Chapter Two: Introduction and Methodology

Overview

This study analyzes the world market for positive displacement flowmeters. The study was conducted by Flow Research. This study includes a technology and product analysis, market share and market size data, and also provides in-depth segmentation of the market by various product and geographic categories. It also includes detailed market growth projections through 2006 for positive displacement flowmeters. Detailed market strategies are provided for suppliers.

The methodology for this study consists of a "bottom-up" approach. Flow Research obtained detailed information about the sales volume of positive displacement and turbine flowmeter suppliers. This information was then compiled into a picture of the total market. Most of the information for this study was obtained through interviews with the suppliers.

In addition to the supplier research, Flow Research and Ducker Research conducted a worldwide survey of flowmeter users. For this research, 300 users were interviewed worldwide, with the following distribution:

- 100 from North America (United States and Canada)
- 100 from Europe (Germany, France, the United Kingdom)
- 100 from Asia (China, Japan, Singapore)

The results of this research have been published as a separate study, called Worldwide Survey of Flowmeter Users. Goals of the survey were to get an understanding of installed base, to find out user purchasing plans, and to determine what problems users are having with their positive displacement flowmeters. Other goals included detecting regional differences in worldwide flowmeters, and providing confirming evidence for the supplier data. These goals were achieved.

While the end-user survey was published as a separate study, the results were available during the forecasting for this study. Of particular interest were the information on flowmeter installed base, user purchasing plans, and comments about communication protocols. This information was taken into account in forecasting growth rates for different types of positive displacement flowmeters.

Worldwide Flowmeter Studies

This study is part of a 9-volume set of studies that defines and analyzes the worldwide flowmeter market. Sometimes when markets are studied in isolation, it is difficult to achieve accurate results. By studying the entire flowmeter market at once, Flow-Ducker Research believes that a complete picture of the market can be obtained that is not skewed in favor of one technology or another. The complete 9-volume set is as follows:

Volume I: The Market for Coriolis Flowmeters Worldwide

Volume II: The Market for Magnetic Flowmeters Worldwide

Volume III: The Market for Ultrasonic Flowmeters Worldwide

Volume IV: The Market for Positive displacement Flowmeters Worldwide

Volume V: The World Market for New Technology Flowmeters (includes DP flow)

Volume VI: Worldwide Survey of Flowmeter Users (results of 300 phone interviews)

Volume VII: The World Market for Positive Displacement Flowmeters

Volume VIII: The World Market for Turbine Flowmeters

Volume IX: The Worldwide Flowmeter Market (covers all technologies, including open channel, thermal, and variable area.

Figure 2-1 lists the different types of new technology and traditional technology flowmeters. Figure 2-2 lists the different submarkets that positive displacement flowmeter suppliers sell into.

The purpose of this series of studies is to give a complete definition and analysis of the worldwide flowmeter market, including all technologies. Some companies approach this subject by doing one study at a time, over a period of months or years. This approach

makes it difficult to obtain meaningful comparisons of market size and market shares across technologies. In some cases, inconsistent definitions and terminology is used. Differences in the scope of geographic regions, definitions of "smart", data gathering methodologies, and ways of dividing up the flowmeter market can create major problems in comparing data. In addition, writing one study at a time inevitably means that studies being compared cover different time periods.

Flow Research, Inc. address these issues by creating a systematic complete intellectual framework in terms of which to view the worldwide flowmeter market. These studies use a consistent set of definitions of flowmeter types, "smart" flowmeters, and geographic regions throughout. We do not claim to have discovered the best possible set of definitions of terms or of geographic regions. What we do claim is to have used a consistent set of definitions of terms and geographic regions throughout these studies. In addition, we have, as much as possible, clearly stated our definitions, so that anyone using a different set of definitions can make the appropriate adjustments. This chapter contains a complete definition of the geographic regions used in these studies, complete with maps to make the regions more easily visualized and understood.

Besides developing a consistent framework in terms of which to view the worldwide flowmeter market, Flow Research has utilized the philosophy of viewpoint pluralism to provide a more complete understanding of the flowmeter market. The philosophy of viewpoint pluralism can be stated very simply: **Our knowledge of any subject or object is proportional to the quantity and quality of the points of view we have of the subject or object**. When the subject is the worldwide flowmeter market, this means looking at the worldwide flowmeter market from a variety of perspectives, or points of view.

The Role of Viewpoint Pluralism in Worldflow™

While some companies write studies that consist primarily of analyzing the perspective of flowmeter suppliers, Flow and Ducker Research has also undertaken to determine the perspective of flowmeter users. Volume VI presents the results of an extensive series of

telephone interviews with 300 flowmeter users worldwide. These interviews were conducted by telephone with users in their native languages. The supplier perspective is a valuable one, and is in fact the most reliable means of determining market size. However, the user perspective is also important because it is the users who actually specify and purchase flowmeters. Anyone who does not take the user perspective into account in writing an analysis of the flowmeter market is simply taking a one-dimensional view.

Flow Research also makes use of other perspectives in analyzing the flowmeter market. These studies contain a very extensive product analysis that provides a very complete overview of all the products available worldwide in a particular technology. By providing a summary, photos, and a product specification sheet for each supplier, Flow Research makes it possible to quickly compare products from different suppliers and to understand what products each company is offering.

Market shares are another important perspective in these studies. Flow Research has spent more than a year researching the worldwide flowmeter markets, and has made every effort to accurately determine sales volume for each supplier. Market share charts provide a very effective means of analyzing which are the leading suppliers for various technologies and segments. Market shares are provided by geographic region so that a region-by-region analysis is possible.

Detailed market strategies are also provided for each type of flowmeter. While there is a common thread to some of these strategies, strategies are stated so as to apply to the particular flowmeter in question. Strategies for suppliers of positive displacement flowmeters for gas flow measurement will differ from strategies for magnetic flowmeters. Strategies are designed with the objective of helping suppliers increase their sales and strengthen their product lines.

Detailed company profiles are provided so that different aspects of each company can be understood. A history of each company is provided, when it is available. The entire

instrumentation lines of companies are provided, so that flowmeters can be seen in the context of other instrumentation products. In many cases, company strategies are discussed.

Viewpoint Pluralism is discussed in more detail in the book **Shades of Experience**. Chapter two of this book discusses the philosophy of viewpoint pluralism. Other portions of this book discuss analogies between electronic transmitters and the brain or mind. Sections of this book talk about the need to revise our language in certain fundamental ways so that it is more descriptive. These ideas may have application to the subject of assigning names to products, and to writing promotional brochures. The entire book can be downloaded at www.ideanetwork.net.

Chapter Three provides the perspective of the paradigm case. Every flowmeter has applications that it is well suited for, and others it is not so suited for. Those applications that a flowmeter of a given type are ideally suited for are the paradigm case applications for that type of flowmeter. For example, paradigm case applications for positive displacement flowmeters are **for clean, non-corrosive, and non-erosive liquids and gases**. **PD meters also are very good for measuring highly viscous liquids, and for measuring fluids at a very low flowrate.** By understanding the paradigm case applications for different flowmeters, users can take the first step in what is sometimes a complex flowmeter selection process. Suppliers also can more easily understand how to advise their customers about what type of flowmeter to use for particular applications.

The Importance of Cross-Technology Research

Rather than sequentially issuing a series of studies on the traditional-technology flowmeter market, Flow Research has studied them all together. As a result, we are able to provide a complete snapshot of the entire traditional-technology flowmeter market as it stood in the year 2001. We are also able to find analogies and parallels among different technologies that would not likely occur to anyone who takes the "one study at a time" approach.

Looking at all the flowmeters together makes it possible to determine which flowmeters are replacing others and which flowmeters are being replaced. Another goal of these studies is to find out how fast each type of flowmeter is growing. By applying a consistent set of definitions and methodologies to accurately determine the market size in the base year for each type of flowmeter, forecasts can be generated that can meaningfully be compared with each other. This is also much more difficult to do when dealing with studies written at different times and, often, by different companies using different methodologies.

Cross-technology research gives suppliers a better handle on the flowmeter market because it shows the strengths and weaknesses of each technology. Because each technology is looked at from a regional and a worldwide perspective, suppliers can more easily determine geographic regions that are more receptive to certain technologies. Certain driving forces like the desire for accuracy and the desire for reliability cut across all the flowmeter markets. Others apply mainly to one or several technologies. Looking at each type of flowmeter in the context of the others provides additional knowledge and insight.

Suppliers can be understood much better when looked at from a cross-technology perspective. Only by looking at the entire flowmeter product line can the strength of a supplier be understood. When looked at in this perspective, companies such as Rosemount, Krohne, Endress & Hauser, ABB, and Foxboro stand out as broad-line suppliers of instrumentation. Others such as Controlotron and Panametrics may have excellent technologies, but they still supply only one type of flowmeter. More customers today are moving towards broad-line suppliers because of the convenience of one-stop shopping.

A worldwide cross-technology analysis that takes geographic regions into account is also very instructive. Our end-user survey found that magnetic flowmeters have a much larger installed base in Europe than the United States. In looking at the three leading suppliers of magnetic flowmeters, it is very interesting, then, that all three are based in

Europe. The location of manufacturing sites is important because it gives companies an advantage in delivery time, cost of delivery, and service over companies that are competing from other regions. A cross-technology approach to different geographic regions shows which types of flowmeters are growing and at what rate in each region.

The Flow-Ducker Research end-user survey also took a cross-technology approach. This survey includes flowmeter users from North America, Europe, and Asia. It includes all types of flowmeters. This survey reveals helps analyze the installed base of flowmeters by type for each geographic region. It also provides a basis for comparing user perceptions of each type of flowmeter. In addition, it greatly strengthens the forecasting process because users are asked to project future purchases for each type of meter.

New Studies vs. Updates

These studies are new; they are not updates. While the author of these studies has previously written numerous studies in flow, these studies are not written as updates to any previous studies. Flow Research has access to flowmeter data going back to 1992, and the author has been closely tracking the flowmeter market throughout most of the past decade. In cases where studies were previously done, it was only after the study was completed that comparisons were drawn with preceding studies. Previous studies are helpful as a resource, but they should not be used to determine current market size.

To start a study with a predetermined market size is to put the cart before the horse. Any market size should be determined based on current supplier interviews, not by projecting the current size based on past forecasts. Unexpected events or "shocks" often occur to upset forecasts in any case. The Asian currency crisis that began in Thailand in July 1997 upset many optimistic growth forecasts for instrumentation markets in Asia. The events of September 11, 2001, also were this type of "shock." Each study should be treated as a new study, even though previous studies can be helpful in providing a list of suppliers and a framework for viewing the market.

Leading Suppliers vs. All Suppliers

This study takes the approach that as many suppliers as possible should be interviewed when conducting a study, not just the leading suppliers. While the leading suppliers obviously have a major influence on the market, smaller companies often develop new technology that sometimes go unnoticed. Smaller suppliers often serve niche markets that make up important segments of the market. They are also important in determining true market size. There is simply no way to determine how many of these smaller companies are out there without undertaking an exhaustive search.

We have also taken the approach of profiling as many suppliers as possible, rather than simply the leading suppliers. This is a more time-consuming approach, of course, but it results in a much more thorough analysis. Sources used for company profiles include interviews, websites, product brochures, and Dun & Bradstreet reports. Ten companies selling five million dollars worth of product each year are selling as much as one company selling 50 million dollars in product. The perspectives, products, and distribution channels of these ten companies are as important a part of the total market picture as the perspective, products, and distribution channels of the large supplier.

Building a Mystery

While we started the series of flowmeter studies with certain ideas about what we would find, we approached this series of studies with completely open minds about the results. We were determined only to be objective, not to favor any particular supplier, and to provide an honest and unbiased assessment of the results. At the same time, we were fortunate in being able to conduct a comprehensive worldwide end-user survey. Ducker Worldwide funded this survey, and it results in a truly unprecedented look at the worldwide flowmeter markets. The results of this research have rewarded our approach.

By looking at multiple flowmeter markets from the points of view of market size, market shares, products, strategies, company profiles, and end-user beliefs and projections, we have been able to create a comprehensive flowmeter database that is detailed in each of the flowmeter studies.

What is it about the flowmeter market that is so compelling? This market has intense competition, paradigm case applications, mergers and acquisitions, communication protocol battles, new technologies, worldwide distribution channels, reselling and private labeling, and many other aspects that make studying it completely fascinating. Even though we have found answers to many of the questions we originally asked when we began "building a mystery," there will always be more perspectives and more fascinating ways to look at the flowmeter markets. How quickly will the multivariable flowmeter market expand? How fast is the market for flowmeters used for custody transfer of natural gas growing? How rapidly is the market for steam flowmeters growing? How quickly will district heating penetrate Asia? Who will be the new market leader in ultrasonic flowmeters? Will there ever be a universal flowmeter? These are but a few of the questions for anyone studying the mystery of flow to ponder. Such is the wonder of viewpoint pluralism, and such is the joy of flow.

Study Objectives

This study analyzes the worldwide market. The objectives of the study are as follows:

- To provide a technology and product analysis for positive displacement and turbine flowmeters
- To provide the market size in US dollars and unit volume for positive displacement flowmeters worldwide
- To provide market shares of the leading suppliers of positive displacement and turbine flowmeters worldwide
- To provide a detailed forecast of the market for positive displacement and turbine flowmeters in dollars and unit volume through 2006.
- To provide market and product strategies for suppliers of positive displacement and turbine flowmeters worldwide
- To provide company profiles of the suppliers of positive displacement and turbine flowmeters worldwide

Methodology

This study is unique in that both extensive supplier analysis and end-user analysis was conducted. This proved very useful, as the end-user analysis provided confirmation for

the supplier data. The end-user analysis also proved very useful in doing market forecasts. The four most important components of the methodology are as follows:

- Input for Suppliers
- Supplier analysis
- OEM and End-User Analysis
- Forecasting

These four components are discussed in the following sections.

Supplier Input. At the beginning of the study, many positive displacement flowmeter suppliers were contacted to find out what information they would like to see in this study. Flow Research prepared an Input Questionnaire that asked companies what information they would like to see in the study. Companies were asked to rank the information in importance on a scale from 1 to 5. These results were tabulated, and used as a guide in conducting the study. The Input Questionnaire is reprinted in Appendix A.

Supplier Analysis. Market size and market shares were determined through a variety of methods. The primary method of determining market size was through interviews conducted with positive displacement and turbine flowmeter suppliers. Most companies were quite forthcoming about revenue figures. Revenue numbers provided by companies were also cross-checked with other sources, including business directories, interviews with other knowledgeable persons, and other publicly available data sources, including Dun & Bradstreet reports. In many cases, Flow Research conducted multiple interviews to get the most accurate understanding of each company. Every effort was made to obtain the most accurate information possible about each company.

Most interviews were conducted by telephone. However, as part of the background research for this study, Flow Research conducted 34 onsite visits to flowmeter suppliers and flow testing laboratories. These visits were conducted in four separate trips occupying 33 days during 2000, 2001, and 2002. In addition, Flow Research visited the International Society for Control and Instrumentation (ISA) in Houston, Texas in

September 2001, where many flowmeter suppliers were represented. Many flowmeter products were on display at this show.

The purpose of the onsite visits was to obtain more in-depth information on flowmeter companies and their products. Seeing flowmeters in a catalog or in the Internet provides one level of knowledge. However, seeing flowmeters being manufactured and tested provides a much better understanding of the products. Visiting companies also provided additional knowledge about company size and strategies, which is helpful in understanding the total flowmeter market.

In those few cases where companies chose not to participate in the study, Flow Research used alternative sources of information. These include business directories, interviews with other knowledgeable persons, and other publicly available information sources. Product information was requested from every company, and the Internet was also used as a source of information, along with Dun & Bradstreet reports.

Total market size for positive displacement flowmeters was determined by aggregating the total sales numbers for individual companies into a total market size. Most sales information from individual companies was in dollars rather than units, although some companies also provided unit numbers. Average selling price was used as a means for calculating unit numbers for positive displacement and turbine flowmeters. Some allowance was made in determining market size for "other" companies that were not interviewed.

In most cases, the persons interviewed for this study are either the product manager or marketing manager for positive displacement flowmeters. In some cases, other persons were interviewed, including company presidents or CEOs. In larger companies, application engineers were interviewed first in some cases to get a better understanding of company products before marketing and product managers were interviewed. Flow Research wishes to thank the many companies who were so diligent in providing

information to make this study both comprehensive and complete. More than 100 interviews were conducted for this study, most with suppliers of PD flowmeters.

OEM and End-User Analysis. Flow-Ducker Research conducted 300 interviews with OEMs and end-users of flowmeters in compiling the user survey. One important purpose of the survey was to provide data for determining the installed base of flowmeters by type. Other questions dealt with applications, projected spending patterns, and levels of satisfaction with flowmeters. Flow-Ducker Research tried to determine the reasons behind spending plans, whenever possible. The results of the end-user survey have been published as a separate study, entitled Worldwide Survey of Flowmeter Users.

Besides presenting the results of the OEM and end-user survey, Flow-Ducker Research compared the results of the user survey with the supplier data. The end-user survey data provides supporting evidence for the supplier data. This greatly strengthens the supplier data, and provides an additional base of support that is lacking in most studies of this type. By integrating the supplier and end-user data, Flow-Ducker Research is able to present a balanced picture of the market that is supported from several independent perspectives. This greatly enhances the value of the data presented.

Forecasts. A number of factors were taken into account in generating forecasts. Suppliers of positive displacement flowmeters were asked individually how fast their companies are growing. Suppliers were also asked to project future sales for their products and for the industry as a whole. OEM and end-user survey data was used, especially data relating to future spending plans by users. Industry growth for the industries covered in this study was considered. Other factors include economic growth in various geographic regions, the recovering Asian economies, and past flowmeter growth. All forecasts are in real, not current, dollars, meaning that the effects of inflation are disregarded.

Definitions

Positive displacement flowmeters operate by repeatedly filling and emptying compartments of known volume with the liquid or gas from the flowstream. The idea is somewhat like Flowrate is calculated based on the number of times these compartments are filled and emptied. The types of positive displacement flowmeters described here are nutating disc, oval gear, and helical gear.

This study includes the following types of positive displacement flowmeters:

- Oval Gear
- Rotary
- Helical
- Nutating Disc
- Piston
- Diaphragm
- Other

With **oval gear** flowmeters, two oval gears or rotors are mounted inside a cylinder. As the fluid flows through the cylinder, the pressure of the fluid causes the rotors to rotate. As flowrate increases, so does the rotational speed of the rotors. Flowrate is calculated based on this rotational speed. Another variation of oval gear meters are spur gear meters.

Rotary flowmeters have one or more rotors that are used to trap the fluid. With each rotation of the rotors, a specific amount of fluid is captured. Flowrate is proportional to the rotational velocity of the rotors. Rotary meters are used for both liquid and gas applications.

Helical flowmeters get their name from the shape of their gears or rotors. These rotors resemble the shape of a helix, which is a spiral-shaped structure. As the fluid flows

through the meter, it enters the compartments in the rotors, causing the rotors to rotate. Flowrate is calculated based on the speed of rotation of the rotors.

Nutating disc flowmeters get their name from the idea of nutation, which means wobbling or rocking. A nutating disc meter has a round disc that is located inside a cylindrical chamber. The disc is mounted on a spindle. By tracking the movements of the spindle, the flowmeter determines the number of times the traps and empties fluid. This information is used to determine flowrate. Nutating disc flowmeters are widely used for residential applications to measure water use in homes. They are also used for commercial applications to measure water use in buildings such as hotels and apartment complexes.

There are several types of **piston** meters. **Oscillating piston** flowmeters have a piston that rotates inside a cylindrical chamber. A control roller guides the piston in its rotation around the cylinder. The piston has holes in it so that the fluid can flow on either side of the piston. As the piston rotates, a specific amount of fluid is trapped. Flowrate is proportional to the piston's rotational velocity. Another type of piston meter is the **reciprocating piston** meter.

Diaphragm meters have several diaphragms that capture the fluid as it passes through the meter. Differential pressure across the meter causes one diaphragm to expand and one to contract. A rotating crank mechanism helps produce a smooth flow of gas through the meter. This mechanism is connected via gearing to the index, which registers the amount of fluid that passes through the meter.

This study includes the following product categories:

- Smart positive displacement flowmeters
- Conventional positive displacement flowmeters

Smart positive displacement flowmeters are discussed in more detail in the next section. Smart positive displacement flowmeters are microprocessor-based, and use some type of

communication protocol to enable the flowmeter to communicate with other devices. Communication protocols included in this study include HART, Foundation Fieldbus, Profibus, Serial, and Other. Most Other protocols are proprietary in nature.

Conventional positive displacement flowmeters normally have a 4-20 mA output, and do not have the capability of remote configuration or communication. There has been a very strong trend towards smart instrumentation, including smart positive displacement flowmeters, over the past five years. While a number of companies still offer conventional products, it is very likely that the number of conventional positive displacement flowmeters will decline rapidly over the next five years. The presence of Foundation Fieldbus and Profibus, and the need for instruments with self-diagnostic capability, will reduce the number of customers who are willing to specify conventional instruments.

Figure 2-3 lists the different types of positive displacement flowmeters offered by positive displacement flowmeter suppliers.

Fluid Types

Positive displacement (PD) meters can be used to measure flow of the following fluid types:

- Liquid
- Gas

PD flowmeters can be used to measure either liquid or gas. They cannot be used to measure steam. Among liquids, there are three main types of liquids measured:

- Water
- Oil
- Process liquids

Residential Use. Positive displacement flowmeters are widely used to measure water in houses. The residential market for measuring the amount of water used in homes is an extremely large market. This market is characterized by high volume and low cost.

Many residential meters are in the $30 - $50 range. Most houses that have running water worldwide have some type of flowmeter to measure water usage. This meter is often a PD meter, either a nutating disc or an oscillating piston type meter. Line sizes for these meters are usually either 5/8 inch, ¾ inch, or one inch.

Commercial Use. While private homes need flowmeters to measure quantity of water usage, the same holds true of office buildings, hotels, apartment complexes, and other commercial buildings. These buildings are most likely to use positive displacement meters, compound meters, or turbine meters, depending on the size of the building and the volume of the water demand.

Many smaller commercial buildings use positive displacement flowmeters to measure water use within the building. Most PD meters for line sizes of 1 ½ inch or 2 inches are used for commercial applications. These meters can handle flow in the 5 to 100, gpm (gallons per minute) range, though some meters can go both lower and higher. The American Water Works Associations (AWWA) specifications for PD water meters are for meters of size two inches and less.

Submetering. The increased cost of water and the increased size of apartment and office buildings has given rise to the practice of submetering. Submetering typically takes place in a large apartment building or office that has many tenants. Under submetering, the tenants are individually metered for their water use. This can occur just as easily for offices as for apartments or condos. Under this system, the owner of the building can pass along the costs of water use to the tenants, based on their actual usage. Some companies have come to specialize in submetering, and PD meters are often used for this purpose.

Industrial use. PD meters are used to measure water use at industrial plants as well as at commercial businesses. This is still a utility measurement; however, since it occurs at a manufacturing plant rather than a commercial business it can be considered to be an industrial measurement. Some flowmeter suppliers do not distinguish their commercial

from their industrial measurement water meters, since they are doing the same type of measurement whether they are in a commercial or an industrial building.

Turbine flowmeters. Turbine flowmeters are used when the line sizes are larger and the flow volume is greater than can be handled by PD meters. One of the main differences between PD meters and turbine meters is that PD meters do better with low flowrates and low flow volumes, while turbine meters excel with medium to high flowrates and flow volumes. Therefore, turbine meters are often used in the larger line sizes, especially those exceeding four inches.

Compound meters. Compound meters are hard to classify because they are actually a hybrid meter that consists of both a PD meter and a turbine meter. Compound meters are often used when the flowrates vary significantly depending on time of day. For example, in a large apartment building, flowrates are likely to be very high in the morning and evening. They will be much lower during the day and at night. Because PD meters are very accurate with low flow measurement, the PD component of a compound meter measures flow during the off hours. During hours of peak usage, the turbine meter does the measuring. Compound meters are not included in the numbers in this report. However, they will be included in the worldwide turbine flowmeter study.

Oil. There is a very large market for measuring the flow of oil, refined fuels, and hydrocarbon products. Here they are all included in the category of "oil." One group of suppliers is focused on providing meters for loading and unloading trucks, tankers, airplanes, and ships. Most of this measurement is for the purpose of custody transfer. This measurement occurs both upstream of refineries and downstream of refineries. Oil trucks that deliver oil to people's houses use a flowmeter to measure the amount of oil dispensed. Often this is a PD meter.

Measurement need not occur on a mobile vehicle, however. Some PD meters rely on the lubricating property of oil or hydrocarbon liquid when the liquid is in contact with the measuring chamber. These meters can measure diesel fuel, heavy fuel oil, gasoline, and

many other hydrocarbon-based liquids. Unlike turbine meters, PD meters can easily handle high viscosity liquids. For this reason, they are often used to measure petroleum at terminals, in production, and downstream for delivery.

Process Liquids. Besides water and oil, PD meters also are used to measure process liquids. These include pharmaceutical chemicals, paints and varnishes, industrial chemicals, printing ink, dairy products, cosmetics, and many other liquid products. In many cases, PD meters provide a highly accurate measurement at a favorable cost relative to other meters such as Coriolis or magnetic.

Gas. Positive displacement meters are used as a billing meter to measure the amount of gas used at houses, commercial buildings, and industrial plants. This study does not include PD meters used at individual houses. It does include those meters used at commercial buildings and industrial plants for billing purposes. Examples of commercial buildings that use gas flowmeters for billing are hotels, apartment buildings, and office complexes. Industrial plants such as chemical, food processing, and pharmaceutical plants also use PD meters for billing purposes. These meters are different from the meters used to measure gas as part of the manufacturing process.

The market for commercial and industrial PD gas meters for billing purposes or to track usage at a commercial or industrial building is called the municipal gas market. This is a utility measurement. A specific group of companies supplies meters to this market. These meters are either diaphragm meters or rotary meters.

Smart Flowmeters

The term ‘smart’ as it is used in this study means “microprocessor based and capable of remote two-way communication.” Being microprocessor-based is a necessary condition for instrument to be smart. In terms of the human analogy that the term ‘smart’ makes use of, a microprocessor in an instrument is like a brain. It allows the instrument to process information, and may also be the basis for self-diagnostic capabilities.

The requirement of being capable of remote two-way communication rules out instruments that can only be programmed or calibrated locally, at the device itself. In effect, this requirement means that the device must be intelligent enough to be able to communicate with another device outside itself. This could be a personal computer, a laptop computer, or a handheld communicator.

The following are five main means of remote two-way communication. These are as follows:

- Serial Ports
- Proprietary Protocols
- HART
- Foundation Fieldbus
- Profibus

These five types of protocols are considered in the next section.

Communication Protocols

Both Foundation Fieldbus and Profibus are forms of fieldbus. Forms of bi-directional, multiplayer digital communication, including those developed by the Fieldbus Foundation, the ISA SP50 Committee, and the Profibus User Organization, are included in the term 'fieldbus' as used in this study.

Serial Communication

Smart Positive displacement flowmeters that have serial communication provide two-way communication with the flowmeter via an RS-232 or RS-485 connection. Flowmeters that have an RS-232 or RS-485 port to send files to a printer, but do not provide for two-way communication, are not considered smart. Smart flowmeters can be interrogated and programmed remotely from a laptop, personal computer, or handheld device. Some software programs can also do data analysis.

The idea of smart instrumentation is often associated with a paradigm of a network of instruments that are digitally integrated with a distributed control system (DCS). The proprietary protocols that have been developed, including DE (Honeywell), FoxCom (Foxboro), and Brain (Yokogawa), were developed to fit this paradigm. Serial communication does not fit this paradigm. Hence flowmeters that use serial communication can be considered "less smart" than those that rely on proprietary protocols, HART, Foundation Fieldbus, or Profibus.

Serial communications are typically implemented with a Recommended Standard (RS). The Electronic Industries Association (EIA) sets these standards in most cases. In most cases, the standard, defines connector pin-out, signal levels, maximum bandwidth, drive capabilities, handshaking signals, and electrical characteristics of the serial lines. RS-232 is probably the most widely used communication standard. Variations of RS-232 are RS-232C and EIA-232.

RS-485 ports have the capability of being connected in a multi-drop bus and selectively polled. The electrical characteristics of RS-485 ports allow for 332 drivers and 32 receivers to be connected to a single line. These features make RS-485 ports ideal for multi-drop or network environments. They also distinguish RS-485 ports, which are addressable, from RS-232 ports, which are point-to-point.

Proprietary Protocols

Proprietary communication protocols were developed by the distributed control system (DCS) suppliers to provide secure, high-speed, digital communication between their field devices and the control room. Examples of proprietary protocol's include Foxboro's FoxCom, Yokogawa's Brain, Honeywell's DE (Digitally Enhanced), and Endress & Hauser's Intensor. Proprietary protocols got the movement started towards standardization of communication protocols via fieldbus. Users soon realized that, as long as they were using a DCS from a particular vendor, they would be unable to use field devices from another supplier so long as they wanted to communicate with those field devices from the control room.

Proprietary protocols have advantages, including security and high-speed communication. However, the days of proprietary communication protocols are numbered. Now that HART, Foundation Fieldbus, and Profibus products are available, users have little incentive to select proprietary protocols. Instead, they have an incentive not to select them, so they can use instruments from more than a single vendor in the plant. While some companies are still shipping instruments with proprietary protocols, these protocols are rapidly disappearing as Foundation Fieldbus and Profibus begin to achieve wider market acceptance.

HART

The term 'HART' stands for Highway Addressable Remote Transducer. Fisher-Rosemount developed HART in 1984. The HART protocol makes use of the Bell 202 Frequency Shift Keying (FSK) standard. HART superimposes a digital signal over a 4-20 mA signal, thereby providing for bi-directional remote digital communication with field devices. Contained in the signal is information about the process and diagnostic information that could not be included in a 4-20 mA signal. Information about the value of the process variables can be included in a HART signal. A handheld device called a HART communicator, a personal computer, or a DCS are used to communicate with field devices, using HART. HART allows a host application to get two or more digital updates each second from a field device. It does not interfere with the 4-20 mA signal.

In 1993, the HART Communication Foundation (HCF) (www.hartcomm.org) was established to support and coordinate the application of the HART protocol. The HCF replaced the Hart User Group that served this function previously. The HCF is still an active organization today, with over 130 members. Many Positive displacement flowmeter suppliers are members of the HCF, including Micro Motion (now part of Emerson Process Management), Endress & Hauser, Krohne, Danfoss, ABB, and Yokogawa.

Many companies are using the HART protocol as a stepping-stone to fieldbus. Using HART, companies can take advantage of the advanced diagnostic capabilities offered by

HART-compatible devices without committing the additional resources to installing a fieldbus network.

As of December 2000, the Device Description Library, owned by the HCF, includes 102 approved flowmeters. This includes several positive displacement and turbine meters. Currently HART installations account for 10 million nodes, and are projected to double to 20 million by 2006 (see "Around the Loop" in Control magazine, May 2001). HART has benefited greatly from the delay in getting Foundation Fieldbus products approved and ready to ship. HART has become the de facto protocol for smart field devices. While some HART users will eventually upgrade to Foundation Fieldbus or Profibus, HART provides a comfortable plateau for many users while they wait for fieldbus protocol issues to be sorted out.

Foundation Fieldbus and Profibus

Foundation Fieldbus is a communication protocol that was developed as a result of the merger of WorldFIP and ISP (InterOperable Systems Project) in the mid-1990s. Both WorldFIP and ISP represented groups of very powerful companies that seemed destined to compete with each other. Clustered around WorldFIP were Honeywell, Allen-Bradley, Elsag Bailey, and Square D. Clustered around ISP were Rosemount, Fisher Controls, Siemens, and Yokogawa. Both groups decided it would be in their best interest to cooperate to form a joint communication protocol. The formation of the Fieldbus Foundation was announced in June 1994.

At the same time the Fieldbus Foundation was being formed, members of the Profibus Users Group took over the work of the ISP. The Process Automation (PA) protocol for intrinsically safe applications was also added to the Profibus group of protocols. Sponsored by Siemens, Profibus attempted to bring out products earlier than the Fieldbus Foundation and also have them commercially installed earlier. Profibus has had good success in Europe, but not as much success in North America or Asia.

The Flow-Ducker Research survey of flowmeter users shows strong penetration of flow users by HART. For example, 36 percent of North American users say they are using HART, and 12 percent of European users. Among Asian users, 14 percent are using HART. There was little enthusiasm for Foundation Fieldbus among European users, however. Only two percent of European users indicated an intention to buy Foundation Fieldbus products in the future, while 13 percent reported that there are already using Profibus. In North America, three percent of users reported using Profibus, while 13 percent said they intent to buy Foundation Fieldbus products in the future. In Asia, no users reported using Profibus, while nine percent said they intend to buy Foundation Fieldbus products in the future.

Based on this data, it is clear that European users feel much more inclined to use Profibus than Foundation Fieldbus as things stand now. This could change, however, as a larger number of Foundation Fieldbus products are released. It does seem that North American and Asian users are more ready to adopt Foundation Fieldbus products. Whatever happens, one thing has been true all along. It is taking longer than anyone expected for these protocols to be incorporated into products, and it will most likely take longer than anyone expected for Foundation Fieldbus and Profibus protocols to be adopted by users. Figure 2-4 shows the communication protocols offered for Positive displacement flowmeters by suppliers. Figure 2-5 shows the new technology flowmeters approved by the Fieldbus Foundation as Foundation Fieldbus products as of August 2001. This list does not include pressure transmitters.

The PD Market is Actually Four Submarkets

The positive displacement flowmeter market actually consists of four separate submarkets. These submarkets are as follows:

1. **Municipal water**, including commercial and industrial PD meters for billing purposes

3. **Municipal and industrial gas**, including PD meters for billing purposes on commercial building and industrial plants. This market also includes gas PD meters used for non-custody transfer applications.
4. **Oil.** This market includes PDs used to measure the transfer of refined fuels, and all meters used to measure the transfer or use of petroleum products
5. **Industrial.** This market includes all PD meters used to measure liquids other than water or petroleum products in industrial and process plants. It may include some water measurement for non-billing purposes.

One chapter this study is devoted to each of the above submarkets. In addition, chapter four is a total chapter for all four submarkets.

Geographic Regions

This study includes the following geographic regions:

- North America (United States and Canada)
- Europe (Western Europe, Eastern Europe, Russia, and the Commonwealth of Independent States)
- Japan
- Asia without Japan (including countries of the Far East, Southeast Asia, India, Pakistan, Australia and the South Pacific, the Indian subcontinent, and all other Asian countries)
- Rest of World (including Mexico, Central and South America, Africa, the Middle East, and all remaining countries)

Countries of the Middle East include: Armenia, Bahrain, Georgia, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Turkey, Turkmenistan, United Arab Emirates, Yemen

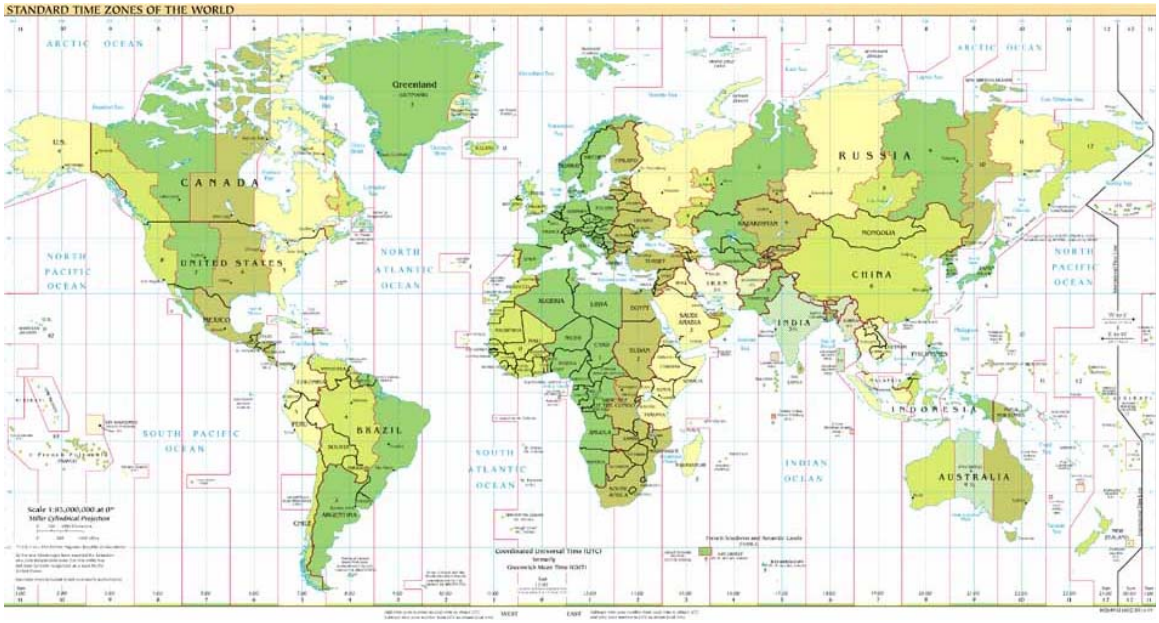
Countries of the Far East, excluding Japan, include: China, Hong Kong, North and South Korea, Macau, Taiwan

Countries of Southeast Asia include Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam

Countries of Australia and the South Pacific include: American Samoa, Australia, Cook Islands, Fiji, Guam, Kiribati, Nauru, New Caledonia, New Zealand, Niue, Pacific Islands, the Pacific, Papua New Guinea, Samoa, Solomon Islands, Tahiti, Tonga, Tuvalu, Vanuatu

Countries of the Indian subcontinent include: Bangladesh, Bhutan, India, Maldives, Nelpal, Pakistan, Sri Lanka

Photo 2-1 World Map



- North America (United States and Canada)
- Europe (Western Europe, Eastern Europe, Russia, Commonwealth of Independent States)
- Japan
- Asia without Japan (including countries of the Far East, Southeast Asia, India, Pakistan, Australia and the South Pacific, the Indian subcontinent, and all other Asian countries)
- Rest of World (including Mexico, Central and South America, Africa, the Middle East, and all remaining countries)

Geographic Regions

Photo 2-2

World Map by Region

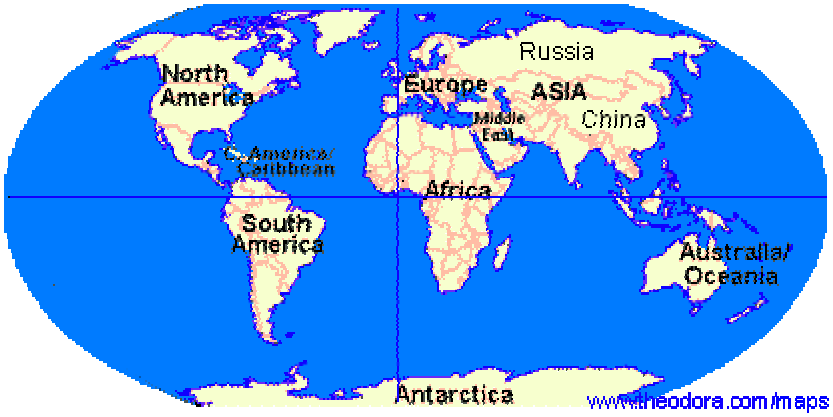


Photo 2-3

Map of Asia

Maps courtesy of www.theodora.com/maps, used with permission.

Photo 2-4

Map of Europe

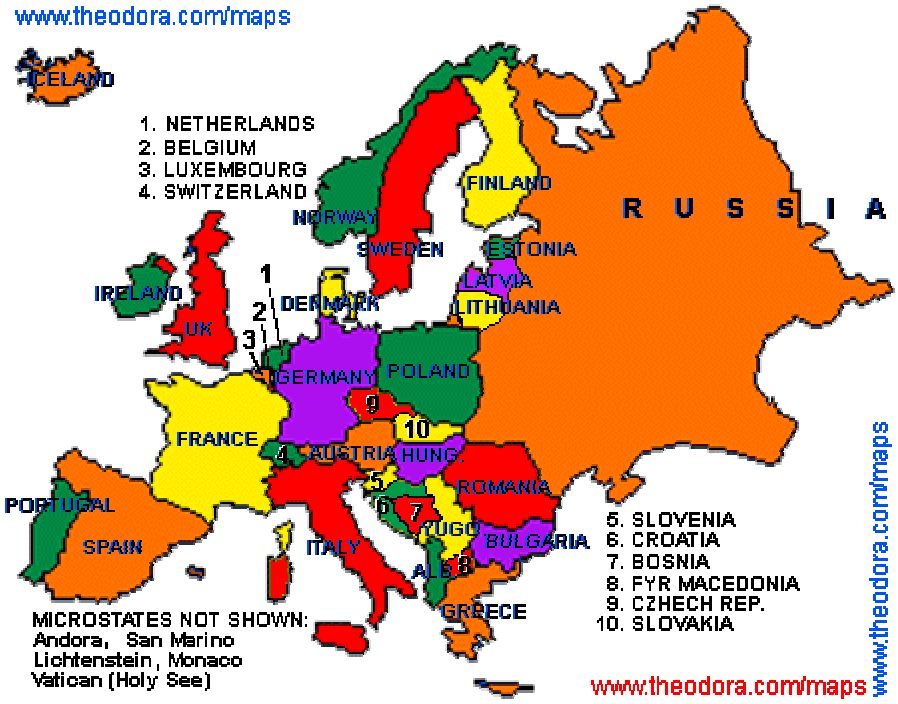


Photo 2-5 Map of the Russian Federation

Maps courtesy of www.theodora.com/maps, used with permission.

Photo 2-6 Map of China

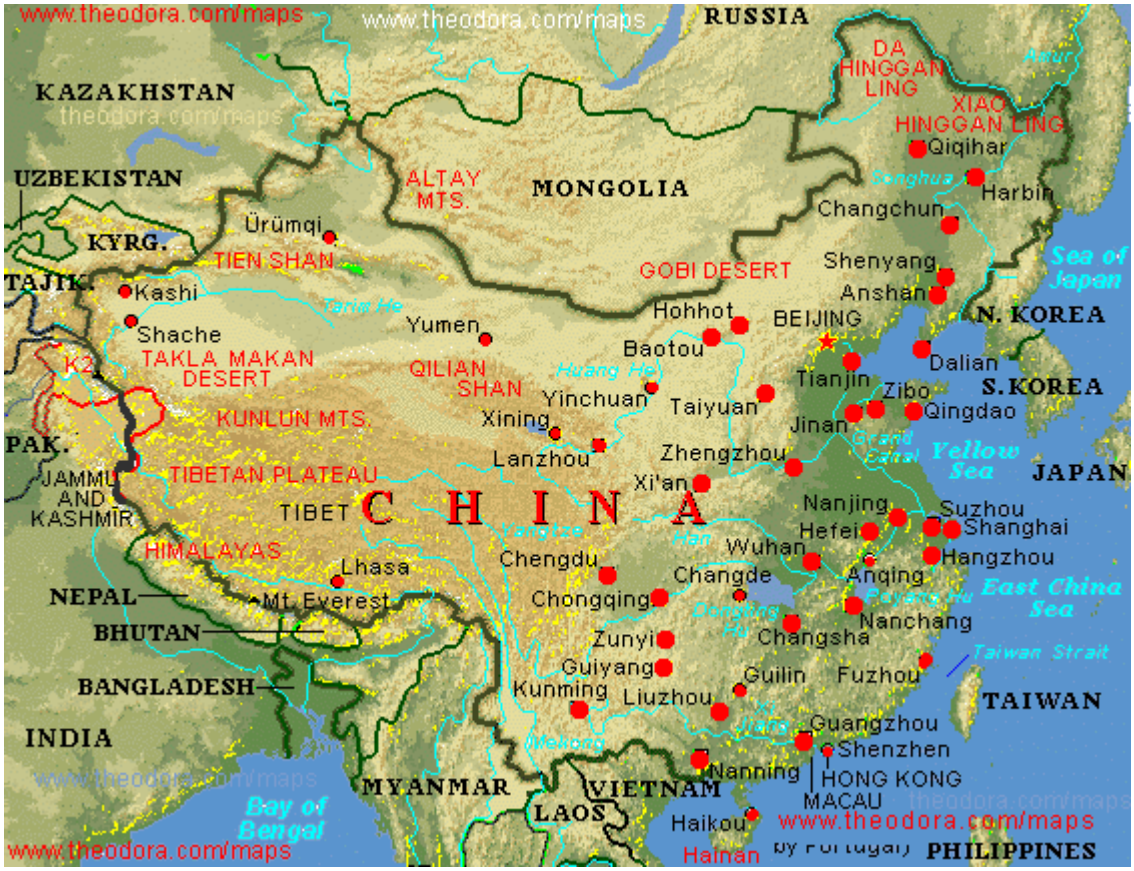
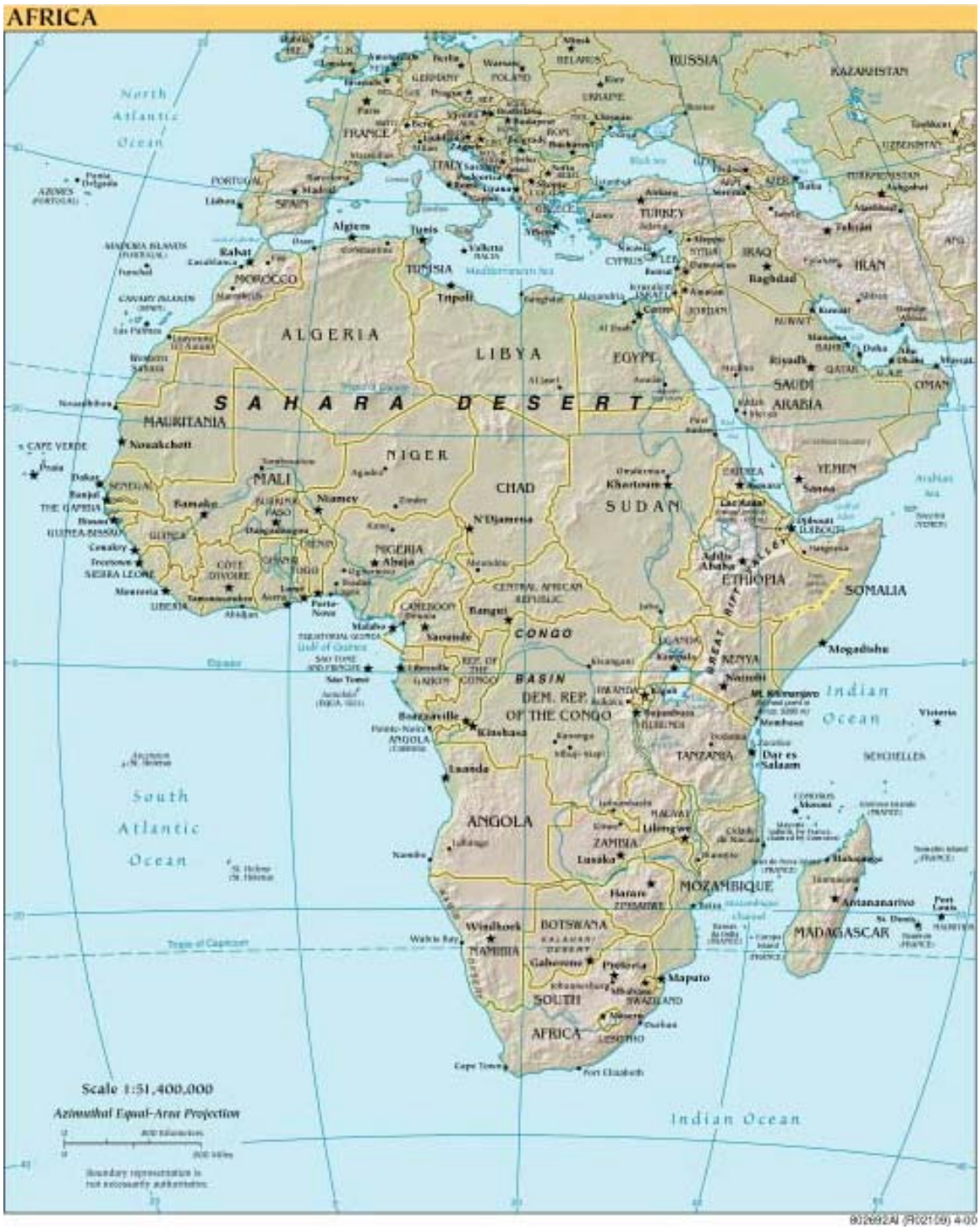


Photo 2-7 Map of Japan

Maps courtesy of www.theodora.com/maps, used with permission.

Photo 2-8

Map of Africa



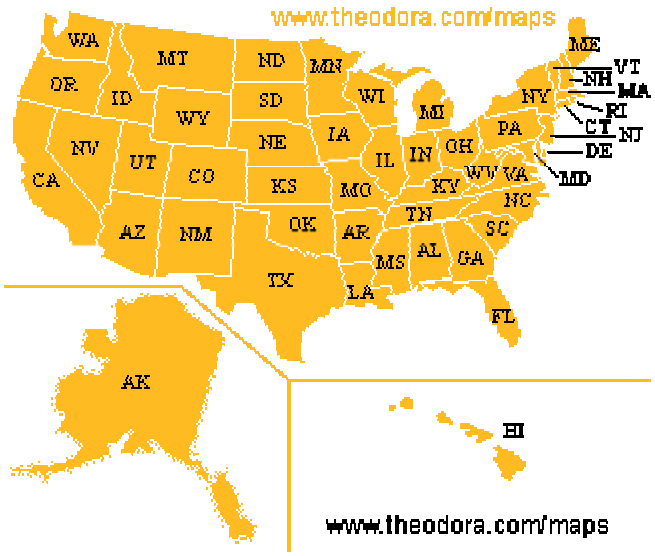
Maps courtesy of www.theodora.com/maps, used with permission.

Photo 2-9 Map of the Middle East

Photo 2-10 Map of Canada

Maps courtesy of www.theodora.com/maps, used with permission.

Photo 2-11 Map of the United States



AL	ALABAMA	KY	KENTUCKY	ND	NORTH DAKOTA
AK	ALASKA	LA	LOUISIANA	OH	OHIO
AZ	ARIZONA	ME	MAINE	OK	OKLAHOMA
AR	ARKANSAS	MD	MARYLAND	OR	OREGON
CA	CALIFORNIA	MA	MASSACHUSETTS	PA	PENNSYLVANIA
CO	COLORADO	MI	MICHIGAN	RI	RHODE ISLAND
CT	CONNECTICUT	MN	MINNESOTA	SC	SOUTH CAROLINA
DE	DELAWARE	MS	MISSISSIPPI	SD	SOUTH DAKOTA
DC	DISTR.COLUMBIA	MO	MISSOURI	TN	TENNESSEE
FL	FLORIDA	MT	MONTANA	TX	TEXAS
GA	GEORGIA	NE	NEBRASKA	UT	UTAH
HI	HAWAII	NV	NEVADA	VT	VERMONT
ID	IDAHO	NH	NEW HAMPSHIRE	WA	VIRGINIA
IL	ILLINOIS	NJ	NEW JERSEY	WA	WASHINGTON
IN	INDIANA	NM	NEW MEXICO	WV	WEST VIRGINIA
IA	IOWA	NY	NEW YORK	WI	WISCONSIN
KS	KANSAS	NC	NORTH CAROLINA	WY	WYOMING

www.theodora.com/maps

Maps courtesy of www.theodora.com/maps**, used with permission.**

End-User Industries

This study includes the process industries, which are as follows:

- Oil & Gas (includes production, transportation, and distribution)
- Refining
- Chemical
- Food & Beverage
- Pharmaceutical
- Pulp & Paper
- Metals & Mining
- Power
- Water & Wastewater
- Semiconductor
- Other, including district heating, cement, ceramic, rubber, paint, and other process industries

Positive displacement Flowmeter Industry Structure

Positive displacement suppliers use a variety of methods to get their products to end-users. Many of the larger companies have direct sales forces. Others use independent representatives who only represent one company for each type of product line. Distributors are another sales channel. The difference between distributors and independent representatives is that distributors normally take control of the product. One disadvantage of using distributors, however, is that manufacturers have less control over purchase price. They also have less control over how their products are portrayed and sold when distributors are used.

Team History and Experience

The Market for Positive displacement Flowmeters Worldwide is the result of a partnership between Flow Research of Wakefield, Massachusetts and Ducker Research Company, Inc. of Bloomfield Hills, Michigan. The lead analyst in the project is Jesse Yoder, president of Flow Research, Inc. Flow Research specializes in market research on instrumentation and process control subjects. Dr. Yoder did the supplier interviews, data

analysis, forecasting, and writing of the study. He has previously written a worldwide flowmeter study, a worldwide ultrasonic study, a worldwide positive displacement study, a worldwide pressure study, and numerous proprietary studies on flowmeters.

Belinda Burum, vice president of Flow Research, Inc., has worked in high tech for 14 years as a technical writer and marketing communications manager. Before that she honed her interviewing skills as a newspaper and wire service reporter. In 1990 and 1991, Ms. Burum wrote newsletters and company profiles for Idea Network. She wrote many of the company profiles for this study.

Michael Kirsch, Senior Analyst, has 30 years of consulting experience in the chemical and plastics industries. He has a BSChE and an MBA. Mr. Kirsch performed the extensive product analyses in chapter three, and also helped identify positive displacement flowmeter suppliers.

Nick Limb, Partner at Ducker Worldwide, has overseen the publication of many reports in areas such as adjustable speed drives and flat glass. He has a Masters Degree in economics. Mr. Limb is the overall manager of the project.

Scott Shober, Project Manager at Ducker Worldwide, has extensive experience in technology-driven markets. He specializes in market sizing and forecasting. He has a B.S. in engineering.

Josiah Waxman, Market Analyst at Ducker Worldwide, has research experience in the building & construction industry. He specializes in size and segmentation studies and has a B.A. in Marketing..

Ducker Research carried out the end-user survey, under the leadership of Scott Shober, assisted by Josiah Waxman. Nick Limb of Ducker Research served as project manager.

Flow Research, Inc.

Flow Research is the only market research company whose primary mission is to research flowmeter markets. Flow Research was founded in 1998. The company provides market studies and custom work in flow, temperature, pressure, and process control. Flow Research has also initiated the Worldflow Monitoring Service, which provides monthly reports on the flowmeter industry, the process industries, and user perspectives.

The lead analyst for this study, Jesse Yoder of Flow Research, has 16 years experience writing about and analyzing process control and instrumentation markets as president and founder of Idea Network. He has written over 40 market research studies and published numerous articles on instrumentation in industry journals. To read more than 25 articles on instrumentation written by Dr. Yoder, visit the Flow Research website at www.flowresearch.com.

Market research studies are sometimes divided into off-the-shelf and custom reports. Off-the-shelf studies, like this one, are not written for, or specified by, a single company. Instead, they are written and then made available to all interested companies. They are called "off-the-shelf" because they are sold as-is, and are not modified for the requirements of an individual company. Off-the-shelf reports are also called syndicated reports.

Companies that want more detailed information on a specific subject commission custom reports. Custom reports are often commissioned to evaluate the future of a product line, or to determine whether to make an acquisition. In most cases, the type of information required in a custom project is too specific and narrow to be available in an off-the-shelf report.

Dr. Yoder has written numerous custom and off-the-shelf studies in the areas of process control and instrumentation. The following is a list of the off-the-shelf studies he has written:

Thermal Transfer Printing: Technology, Products, Prospects (1983)

World Markets for Distributed Control in the Process Industries (1991)

World Markets for Barcode Equipment (1991)

World Test & Measurement Equipment Markets (1992)

European Market for Test & Measurement Equipment (1992)

The Market for Nondestructive Test Equipment (USA) (1993)

The Evolving U.S. Market for Personal Computers and Software for Programming and Online Operation with Programmable Logic Controllers (1994)

World Market for Industrial Process Control Equipment (1994)

The World Market for Flowmeters in the Process Industries (1994)

The World Market for Intelligent Field Devices (1995)

World Market for Controllers and Control Technology Products (1995)

European Pressure Transmitter Outlook (1996)

Worldwide Vortex Flowmeter Outlook (1997)

Worldwide Ultrasonic Flowmeter Outlook (1997)

Worldwide Pressure Transmitter Outlook (1998)

The Market for Temperature Sensors & Transmitters in the Americas (2000)

The Market for Infrared Thermometers and Thermal Imagers Worldwide (2000)

The World Market for Coriolis Flowmeters (2001)

The World Market for Magnetic Flowmeters (2001)

The World Market for Ultrasonic Flowmeters (2001)

The World Market for Vortex Flowmeters (2001)

The World Market for New Technology Flowmeters (2001)

Worldwide Survey of Flowmeter Users (2001)

The World Market for Positive Displacement Flowmeters (2002)

The World Market for Turbine Flowmeters (2002)

The Worldwide Flowmeter Market (2002)

The following are articles on instrumentation written by Dr. Jesse Yoder:

Go New-tech or Stick with DP? – Control, June 2002

Multivariable: The Hot New Trend in Vortex Flowmeters – Flow Control, June 2002

Ultrasonic Flowmeter Market is Expected to Grow Strongly – Pipeline & Gas Journal, April 2002

New-Technology Flowmeters Offer Performance Breakthroughs – Control Solutions, April 2002

A Complex Flow Instrumentation Market, Intech, February 2002

Multivariable and New-Technology Flowmeters Lead the Way, Control, January 2002

Big Shift to New Technology Flowmeters Predicted, Flow Control, January 2002

Ultrasonic Flowmeters: The Fastest Growing Market, Flow Control, November 2001

Mass Appeal, Plant Services, April 2001

Flowmeter Shootout, Part III: How Users Choose, Control, April 2001

Flowmeter Shootout, Part II: Traditional Technologies, Control, March 2001

Flowmeter Shootout, Part I: New Technologies, Control, February 2001

Raising the Bar for Primary Elements, Control Engineering, October 2000

Flowmeter Calibration: How, Why, Where, Control, July 2000

Ultrasonics Reverberate Through the Market, Intech, July 2000

Ultrasonic Flowmeters: A Natural Choice to Measure Gas Flow, July 2000

Growth Prospects for I/P Transducers, Plant Services, July 2000

Taking the Mystery out of Infrared, Control, June 2000

Making Contact with Temperature, Control Engineering, April 2000

Thermocouple Technology, A Matter of Resistance and Metal, Intech, March 2000

Plumbing the Depths of Open Channel Flow Measurement, Control, July 1999

Using Meters to Measure Steam Flow, Plant Engineering, April 1998

Flow Measurement Technologies Move Forward, I&CS, November 1997

Ultrasonic Flowmeters: A Technology Whose Time Has Come, Chemical Engineering World, November 1997

Fast Action, Plus Emissions Control, Boosts Quarter-Turn Valves in Batch, InTech, November 1997

Major Forces Drive Industrial Automation, Honeywell Journal, April 1995

Getting to the Heart of Smart, Intech, February 1995

In addition to the twelve years he spent writing market studies, Dr. Yoder spent ten years as a technical writer. Almost four years of this were spent writing technical manuals and training guides for the process control division of Siemens. He also taught technical writing at the graduate level at Northeastern University and the University of Massachusetts Lowell. Chapter Three of this book brings this experience to bear on the flowmeter market. He has recently published a philosophy book called Shades of Experience that is available online at www.ideanetwork.net. **Shades of Experience** explains the philosophical basis for viewpoint pluralism, and argues that our language needs to be altered in certain fundamental ways. Viewpoint pluralism is the philosophy that underlies the research performed by Flow Research and Idea Network. The overall goal of **Shades of Experience** is to find better ways to describe our experience.

In describing and analyzing the products covered in a report, many market studies content themselves with a table that lists the model names of the products manufactured by the leading suppliers. While this provides a thumbnail sketch of the products available, it provides very little knowledge of the products.

Chapter Three of this book takes a different approach. This chapter, which is a product and technology analysis, devotes a section to many of the suppliers of positive displacement flowmeters worldwide for which product information was available.

Specifications for positive displacement flowmeters include the following:

- Applications
- Diameter Range
- Connection Type
- Flow Range
- Temperature Range
- Approvals
- Pressure Range
- Measuring Tube Material

Information listed in the specification tables was taken from product brochures, data sheets, and websites. The specifications listed by companies were not tested or verified independently. In some cases, certain product information was not available, so those categories were left blank. We would like to thank the many positive displacement flowmeter suppliers who helped provide information for the specification tables.

We believe that providing this type of detailed product information is extremely valuable, and provides a very effective means of comparing the products offered by different suppliers. While much of this information is publicly available, it has not previously been available in a single location. Even though some information is publicly available, it may not be accessible. Some companies have websites that are written in the native language of the country where they are located, and the information on these websites is not accessible to people who do not speak that language.

Chapter Three represents many of the positive displacement flowmeters manufactured worldwide as of April 2001. However, this information will change as new products are added and as new specifications are introduced. For this reason, Flow Research has begun a new service called the Living Database. The Living Database takes the Chapter Three information from each worldwide flowmeter study and merges them all together. Using the Living Database, it will be possible to tell quickly what products are offered by what suppliers for each type of flowmeter.

Flow Research is keeping the Living Database up to date by adding new products when they become available, and by updating specifications when they change. This unique service is now available, and is part of the Worldflow Monitoring Service. Contact Flow Research for more information.

Ducker Research

Ducker Research has 40 years of experience in researching industrial and business markets. This experience gives Ducker Research (www.ducker.com) access to a wide array of industry knowledge, technology awareness and current market trends.

Today, the firm has a staff of 65 in its Bloomfield Hills, Michigan offices. This staff includes 30 professionals in engineering and scientific disciplines. In addition, the company has a dedicated, full-time staff of 35 experienced interviewers and support staff. Ducker maintains the capabilities to conduct all phases of a research project, without outside support, in its offices.

Ducker Worldwide services a worldwide clientele through its Michigan-based staff and through its offices and partner firms throughout the world. In addition to Ducker's international offices and capabilities, on staff in Detroit are several individuals with multi-lingual capabilities. Several staff members (analysts and project managers) are fluent in French, Spanish, Italian, German and Japanese. With this capability, coupled with offices overseas and many long-standing relationships with partner firms, Ducker has successfully studied world markets for over three decades.

Custom Projects

Flow Research maintains an ongoing interest in the flowmeter industry. We are prepared to do further research that builds on the comprehensive research that is detailed in this study. Companies that would like further detailed research are invited to call Flow Research for more information or to discuss specific research needs. We work with many companies that are looking to expand their product lines, introduce new products, or understand better how to penetrate the markets. For more information, please visit www.flowresearch.com.

Figure 2-1
New Technology and Traditional Technology Flowmeters

New Technology Flowmeters	Traditional Technology Flowmeters
Coriolis	Differential Pressure (DP)
Magnetic	Open Channel
Ultrasonic	Positive Displacement
Vortex	Thermal
Multivariable Differential Pressure	Turbine
	Variable Area
	Other