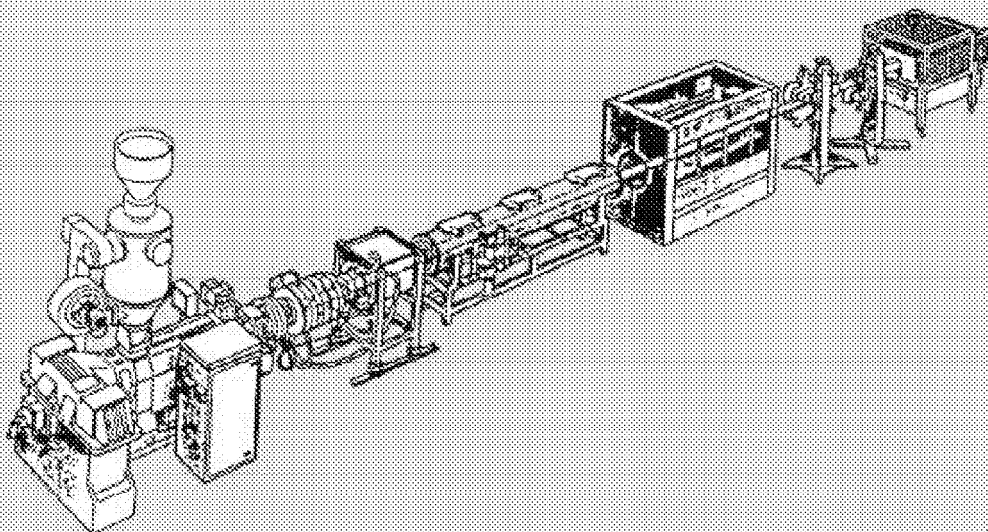




The Plastics Pipe Institute, Inc.

Polyethylene Pipe and Fittings Manufacturing



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Foreword

Polyethylene Pipe and Fittings Manufacturing is one of the chapters in the Plastics Pipe Institute's *PPI Handbook of Polyethylene Piping*. Other topics to be addressed in the Handbook include: engineering Principles, design and installation of polyethylene piping systems. and relevant codes and standards.

PPI is the major U.S. trade association representing all segments of the plastics piping industry.

The PPI Handbook of Polyethylene Piping is produced by the Municipal and Industrial (M&I) division of PPI. M&I membership consists of major North American manufacturers of polyethylene (PE) pipe and fittings, PE piping materials, machinery, and equipment used for joining and installing PE piping, related test laboratories, and professional organizations.

PPI has divisions which address other applications, such as gas distribution. PPI provides technical and promotional support for the effective use and continued application of thermoplastics pipe and related products, consistent with the best public interest. PPI membership also includes producers of polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC), polybutylene (PB), and cross linked PE (PEX) piping products and materials.

For a literature list of other publications available from PPI and/or further information, please contact:

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1-888-314-6774

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Chapter 4

Polyethylene Pipe and Fittings Manufacturing

Scope

This chapter describes the production of extruded solid wall and profile wall polyethylene pipe and the molding and fabrication of fittings. Quality assurance and control tests that are required under typical ASTM specifications will also be discussed.

Introduction

The principles of pipe and fitting production are to melt and convey polyethylene into a particular shape and hold that shape during the cooling process. This is necessary to produce solid wall and profile wall pipe as well as injection molded fittings.

The smaller diameters of solid wall polyethylene pipe are continuously extruded through an annular die. For large diameter profile wall pipes, the profile is spirally wound onto a mandrel and sealed along the seams.

Solid wall polyethylene pipe is currently produced in sizes ranging from 1/2 inch to 63 inches in diameter. Spirally wound profile pipe may be made up to 10 feet in diameter or more. There are several specification standards that govern the manufacturing processes for polyethylene pipe, but the main standards for solid wall and profile pipe include:

ASTM D2239 Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter

ASTM D2447 Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on outside Diameter

ASTM D2513 Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings

ASTM D3035 Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Controlled Outside Diameter

ASTM F714 Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter

*ASTM F894 Standard Specification for Polyethylene (PE) Large
Diameter Profile Wall Sewer and Drain Pipe*

Generally, thermoplastic fittings are injection molded, fabricated using sections of pipe, or machined from molded plates. Injection molding is used to produce fittings up through 12 inches in diameter, and fittings larger than 12 inches are normally fabricated from sections of pipe. The main ASTM specifications for injection molded fittings include:

*ASTM D2683 Standard Specification for Socket-Type Polyethylene
Fittings for outside Diameter-Controlled Polyethylene Pipe and Tubing*
*ASTM D3261 Standard Specification for Butt Heal Fusion Polyethylene
(PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing*
*ASTM F1055 Standard Specification for Electrofusion-Type
Polyethylene Fittings for Outside Diameter-Controlled Pipe and Tubing*

Currently, there is not an ASTM specification for fabricated fittings, but an ASTM task group is working on this matter. The industry recognizes the need for this new specification due to the rapid growth of demand for large diameter pipe.

All of these standards specify the type and frequency of quality control tests that are required. There are several steps during the manufacturing process that are closely monitored to ensure that the product complies with these rigorous standards. Some of these steps are discussed in the section of this chapter on quality control and assurance.

Pipe Extrusion

The principal aspects of a solid wall polyethylene pipe manufacturing facility are presented in figures 1 and 2. This section will describe the production of solid wall pipe from raw material handling, extrusion, sizing, cooling, printing, and cutting, through finished product handling. Details concerning profile wall pipe are also discussed in the appropriate sections.

Raw Materials Description

The quality of the starting raw material is closely monitored at the resin manufacturing site. As discussed in Chapter 2, *Standards and Codes*, a battery of tests is used to ensure that the resin is of prime quality. A certification sheet is sent to the pipe and fitting manufacturer documenting important physical properties such as melt index, density, ESCR (environmental strength crack resistance), stabilizer tests, and tensile strength. The resin supplier and pipe manufacturer agree upon the specific tests to be conducted.

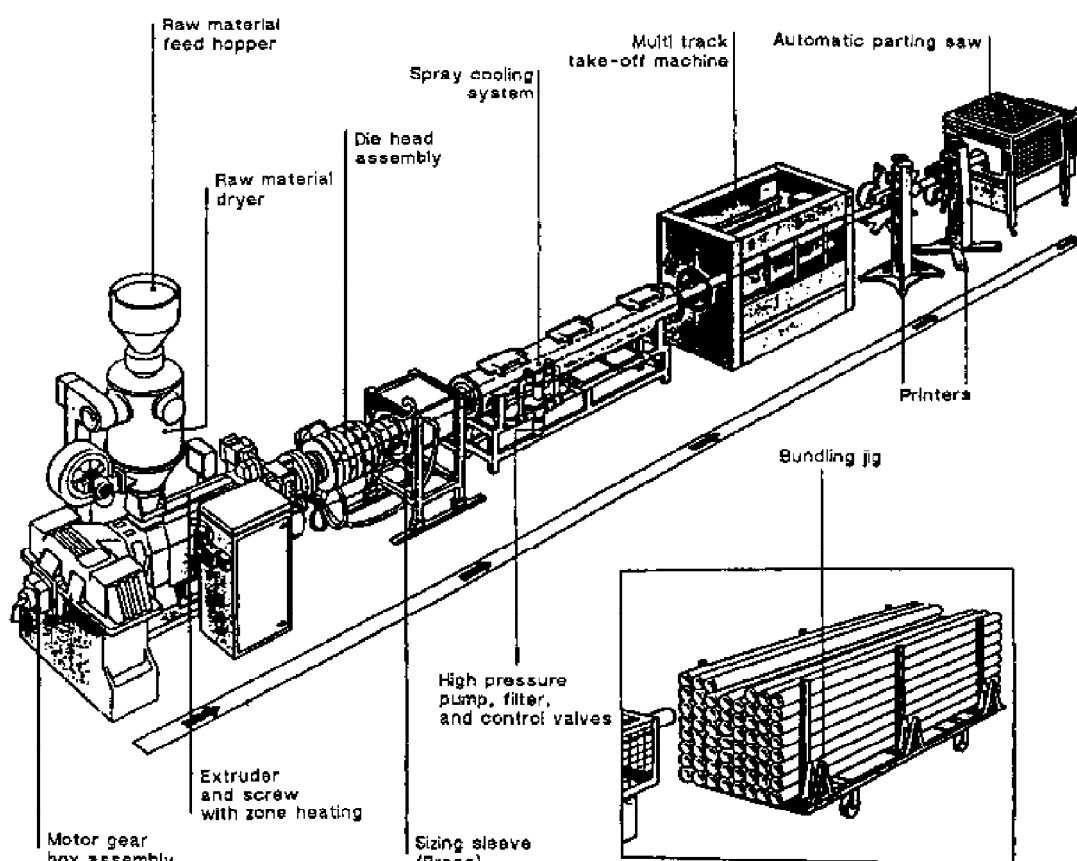


Figure 1. Aerial View of Typical Conventional Extrusion Line
(Courtesy of Phillips Driscopipe, Inc.)

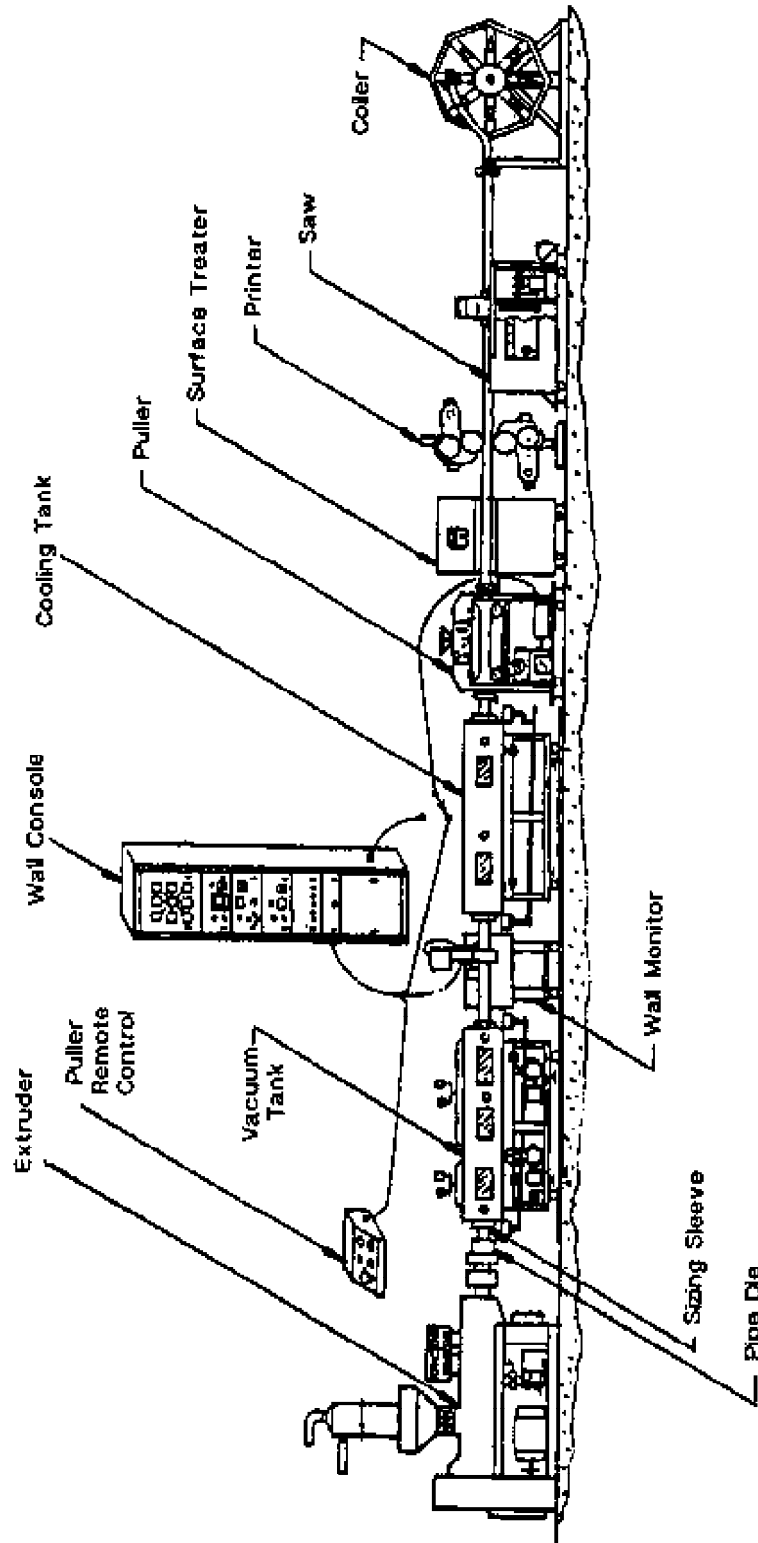


Figure 2. Profile View of Typical Conventional
Extrusion Line
(Courtesy of Phillips Driscopipe, Inc.)

The raw materials used to manufacture polyethylene pipe are generally supplied as pellets. The resin is stabilized as required in ASTM D3350 against thermal oxidation. The resin is supplied in either the natural state (milky white) or in a precolored form. In the United States, the most common colors are black, tan, yellow, and orange. The choice of color will depend upon the intended application and the requirements of the pipe purchaser. Carbon black is the most common pigment used for water, industrial, sewer, and above-ground uses. All of the above mentioned colors are used for gas distribution and oil gathering.

All ASTM and many other industry standards specify that a PPI-listed compound shall be used to produce pipe and fittings. A compound is defined as the blend of natural resin and color concentrate and the ingredients that make up each of those two materials. The pipe producer must not change any of the ingredients in the listed compound, such as substituting a different color concentrate, that could affect the long term strength performance of the pipe. These stringent requirements ensure that only previously tested and approved compounds are being used.

If the resin is supplied as a natural pellet, the pipe producer will blend a color concentrate with the resin prior to extrusion. In order to obtain a PPI Listing, each manufacturer producing pipe in this manner is required to submit data, according to ASTM 2837, to the PPI Hydrostatic Stress Board. A careful review of the data is made according to PPI Policy TR-3^[5] to assess the long term strength characteristics of the in-plant blended compound. When those requirements are met, the compound is listed in the PPI Publication TR-4^[6], which lists compounds that have satisfied the requirements of TR-3. Producers of potable water pipe are usually required to have the approval of the NSF (National Sanitation Foundation, Ann Arbor, Michigan) or an equivalent laboratory. NSF conducts un-announced visits during which time they verify that the correct compounds are being used to produce pipe that bears their seal.

Raw Materials Handling

After the material passes the resin manufacturer's quality control tests, it is shipped to the pipe manufacturer's facility in 180,000- to 200,000-pound capacity railcars, 40,000-pound bulk trucks, or 1000- to 1400-pound boxes.

Each pipe producing plant establishes quality control procedures for testing incoming resin against specification requirements. The parameters that are typically tested include: melt index, density, tensile strength, and environmental stress crack resistance (ESCR). Many resin producers utilize statistical process control (SPC) on certain key physical properties to ensure consistency of the product.

Resin is pneumatically conveyed from the bulk transporters to silos at the plant site. The resin is then transferred from the silos to the pipe extruder by a vacuum transfer system. Precolored materials can be moved directly into the hopper above the extruder. If a natural material is used, it must first be mixed homogeneously with a color concentrate. The resin may be mixed with the color concentrate in a central blender

remote from the extruder or with an individual blender mounted above the extruder hopper. The blender's efficiency is monitored on a regular basis to ensure that the correct amount of color concentrate is added to the raw material.

Color concentrate is important for protecting the pipe from the effects of ultraviolet radiation that can cause degradation. Black concentrate alone is very effective in absorbing ultra-violet radiation whereas non-black concentrates use an ultra-violet stabilizer to provide protection. Refer to Chapter 3, *Engineering Properties of Polyethylene*, for further details.

Drying

Polyethylene is not hygroscopic, but, for the ease of processing and to ensure finished product quality, the resin and black concentrate should be dried prior to extrusion. The drying step ensures that the pipe quality will not be affected due to voids caused by water vapor trapped within the pipe wall. The resin manufacturer is the best source of specific recommendations for drying times and temperatures.

Extrusion Principles

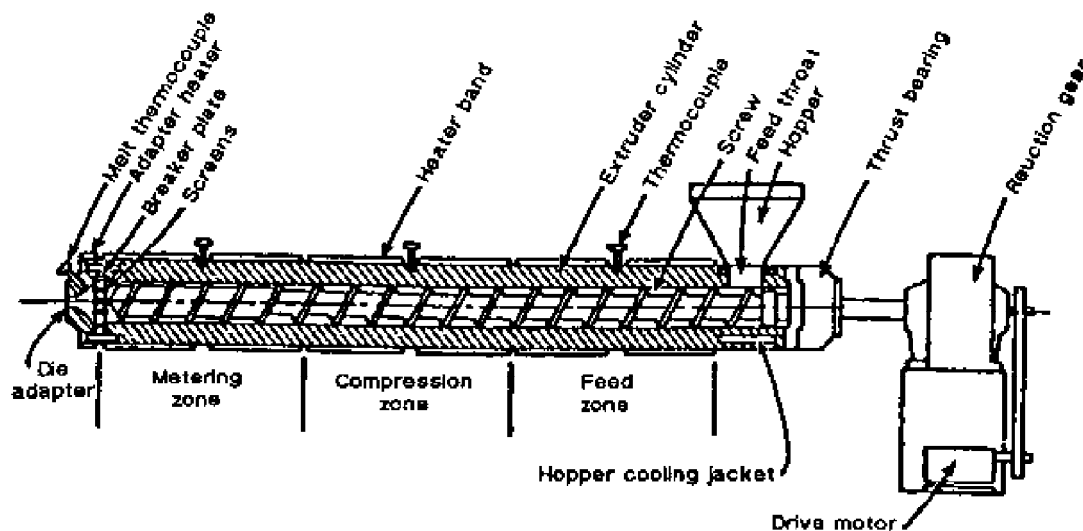


Figure 3. Typical Single-Stage, Single-Screw Extruder
(Resin Flow from Right to Left)

The function of the extruder is to heat, melt, mix, and convey the material to the die, where it is shaped into a pipe^[8]. The extruder screw design is critical to the performance of the extruder and the quality of the pipe. The mixing sections of the screw are important for producing good carbon black incorporation when extruding natural and concentrate blends and to produce a homogeneous melt. A typical extruder is shown in figure 3.