The Ohio Polymers Industry:
Rubber and Plastic Resins and Products, and Related Machinery

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Industry Definition and Examples of Products

Beginning in 1997, the nation’s industry statistics have been collected under the North American Industry Classification System (NAICS) (Office of Management and Budget, 1998). Establishments producing goods or services sufficiently alike are classified in the same industry, and assigned a six-digit code number. Closely related industries form an industry group. The first four digits of the industry code indicate the group to which the industries belong. (A five-digit code defines a subgroup when it subsumes more than one six-digit code; otherwise, it defines an industry.) In turn, the first three digits indicate the major industry of which the groups are a part. In this report the polymers industry is defined as the combination of one subgroup, one specific industry, and one major industry: resin and synthetic rubber manufacturing (NAICS 32521), custom compounding of purchased resins (325991), and plastic and rubber products manufacturing (326). Definitions and examples of specific industry products follow.

32521 Resin and Synthetic Rubber.
325211 Plastic Materials and Resins. Examples include nonvulcanizable elastomers. Plants may also mix or blend their own resins on a customized or standard basis.
325212 Synthetic Rubber. Examples include vulcanizable elastomers. Rubber adhesives are excluded from the industry.

325991 Custom Compounding of Purchased Resins. Resins made elsewhere are mixed or blended. Reformulated resins from recycled plastic products also are included.

326 Plastic and Rubber Products. Establishments in this sub-sector make goods from plastic resins and raw and synthetic rubber. Plastic and rubber products are included in this sub-sector because both are elastomers manipulated with similar technologies. (Individual products are classified as one or the other based on their proportions when blended. See the next section.) Goods combining plastic and rubber products with other material are classified outside of the Industry because different technologies are used to produce them. Examples of the latter include rubber and plastic footwear, furniture, and cloth or paper laminated with plastics.

3261 Plastic Products. These are intermediate and final goods made from new and/or recycled resins. Common technologies in this group include casting and various types of molding: blowing, compressing, extruding, and injecting.

32611 Unsupported Plastic Films, Sheets, and Bags.
326111 Unsupported Plastic Bags. Resins are processed into bags and/or coat or laminate film and sheet into bags. Manufacturers also may print on the bags.
326112 Unsupported Plastic Packaging Film and Sheet.
Unsupported Plastic Film and Sheet (Except Packaging). This industry produces films and un laminated sheets for purposes other than packaging.

Plastic Pipe, Pipe Fitting, and Unsupported Profile Shapes.

Unsupported Plastic Profile Shapes. Non-rigid profile shapes such as rods, tubes, and sausage casings are examples.

Plastic Pipes and Pipe Fittings. The pipes and fittings are rigid.

Laminated Plastic Plate, Sheet, and Shapes. Laminating generally involves bonding or impregnating the material with resins and compressing them under heat. Laminating packaging material is classified elsewhere in the Industry. Coating or laminating non-plastic materials such as paper or cloth is classified outside of the Industry.

Polystyrene Foam Products. The food containers used by many restaurants for take-out orders are just one example of this industry’s products.

Foam Products (Except Polystyrene). Urethane is the principal resin used in industry products.

Plastic Bottles. Other containers are classified elsewhere in the Industry.

Other Plastic Products.

Plastic Plumbing Fixtures. Examples include bathtubs, hot tubs, portable toilets, shower stalls, and urinals. Fiberglass may be incorporated. Plastic pipes and fittings are classified elsewhere in the Industry. Assembling plastic components into plumbing fixtures such as faucets is classified outside of the Industry.

Resilient Floor Coverings. Products may be either sheets or tiles.

All Other Plastic Products. Examples include air mattresses, inflatable boats, bowls and their lids, clothes hangers, gloves, hardware, siding, trash containers, and non-foam cups and dinnerware.

Rubber Products. Products may be intermediate or final, and come from natural, synthetic, or reclaimed rubber. Common technologies used in this group include vulcanization, cementing, molding, extruding, and lathe cutting.

Tires.

Tires (Except Retreading). New tires and inner tubes of all shapes and sizes are included. Most tires are produced for the motor vehicle industry.

Tire Retreading. The feature distinguishing this industry from tire repair service is the reliance on assembly line operations. Retreads are used by commercial trucks and aviation, school buses, and off-road vehicles included in agricultural, industrial, and mining equipment. These markets are much smaller than the market for passenger cars and non-commercial light trucks.

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Rubber and Plastic Hoses and Belts. Plants making garden hoses from purchased hose are included.

Other Rubber Products.

Rubber Products for Mechanical Use. Products are typically used in transportation equipment, machinery, and other equipment. Tubes are classified elsewhere in the Industry.

All Other Rubber Products. Examples include balloons, bath and doormats, birth control devices, combs, inflatable life rafts, latex foam rubber, reclaimed rubber, rubber bands, and tubes (except extruded, lathe-cut, and molded). Rubberized fabrics, and rubber clothing accessories (e.g., bathing caps), gloves, toys, and gaskets, packing, and sealing devices are classified outside of the Industry.
A Polymer Primer

In the general manufacturing processes for plastics and synthetic rubbers (SRs), the raw materials – natural gas, petroleum, and coal tar – are refined, distilled and/or fractionated to produce gases, light oils, middle fractions, and heavy oils. These materials may be mixed with substances such as ammonia or formaldehyde, or further chemically decomposed to yield intermediates. Intermediates are catalyzed into monomers. More specifically, the olefins in natural gas – ethane, propane and butane – are separated and steam-cracked to yield ethylene, propylene and butadiene. Aromatics, particularly benzene and xylenes, are derived primarily from petroleum, but may also be produced from coal tar or olefin operations using steam cracking. Styrene and phenol are the two most common derivatives from benzene, while xylenes are used in producing esters (compounds formed by eliminating water and bonding an alcohol with an organic acid). These monomers are finally catalyzed into polymers. Polymers are strings of petrochemical monomers. Polyethylene (PE), polypropylene (PP), polystyrene (PS), and polyester are chains of ethylene, propylene, styrene, and ester monomers. Initial outputs take various forms: pellets, flakes, granules, powders, liquid resins, sheeting, and film (O’Reilly, 2010: 23, 29-32; Prat, 1993; Standard & Poor’s, 1994).

The production of plastic resins and SRs is more complex than described above. Examples abound, but a few illustrate the point. About three-fourths of ethylene output is used to make PE, polyvinyl chloride (PVC), and PS, with an additional portion used in SR production. About one-half of propylene output is used to produce PP; propylene also is used to make intermediate chemicals that, in turn, are used to make acrylonitrile-butadiene-styrene (ABS) and polyesters (thermoplastics) as well as phenolics and urea (thermosetting resins). About two-thirds of butadiene production is used to make SRs, which, in turn, are used in tires and other fabricated rubber products; butadiene also is used in manufacturing nylon and ABS resins. In addition to styrenes and phenols, benzene also is used to make epoxy, polyurethanes, nylon and SR’s; and xylenes also are used to make vinyl resins (O’Reilly, 2010: 29-32).

Plastics may be grouped by a variety of characteristics, but the most basic and familiar one is whether they are thermoplastics or thermosets. Thermoplastics can be re-softened by reheating, and therefore can be reused. On the other hand, thermosets are heat resistant to a point, but reheating them to higher temperatures destroys the cross-linked polymers that at their cores. (However, thermosets may be ground up and reused as filler.) Major thermoplastics, ranked in descending order of production volume and with their common uses, include:

- PE – including high and low density varieties:
  - HDPE: detergent bottles and milk jugs;
  - LDPE and LLDPE: dry-cleaning and produce bags, trash can liners, and food storage containers;
PP: drinking straws, bottle caps and food containers; also parts in appliances and motor vehicles;
PVC and copolymers (polymers made by alternating two different monomers in sequence): plumbing pipes and
guttering, flooring, outdoor furniture, shower curtains, window frames, shrink-wrap, water bottles, and containers for
salad dressings and liquid detergents; poly-vinylidene chloride (PVDC) is a related plastic used for food packaging
(Saran wrap);
PS – straight and rubber-modified: in foam form – packaging pellets, cups, meat trays, and clamshell take-away
food containers; in non-foam form – tableware and cutlery;
Thermoplastic polyester, including polyethylene terephthalate (PET or PETE): films, jars, synthetic fibers such as
Dacron, bottles for carbonated drinks, microwavable packaging, and cooking oils; teflon is a closely related
plastic used for low friction and heat resistant applications such as water slides and frying pans; and
Polyamide (nylon): in fiber form – fabrics, toothbrush bristles and fishing lines; in block form – gears, bearings,
bushings, and other mechanical parts.

Other notable thermoplastics include ABS and polycarbonate (PC). ABS is light and rigid, yet is good for shock absorb-
ance. It is used in pipes, golf club heads, motor vehicle body parts, protective head-gear, electronic equipment cases
such as monitors, printers and keyboards, and toys (e.g., Lego bricks). PCs are used in CDs, DVDs, riot shields, security
windows, traffic lights, lenses and eyeglasses. Bayblend mixes ABS and PC, creating a stronger plastic used in cars.
Thermoplastics have accounted for at least 90 percent of the total weight of plastics production for years, and continue to
have the more-promising growth prospects (O’Reilly, 2010: 31; Wikipedia, 2010).

Common thermosets, ranked descending order of production volume, include:
Phenolic (Bakelite): phenolics have been largely replaced by cheaper and less brittle plastics, but they are still used
in applications requiring heat-resistant and insulating properties such as electronic circuit boards;
Urea, as part of blown polyurethane: mattresses, furniture padding, and thermal insulation; as part of non-blown
polyurethane: coatings, printing rollers, and a component of spandex;
Epoxies: used in coatings, adhesives and composite materials such as fiberglass and carbon fiber; and
Melamine: produced from urea, it is used in kitchen utensils and plates; it is the main ingredient in Formica.

Thermosets are relatively mature products, with at least two-thirds of demand tied to construction and consumer durables
(O’Reilly, 2010: 32; Wikipedia, 2010).
Plastics and SRs use some of the same molecules, but they may be classified as one or the other based on the amounts of polymers comprising them. For example, a compounded resin with at least 50 percent butadiene is classified as a SR, but one with less than 50 percent butadiene is classified as a plastic. However, the key distinction between plastics and SRs is that the latter are vulcanized elastomers. Adding sulfur and “cooking” the mixture cross-links the polymers, increasing their resiliency and strength, and giving them elastic and yield properties similar to natural rubber. This converts the rubber hydrocarbon from a thermoplastic into a thermoset. (Natural rubber is mostly latex, or isoprene, with some impurities. Its properties also are improved by further processing, including vulcanization.) Plastics are non-vulcanizable elastomers (Parker, 1984; Standard & Poor’s, 1989; Wikipedia, 2010). The most common SRs are butadiene and styrene-butadiene rubber (BR and SBR), chloroprene, isobutylene-isoprene, and ethylene-propylene (co-and terpolymers). The tire industry uses about 76 percent of SBR production (Yoder, 2000). SRs also are used in inner tubes, laboratory tubes, hoses, plumbing fixtures, gaskets, mechanical belts and seals, gloves, footwear, scuba diving equipment, inflatable boats, mouse pads, orthopedic braces, adhesives, solid rocket propellant, and radar absorbent material (Wikipedia, 2010). Plastics and SRs also are classified by their production characteristics. Commodity resins are produced in high volumes at low cost. PEs, PVCs, PPs, PSs, and SRs such as those including butadiene and propylene are examples. The primary cost determinant is the price of the feedstock. Engineered resins are custom designed for specific requirements. They are produced in low volumes, with engineering services a large part of their higher cost (O’Reilly, 2010: 23).

Finished plastic products typically include a combination of additives. Processing-aids improve the compounding and molding of resins. They include lubricants, which enhance resin flow and mold release, and compensate for imperfections in the machinery and resins, and anti-blocking agents, which prevent layers of film from sticking together. Modifiers increase the materials’ flexibility or (if rubber-based) stress resistance. Extenders are a broad class of materials used to ensure the stability of resins during processing or prolong the useful life of the product. Extenders include antioxidants, anti-static agents, biocides, flame-retardants, and heat and light stabilizers. Colorants may be used. Additives are sold mostly to resin producers and compounders. PVCs use the greatest portion of these additives, but PEs, PSs, and PPs use significant amounts of antioxidants (O’Reilly, 1997b, 1999, 2003).

Recent high prices for oil and natural gas have spurred an interest in developing alternative and renewable – i.e. bio-based – sources for resin and additive production. One product from this research is the development of polylactic acid (PLA), a polymer derived from corn sugars with properties similar to petroleum-based resins. PLA may be processed with standard equipment and output as films or fibers as well as molded into parts. International Paper uses it to coat paper cups. Another line of inquiry is evaluating dandelions as source for natural rubber (Ohio Dept. of Agriculture, 2010; Ohio State University, 2010).
NOTES:

1  Total company employment figures for the polymers industry include the sites employing less than 50 people. The complete list for companies appears in appendix table A1.

2 2007 Census of Manufactures data for Ohio are still unavailable as we go to press. 2002 value-added data for plastic resin and synthetic rubber production and the custom compounding of purchased resins have been suppressed to maintain confidentiality. The calculation of value-added typically starts with the value of shipments (products manufactured plus receipts for services rendered) and subtracts the cost of materials, supplies, containers, fuel, purchased electricity, and contract work. The result is adjusted by adding the value of merchandising operations and the net change in finished goods and work-in-progress between the beginning and end of year inventories. Value-added avoids the duplication in the value of shipments figure resulting from the use of products of some establishments as material by others. Value-added is considered the best available measure for comparing the relative economic importance of manufacturing among industries and geographic areas. The Bureau of Economic Analysis starts with the Census Bureau’s value-added figures when estimating gross domestic product for a major manufacturing industry, but goes on to subtract additional costs – e.g., the value of purchased services – in calculating the industry’s net output. (This is why gross domestic product figures are smaller than value-added.) Value-added data, though, are available where gross domestic product data are not.

3 Employment figures for almost all of the counties with industry establishments should be regarded as more or less rough estimates because the Census Bureau does not disclose precise figures if doing so would violate the confidentiality of respondents. The Bureau merely provides a range encompassing the jobs figure for the establishment(s) in the county under such circumstances. The figures in the text and tables A5-A7 are the result, at least in part, of an estimation technique thought to be fairly accurate on average. Thirteen counties were mentioned in the preceding text; Hamilton is the 14th and last county needed to account for the majority of industry jobs in Ohio.

4 Net growth or contraction in industries showing cyclical changes in output may be a function of the starting and ending times chosen. Therefore, caution is warranted when trying to discern trends.

5 The figures shown in the chart have not been adjusted for inflation. The 16 percent figure was calculated after adjusting them for inflation by using the U.S. Bureau of Labor Statistics (2010) producer price index values for the industry.
Although O'Reilly (2010) was writing about the chemical industry (NAICS 325), the observation may apply by extension because plastic and rubber products (326) are made from resins and synthetic rubber (32512) and custom-compounded resins (325991).

A significant part of capital expenditures by companies in Ohio stays in the state. Ohio is the leading source of plastics- and rubber-working machinery (NAICS 33322). Judging by the value of shipments in 2002, 20.4 percent – or $626.7 million – of new machinery used by the polymers industry came from Ohio. $409.0 million – 65.3 percent – of that industry figure was comprised of shipments of plastics-working machinery and equipment, excluding patterns and molds (3332201). Rubber-working machinery and equipment, excluding tire molds (3332203), was valued at $100.7 million, or 16.1 percent. However, that $100.7 million represented 47.9 percent of all such rubber-working goods made in America, while the $409 million was 17.2 percent of plastics-working goods. In both cases, Ohio was the leading source of such machinery (U.S. Bureau of the Census, 2005d).

The Census statistics cited above convey the concentration of the industry here, but do not indicate the variety of machinery and equipment made in the state for manufacturing synthetic rubber, plastic resins, and the myriad products. There are molds and machines for working plastics and rubber, including new and retread tires. They may come off an assembly line or be custom made. There are dozens of companies in Ohio making such products, most of which are small. The largest employ over 100 people each, and include Kurz-Kasch, Liqui-Box, Master Industries, and Milacron (Harris, 2009).

Numbers from the Bureaus of Labor Statistics and the Census differ due to different methodologies.

In July, 2009, NOVA Chemicals was acquired by International Petroleum Investment, a concern wholly owned by the Emirate of Abu Dhabi (O’Reilly, 2010: 14-15).

The dominance is more pronounced when considering parent companies. From that perspective, there are only 19 names. Five appear twice (Access Industries, Chevron-ConocoPhillips, Dow Chemical, ExxonMobil and Total), one three times (INEOS), and one four time (Formosa Plastics).
11 The regulation of resin producers stems from their frequent work with hazardous materials. The rules contribute to worker safety, public health, and environmental protection. Chemical companies (including others in addition to resins and rubber producers) developed techniques to reduce, treat, handle and dispose of hazardous waste largely in response to tighter restrictions on emissions of harmful compounds. They also have developed a voluntary, self-regulatory program to improve health, safety and environmental performance – in part to avoid more onerous regulations as well as to improve their public images. Indeed, toxic chemical releases have been reduced 83 percent between 1988 and 2007 as overall production from 1988 to 2008 rose 45 percent (O'Reilly, 2010: 21). Major laws affecting the industry include the Clean Air Act, the Clean Water Act, the Resource Conservation and Recovery Act, the Toxic Substance and Control Act, and the Comprehensive Environmental Response Compensation and Liability Act (a.k.a., the Superfund program) (O'Reilly, 2010: 25).

12 Two examples illustrating some of these principles are found in Ohio. Hexion Specialty Chemicals was formed by the merger of Borden Chemical, Resolution Specialty Materials and Resolution Performance Products in 2005, and has made acquisitions since. Dow Chemical’s purchase of Rohm and Hass is another. Specialty chemical production is more resilient in downturns and less energy- and capital-intensive (O'Reilly, 2010: 16-17).

13 The nature of research and development (R & D) varies by product. Specialized products are designed to meet the requirements of specific customers, and basic or exploratory R & D activities are an intrinsic part of their creation. On the other hand, R & D for high-volume commodity products focuses on reducing feedstock, energy and labor cost by improving production processes (O'Reilly, 2010: 23). Other R & D efforts are geared toward improving the performance of existing resins by alloying and blending resins, or incorporating non-plastic materials in plastic resins to create composites. New uses of plastics are mentioned in the popular media; examples can be found at Scientific American’s website – www.sciam.com – by searching on keywords “plastic” and “rubber.”

14 Projecting employment levels for industries is difficult; the most recent data from the U.S. Bureau of Labor Statistics (2010) estimated 38,100 plastic group jobs in Ohio in 2009, part of 505,200 such jobs across the nation. Both are less than what was predicted for 2016. Whether jobs will be regained in an economic recovery and how many they will number in 2016 remains to be seen.
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