

*McGraw-Hill* **HANDBOOKS**

# PLASTIC PIPING HANDBOOK



DAVID A. WILLOUGHBY  
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**McGRAW-HILL**

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# PREFACE

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This is a reference handbook for the engineer, designer, technician, contractor, and utility manager involved in the design, installation, and operation of plastic piping systems. The goal of this handbook is to provide easy-to-access and essential information about the use of plastic pipe, especially in the gas and water industries. There are many manufacturers manuals and documents from organizations such as the Plastic Pipe Institute that provide valuable information concerning the use of plastic pipe. This handbook provides a single text that contains much of the frequently required data and procedures used in the design and installation of plastic pipe systems. This handbook presents the practical aspects of the use of plastic piping systems. It provides the reader with many frequently used equations, charts, and guidelines.

This book is primarily a reference book. It contains many tables that will guide the reader to understand many of the issues about plastic piping systems and sources of additional information. The book also provides example specifications for a natural gas plastic pipe system and horizontal directional drilling with plastic pipe. This book is a ready reference for the field and office.

Thanks to George Fischer Inc. for the use of figures from the *George Fischer Engineering Handbook*.

I hope that readers will find this handbook useful. I invite all readers to suggest any additional data that they would like to see covered in revised versions and anything that they feel will improve this handbook.

*David Willoughby, P.O.E.*

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# ABOUT THE AUTHOR

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## **David A. Willoughby, P.O.E.**

Mr. Willoughby has 21 years of experience in engineering, technical writing, and management in the natural gas, pipeline, and petroleum facility industry. His experience includes gas transmission and distribution systems, petroleum facilities from conception through design, construction and testing, economic evaluation, and project field supervision. Mr. Willoughby is registered by the Council of Engineering Specialty Boards as a Petroleum Operations Engineer.

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# CONTENTS

---

Preface xiii  
About the Author xiv

---

## Chapter 1 General Information 1.1

Introduction / 1.1  
History of Plastic Pipe Materials / 1.2  
Common Applications / 1.2  
Definitions and Abbreviations / 1.3  
Acronyms and Abbreviations / 1.5  
Plastic Piping Codes and Standards / 1.6  
    Codes / 1.6  
    Standards / 1.6

---

## Chapter 2 Plastic Piping Characteristics 2.1

Advantages and Limitations of Plastic Piping / 2.1  
    Advantages / 2.1  
    Limitations / 2.2  
Thermoplastic Piping Materials / 2.3  
    Principal Materials / 2.3  
    Available Products / 2.4  
Plastic Piping Components / 2.15

---

## Chapter 3 Fluid Flow 3.1

General / 3.1  
Liquid Flow / 3.1  
    The Energy Principle / 3.2  
    The Energy Equation / 3.4  
    Hydraulic and Energy Grades / 3.4  
    Pipe Sizing / 3.4  
    Energy Losses in Pipes / 3.5  
    Pressure Flow of Liquids / 3.6  
    Water Hammer/Pressure Surge / 3.10

- Compressible Gas Flow / 3.12
- Gas Laws / 3.13
- Gas Pipeline Hydraulics / 3.17

## **Chapter 4 General Design Procedures**

**4.1**

- Introduction / 4.1
- Design Methodology / 4.1
  - The Design Analyses / 4.1
- Drawings / 4.3
  - Process Flow Diagram (PFD) / 4.3
  - Piping and Instrumentation Diagram (P&ID) / 4.3
- Design Bases / 4.4
- Service Conditions / 4.4
- Loading Conditions / 4.7
  - Sustained Loads / 4.7
  - Occasional Loads / 4.8
- Piping Layout / 4.10
- Computer Aided Drafting and Design / 4.10
  - Piping Layout Design / 4.10
- Preliminary Design Data / 4.11
- Pipeline Life Requirements / 4.11
- Flow Requirements / 4.12
  - Compatibility / 4.12
- Installation Considerations / 4.13
- Design Considerations For Plastic Piping Systems / 4.14
  - Corrosion / 4.15
  - Operating Pressures and Temperatures / 4.16
  - Sizing / 4.16
  - Joining / 4.17
  - Thermal Expansion / 4.17
- Piping Support and Burial / 4.19
- General Design Considerations / 4.23
- System Flow Requirements / 4.24
  - Pressurized Full Flow / 4.24
- Pressure Loss in Fittings / 4.25
- Gravity Flow / 4.26
- Sliplining Flow Capacity / 4.28
  - Slurry Critical Flow / 4.28
- Gas Flow / 4.30
- Life Expectancy / 4.30
- System Pressure / 4.30
- Positive Pressure Pipelines / 4.31
  - Cyclic Overpressure / 4.33
  - Longitudinal Stress from Internal Pressure / 4.33
  - Thermal Expansion and Contraction / 4.34
  - Supported Pipelines / 4.34
  - Overland Pipes / 4.34

Buried Pipelines / 4.35	
Transition Connections / 4.35	
Design of Collar / 4.37	
Design Considerations for Various Thermoplastic Pipe Materials / 4.37	
Polyvinyl Chloride (PVC) / 4.37	
Acrylonitrile-Butadiene-Styrene (ABS) / 4.38	
Chlorinated Polyvinyl Chloride (CPVC) / 4.39	
Polyethylene (PE) / 4.39	

---

## **Chapter 5 Above Ground Pipe Design 5.1**

Receiving Materials / 5.3	
General Above-Ground Recommendations / 5.6	
Support Spacing / 5.6	
Hangers / 5.7	
Polyethylene Pipe / 5.11	
Expansion / 5.12	
Ultraviolet Effects / 5.15	
Durability / 5.15	
External Damage / 5.15	
Installing PE Pipe On Grade / 5.15	
Anchored Pipe Runs / 5.16	
Installing PE Pipe Above Grade / 5.17	
Following Instructions / 5.17	

---

## **Chapter 6 Buried Pipe Design 6.1**

Preliminary Work / 6.2	
Digging / 6.2	
The Bed / 6.3	
Placing Pipe / 6.4	
Thermal Contraction / 6.4	
Avoiding Bending and Stress / 6.5	
Thrust Blocks / 6.5	
Vertical Pipe Sections / 6.7	
Plowing / 6.7	
Backfilling / 6.7	
General Design Procedure / 6.8	
Dead Load / 6.8	
Prism Load / 6.8	
Arching / 6.9	
Marston Load / 6.9	
Soil Creep / 6.10	
Surcharge Loads / 6.10	
Wall Compressive Strength / 6.10	
Shallow Cover / 6.13	
Groundwater / 6.13	



Manholes / 6.14
Designing for a Water Environment / 6.14
Unconstrained Buckling / 6.14
Different Types of Pipe / 6.18

---

<b>Chapter 7 Pipe Handling and Construction</b>	<b>7.1</b>
---	------------

PVC Pipe / 7.1
Solvent-Welded Joints / 7.6
Gasket Joints / 7.9
Trench Installation / 7.9
Polyethylene Pipe / 7.10
Pipe-Joining Procedures / 7.11
Electrofusion / 7.13
CPVC Plastic Pipe / 7.13
Other Types / 7.15

---

<b>Chapter 8 Horizontal Directional Drilling</b>	<b>8.1</b>
--	------------

Advantages of HDD / 8.1
Applications / 8.2
HDD Process / 8.2
Bore Installation / 8.3
Drilling and Steering / 8.4
Tracking / 8.5
Drilling Fluids / 8.6
HDD Considerations / 8.7
Feasibility / 8.7
Subsurface Soil Material / 8.8
Design Factors / 8.8
General Guidelines / 8.9
HDD Site Characterization / 8.10
Site Survey / 8.10
Geotechnical Factors / 8.10
Soil Type Classification / 8.13
Surface Working Space / 8.15
Drilled Path Design / 8.16
Construction Monitoring / 8.16
Drilled Path / 8.18
Pilot Hole / 8.18
HDD Performance / 8.20
Downhole Survey Calculations / 8.20
Average Angle Method / 8.22
Balanced Tangential Method / 8.22
Minimum Curvature Method / 8.23
Radius of Curvature Calculations / 8.23
Pipe Installation / 8.24

HDD Stresses and Forces /	8.24
HDD Design Considerations for Plastic Pipe /	8.26
Pull Back Force /	8.26
Frictional Drag Resistance /	8.27
Capstan Force /	8.27
Guidelines and Specifications for Installation by HDD Technology /	8.29
Contract Considerations /	8.29
Contractor Proposal/Bid /	8.30
Construction Plan /	8.30
Drilling Fluids Management Plan /	8.31
Previous Experience /	8.31
Safety /	8.31
Contingency Plans /	8.32
Communication Plan /	8.32
Traffic Control /	8.32
List of Subcontractors /	8.32
Other Considerations /	8.33
Site Evaluation /	8.33
Pre-Construction /	8.33
Drilling Operations /	8.34
Equipment Setup and Site Layout /	8.35
Drilling and Back-Reaming /	8.35
Segment Jointing (Butt-Fusion/Welding) /	8.36
Tie-Ins and Connections /	8.36
Alignment and Minimum Separation /	8.37
Break-Away Pulling Head /	8.37
Drilling Fluid—Collection and Disposal Practices /	8.38
Site Restoration and Post Construction Evaluation /	8.38
Glossary /	8.39

---

<b>Chapter 9 Chemical Resistance of Plastics and Elastomers</b>	<b>9.1</b>
---	------------

---

<b>Chapter 10 Sliplining Sewers</b>	<b>10.1</b>
-------------------------------------	-------------

Preparation /	10.2
Blockages /	10.2
Installation /	10.3
Grouting /	10.4
Connections /	10.4
Backfilling /	10.4
Cost Effectiveness /	10.5

---

<b>Chapter 11 Testing</b>	<b>11.1</b>
---------------------------	-------------

Low-Pressure Test /	11.3
High-Pressure Test /	11.4

- Underground Piping / 11.4
- Test Caps / 11.5
- Above Ground Tests / 11.5

## **Chapter 12 Protecting Public Safety Through Excavation Damage Prevention**

12.1

- Introduction / 12.1
- Overview of Subsurface Infrastructure and Regulatory and  
Legislative Initiatives / 12.4
- Subsurface Infrastructure / 12.4
- Regulatory and Legislative Initiatives / 12.5
- Damage Prevention Practices / 12.8
- Mandatory Participation / 12.8
- One-Call Notification System / 12.14
  - Function and Structure of the Centers / 12.14
  - Methods of Operation / 12.16
  - Excavation Notification Tickets / 12.17
- Effective Sanctions / 12.17
  - Excavation Marking / 12.20
- Employee Qualifications and Training / 12.21
  - Discussion / 12.26
- Accuracy of Information Regarding Buried Facilities / 12.27
  - Underground Detection Technologies / 12.27
- Vertical/Depth Location / 12.28
- Directional Boring/Trenchless Technology / 12.30
- Mapping / 12.32
- Subsurface Utility Engineering / 12.34
- System Performance Measures / 12.36
- Risk Exposure / 12.37
- Accident Reporting Requirements of RSPA / 12.38
- Accident Causes / 12.40
- Conclusions / 12.44
- Recommendations / 12.46

## **Chapter 13 Brittle-Like Cracking in Plastic Pipe for Gas Service 13.1**

- Introduction / 13.1
- Investigation / 13.4
  - Accident History / 13.4
  - Strength Ratings, Ductility, and Material Standards for  
Plastic Piping / 13.7
  - Century Pipe Evaluation and History / 13.13
  - Installation Standards and Practices / 13.18
  - Gas System Performance Monitoring / 13.23
- Conclusions / 13.25
- Recommendations / 13.26

<b>Appendix A Specifications for Materials and Construction for a Natural Gas System</b>	<b>A.1</b>
<b>Appendix B Transportation of Natural or Other Gas by Pipeline: Minimum Federal Safety Standards</b>	<b>B.1</b>
<b>Appendix C Plastic Piping Systems Components</b>	<b>C.1</b>
<b>Appendix D Plastic Pipe Fittings</b>	<b>D.1</b>
<b>Appendix E Glossary</b>	<b>E.1</b>
<b>Index</b>	<b>I.1</b>

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# CHAPTER 1

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## GENERAL INFORMATION

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### **INTRODUCTION**

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The purpose of this handbook is to provide accurate and reliable information concerning the application, design, and installation of plastic pipe for water and gas systems.

Thermoplastic piping is the material that has the widest range of applications. Thermoplastic piping includes many materials that have significant differences in characteristics and uses. It is important that the correct thermoplastic material be specified for the various applications. Because of the frequent use of polyethylene (PE) and polyvinyl chloride (PVC) pipe material in the water and gas markets, this handbook will focus primarily on these types of plastic pipe. Other types of plastic pipe and their applications will be introduced to provide the reader with a background in the various possible uses of the material. The design and installation information, however, will deal primarily with PE and PVC pipe.

Each project is different and can have unique conditions. A design or installation necessity for one project might be excessive for another project. The ways the engineer and designer interpret and approach the various conditions are important to achieve an effective and efficient project. The proper design and installation of plastic piping systems require the use of sound engineering judgment and principles. It is the goal of this handbook to provide the information needed by designers, engineers, and installation personnel working in the water and gas fields.

Plastic piping has many applications in today's marketplace and its popularity continues to grow. It is used in a variety of commodities such as acid solutions, chemicals, corrosive gases, corrosive waste, crude oil, drainage, fuel gases, mud, sewage, sludge, slurries, and water. One major reason for the growth in the use of plastic pipe is the cost savings in installation, labor, and equipment as compared

to traditional piping materials. Add to this the potential for lower maintenance costs and increased service life and plastic pipe is a very competitive product. The popularity of plastic pipe in the water and natural gas industry has played a significant role in the growth of the industry. The shipment of PE products alone increased by 26 percent from 1996 to 1997 [1].

## ***HISTORY OF PLASTIC PIPE MATERIALS***

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Plastics have been in use for more than 100 years, and polyethylene, the primary plastic pipe used in the natural gas industry, was invented in the 1930s. Early polyethylenes were low density and were used primarily for cable coatings. World War II provided a catalyst for the development and use of plastic products, largely because of the shortage of other materials. Today's modern polyethylene piping systems began with the discovery of high-density polyethylene in the early 1950s [2].

## ***COMMON APPLICATIONS***

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Thermoplastics make up the majority of plastic pipe in use today. PVC accounts for the majority of the thermoplastic pipe in use, with PE coming in second. Although thousands of miles of plastic pipe are in service in natural gas and municipal applications, many other uses also exist. Some of the other common uses of plastic piping are:

- Chemical processing
- Food processing
- Power plants
- Sewage treatment
- Water treatment
- Plumbing
- Home fire and lawn sprinkler systems
- Irrigation piping

Detailed information about various piping products and their applications can be obtained from the Plastic Pipe Institute and plastic pipe manufacturers.

In the last 25 to 30 years, plastic piping products have become the predominant piping materials in many markets. As a result of the high demand, the availability and types of plastic piping products in many materials and sizes have increased significantly. This increase provides the piping engineer with many products to choose from when specifying plastic piping products. To select the best product for the desired application, the engineer and designer must have a good knowledge of the plastic piping products available.

## DEFINITIONS AND ABBREVIATIONS

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**adhesive joint:** A joint in plastic pipe made by an adhesive substance that forms a continuous bond between the materials without dissolving either of them.

**ambient temperature:** The prevailing temperature in the surrounding medium usually refers to the temperature of the air surrounding an object.

**anchor:** A rigid device used to secure the pipe, permitting neither translatory nor rotational displacement of the pipe.

**angle of bend:** The angle between the radial lines from the beginning and end of the bend to the center.

**backfill:** The material that is placed around and over the pipe after trench excavation.

*primary initial backfill:* This part of the backfill supports the pipe against lateral pipe deformation.

*secondary initial backfill:* This part of the backfill distributes overhead loads and isolates the pipe from any adverse conditions encountered during the placement of the final backfill.

*final backfill:* The final material inserted in the trench to complete the fill from the initial backfill to the top of the trench.

**ball valve:** A valve with a ball-shaped disk that has a hole through the center, providing straight-through flow.

**blind flange:** A flange used to close the end of a pipe.

**block valve:** A valve used for isolating equipment.

**burst pressure:** The pressure that can be applied slowly to plastic pipe or component at room temperature for 30 seconds without causing rupture.

**burst strength:** The internal pressure required to break a pipe or fitting. This pressure will vary with the rate of buildup and the time the pressure is maintained.

**butt fusion:** A method of joining thermoplastic pipes and components that involves heating the ends of two pieces that are to be joined and quickly pressing them together.

**butt joint:** A joint between two pipe components in the same plane.

**butterfly valve:** A valve that gets its name from the wing-like action of the disk.

**bypass valve:** A valve and loop used to direct the flow in a pipeline around some part of the system.

**check valve:** A device that allows flow in one direction only in a pipeline.

**coefficient of expansion:** The increase in unit length, area, or volume for a unit rise in temperature.

**compression fitting:** A fitting used to join a pipe by pressure or friction.

**compression joint:** Multi-piece joints with cup-shaped threaded nuts that compress sleeves when tightened so they form a tight joint.

**compression strength:** The failure crushing load of a pipe or component divided by the number of square inches of resisting area.

**control piping:** All piping, fittings, and valves used to connect control devices to the piping system components.

**creep:** Time-dependent strain caused by stress. Creep is a dimensional change with respect to time caused by a load over the elastic deformation.

**density:** The mass of a substance per unit volume.

**depth of fusion:** The distance that a fusion extends into the base material.

**deterioration:** The permanent adverse change in the physical properties of a plastic.

**dimension ratio:** The diameter of a pipe divided by the wall thickness.

**elasticity:** The material property that tends to retain or restore the materials original shape after deformation.

**elastomer:** A material that, under ambient conditions, can be stretched and returns to approximately the original size and shape after the applied stress is released.

**elevated temperature testing:** Test on plastic pipe above 73°F.

**environmental stress cracking:** Cracks that develop when the material is subjected to stress in the company of certain chemicals.

**expansion joint:** A piping component used to absorb thermal movement.

**expansion loop:** A bend in a pipe run that adds flexibility to the piping system.

**flexural strength:** The pressure (psi) required to break a piping sample when the pressure is applied at the center and the pipe is supported at both ends.

**full port valve:** A valve that, when in the fully open position, is equal to an equivalent length of pipe.

**gate valve:** A valve that opens to the complete cross section of the line. Under most conditions, a gate valve is not used for throttling or control of the flow. It usually is used for complete open or complete shutoff of the fluid flow.

**globe valve:** A valve used for throttling or control.

**haunching:** The area from the trench bed to the spring line of the pipe. Provides most of the load bearing for buried piping.

**heat joining:** The making of a pipe joint in thermoplastic piping by heating the ends of both sections so they fuse when the parts are pressed together.

**incomplete fusion:** A fusion that is not complete and does not result in complete melting throughout the thickness of the joint.

**joint:** A connection between two sections of pipe or between a section of pipe and a fitting.

**long-term burst:** The internal pressure at which a pipe or fitting will fail due to constant internal pressure held for 100,000 hr.

**nominal Pipe Size (NPS):** A dimensionless designator of pipe size. It indicates standard pipe size when followed by the specific size designation number without an inch symbol (e.g., NPS 2, NPS 10) [3].

**non-rigid plastic:** A plastic whose modulus of elasticity is not greater than 10,000 psi in accordance with the American Society of Testing and Materials (ASTM) Standard Method of Test for Stiffness in Flexure of Plastics.

**pipe alignment guide:** A piping restraint that allows the pipe to move freely in the axial direction only [4].

**pipe stiffness:** A measure of how flexible pipe will be under buried conditions.

**pipe supports:** Components that transfer the load from the pipe to the support structure or equipment.



**plastic:** A material that contains an organic substance of high to ultra-high molecular weight, is solid in its finished state, and at some stage of its processing can be shaped by flow.

**plastic, semi-rigid:** A plastic whose modulus of elasticity is in the range of 10,000-100,000 psi in accordance with the Standard Method of Test for Stiffness in Flexure of Plastics.

**plug valve:** A valve that consists of a rotating plug in a cylindrical housing with an opening running through the plug.

**pressure rating:** The maximum pressure that can be inserted in the pipe without causing failure.

**reinforced plastic:** According to American Society for Testing and Materials, plastics having superior properties as compared to plastics consisting of base resin because of the presence of high-strength filler material embedded in the composition.

**relief valve:** A safety valve for the automatic release of pressure at a set pressure.

**standard dimension ratio (SDR):** A series of numbers in which the dimension ratio is constant for all sizes of pipe.

**stiffness factor:** A property of plastic pipe that indicates the flexibility of the pipe under external loads.

**sustained pressure test:** A constant internal pressure test for 1,000 hours.

**thermoplastic:** A plastic that can be softened repeatedly by heating and hardened by cooling. During the soft state, it can be shaped by molding or extrusion.

**thermosetting:** A plastic that is capable of being changed into an infusible or insoluble product when cured by heat or chemical means.

**yield stress:** The force required to initiate flow in a plastic.

**Young's modulus of elasticity:** The ratio of stress in a material under deformation.

## **ACRONYMS AND ABBREVIATIONS**

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ASME	American Society of Mechanical Engineers
ANSI	American National Standards Institute
API	American Petroleum Institute
ASCE	American Society of Civil Engineers
ASPOE	American Society of Petroleum Operations Engineers
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
BBL	Barrel = 42 U.S. gallons
BTU	British thermal unit
CAD	Computer-aided design
FRP	Fiberglass-reinforced plastics
GPM	Gallon per minute
HDPE	High-density polyethylene
LDPE	Low-density polyethylene
MDPE	Medium-density polyethylene