Hexane
		Total Emission Rate		36.5			

[a]Source of information: Industry correspondence.
[b]HR = material recovery; PR = polymerization reaction.
[c]See Figure 3-3 for stream identification.

5. High density polyethylene - liquid phase slurry process,
6. High density polyethylene - liquid phase solution process,
7. Polystyrene - continuous process,
8. Expandable polystyrene - post-impregnation suspension process,
9. Expandable polystyrene - in-situ suspension process,
10. Poly(ethylene terephthalate), (PET) - DMT process, and
11a. Poly(ethylene terephthalate), (PET) - TPA process, for low viscosity PET and high viscosity PET with a single end finisher,
11b. Poly(ethylene terephthalate), (PET) - TPA process for high viscosity PET with multiple end finishers.

The model plants were selected to be representative of basic manufacturing processes used in plants making these polymers and resins and not of any individual processes used by a specific plant. However, in order to provide a basis for economic analysis, data from a specific plant and its process were used. No model plant was developed based upon the polystyrene batch process for the production of crystal or impact polystyrene because available information indicates that new plants that produce crystal or impact polystyrene are unlikely to use this process.

Tables 6-1 through 6-11b summarize the parameters for process emissions for each model plant used in the study. The model plants are based upon the respective plant descriptions in Chapter 3. Each model plant is presented on the basis of its process sections; thus, the parameters and offgas stream characteristics presented in Tables 6-1 through 6-11b are the combined characteristics of the individual streams in each process section as identified in Chapter 3.

As noted in Chapter 6, "Model Process Units and Regulatory Alternatives," of the report "VOC Fugitive Emissions in Synthetic Organic Chemicals Manufacturing Industry - Background Information for Proposed Standards" (EPA-450/3-80-033a), fugitive emissions are proportional to the number of potential sources, but are not related to capacity, throughput, or age. Based on a qualitative assessment of both the emission source counts and emission estimates (see Appendix C), a single model unit, as presented in Table 6-12, was chosen to represent the fugitive emission characteristics of the polymers and resins industry. This model plant, however, was not applied to the poly(ethylene terephthalate) model plants because those PET plants using the DMT process are already covered by the

Table 6-1. MODEL PLANT CHARACTERISTICS FOR PROCESS EMISSIONS FROM THE POLYPROPYLENE LIQUID PHASE PROCESS

Process Section	Nature of Stream(s)	Uncontrolled Emission Rate, kg VOC/Mg Product	Uncontrolled VOC Emissions: Process Total, Mg/yr	Uncontrolled VOC Emissions: Process Train, Mg/yr	Estimated Flow (scfm): Total Plant	Estimated Flow (scfm): Process Train	Temp., °C	Heating Value, Btu/scf	Composition, wt. %	Average VOC Molecular Weight
1. Raw Materials Preparation	Cont.	0.07	10.5	3.5	0.2	0.07	29	4,320	100 VOC[a]	86
2. Polymerization Reaction	Cont.	4.1	615	205	25	8	54	2,260	100 VOC[b]	44
	Inter.	0.38	57	19	3,330	1,110	65	2,380	93 VOC[b] 6.5 N_2 0.5 H_2	48
3. Material Recovery	Cont.	30	4,500	1,500	140	46	54[f]	2,210	100 VOC[d]	54
4. Product Finishing	Cont.	2.6	390	130	230	71	29[f]	115	9.3 VOC[e] 90.7 Air	45
5. Product Storage	---	---			---				---	---
TOTALS		37.2	5,573	1,858						

Model Plant Capacity: 150 Gg/yr
No. of Process Trains: 3
Capacity per Process Train: 50 Gg/yr
Total Operating Hours per Year: 8,600
Standard Conditions: 21°C (70°F) and 0 psig

[a]Assumes VOC is diluent, which, in turn, is assumed to be hexane.

[b]Assumes 47.5 percent is C_3H_6, 47.5 percent is C_3H_8, and 5 percent is hexane.

[c]Assumes C_2 - C_6 with an average molecular weight of 50 and a heating value of 19,800 Btu/scf.

[d]Assumes 2.07 percent is C_3H_6; 2.07 percent, C_3H_8; 1.25 percent, C_4H_{10}; 62.04 percent hexane; and 33.52 percent, methanol.

[e]Assumes 90.7 percent is air; 3.0 percent, hexane; 3.0 percent propane; and 3.3 percent, methanol.

[f]Assumed.

fugitive emission standards for the synthetic organic chemicals manufacturing industry (SOCMI) due to their methanol by-product production and those PET plants using the TPA process use only "heavy" liquids (i.e., ethylene glycol) and solids.

6.2 REGULATORY ALTERNATIVES

This section defines various regulatory alternatives or possible courses of action EPA could take to reduce VOC emissions from the polymers and resins industry. These alternatives provide a basis for determining the air quality and nonair quality environmental impacts, energy requirements, and costs associated with varying degrees of VOC emissions reduction and represent comprehensive programs for reduction of emissions.

The regulatory alternatives were developed in two basic steps: (1) determination of baseline control and (2) determination of more stringent levels of VOC control based upon applicable VOC control techniques. In addition, the regulatory alternatives were developed by applying baseline control and more stringent control to emissions from process sections within a single process line for each model plant.

6.2.1 Baseline Control

Baseline control reflects the level of VOC control that is likely to be employed in a new plant in the absence of the new source performance standard. Its determination is difficult. As discussed in Chapter 3, not all States regulate VOC emissions and the States that do regulate these emissions have regulations of different stringency. In addition, the level of control employed by two plants producing the same product with the same basic process in the same State may vary due to differences in detail of the process. Finally, the actual capacity of the new plant may determine the level of emission control employed. Given these difficulties, the following methods were used for determining baseline control.

6.2.1.1 Process Emissions. For polyolefin plants, individual process VOC emission streams from the plant descriptions in Chapter 3 were identified as the streams most likely to be controlled in the absence of a standard by the following conditions:

- Intermittent streams;
- Continuous streams of mass flow rates greater than 91 Mg/yr (100 tons/yr); and
- Exceptions to the above based on specific process information pertaining to the plant process.

The streams identified as most likely to be controlled were assumed to be presently flared. Intermittent streams are generally controlled by a flare for safety reasons and large continuous streams are likely to be controlled, typically by a flare since flares are acceptable control devices in States with VOC regulations.

For the polystyrene and the PET model plants, a different basis was used to identify the regulatory baseline. Both industries currently use various recovery or combustion technologies that achieve varying levels of VOC emission reductions. For the crystal or impact polystyrene segment, baseline control reflects the use of condensers on the material recovery emission streams (i.e., devolatilizer vent stream and styrene condenser vent stream). As current industry practice in controlling emissions from expandable polystyrene plants varies considerably between plants, it was assumed for analyses purposes that there would be no baseline control. For the poly(ethylene terephthalate) segment, baseline control reflects the use of spent ethylene glycol condensers to recover the ethylene glycol from the polymerization reactors and reflux condensers on the esterifiers, if a low viscosity product is produced or if a high viscosity product is produced using a single end finisher. Baseline control for a plant producing high viscosity PET using multiple end finishers reflects the use of spent ethylene glycol spray condensers on the initial end finisher only and distillation columns on the esterifiers and cooling tower.

6.2.1.2 Fugitive Emissions. Fugitive emission baseline control, which applies to all model plants except the PET plants, assumes that 75 percent of all gas safety/relief valves and sampling connections, most of the open-ended lines, and 0 percent of all other fugitive emission sources are controlled. These assumptions are consistent with those made in the analysis of fugitive emission baseline chosen for SOCMI.

6.2.2 Control Techniques

Process emissions may be controlled by flares, thermal incinerators, catalytic incinerators, boilers, condensers, absorbers, and adsorbers. Fugitive emissions may be controlled through leak detection and repair programs and equipment, design, and operational requirements. These control techniques and their associated emission reductions, which are discussed in detail in Chapter 4, "Emission Control Techniques," were examined to determine technical feasibility when applied to each model