THE TEN BILLION DOLLAR STANDARD

ASTM D-2513

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ABSTRACT

Over the past forty years or more, the natural gas distribution industry in the U.S. has made a remarkable transformation from a near-exclusive metallic distribution piping network to a near-exclusive thermoplastic piping distribution network, primarily driven by the development, implementation and constant upgrading of one standard, ASTM-D-2513, "Thermoplastic Gas Pressure Pipe, Tubing, and Fittings". This transformation from metal to plastic has saved US natural gas utilities in excess of $10 Billion in installation and maintenance costs over this period of time.

PREFACE

In its simplest form, the natural gas industry is organized around two major functions- "Transmission" and "Distribution".

"Transmission" activities focus on the collection of natural gas from underground wells or "Liquefied Natural Gas" (LNG) terminals, imported from abroad, and "transmission" via large diameter, high pressure pipelines throughout North America. The pressure within a transmission line is in the 1500 psi range. This is a very efficient means or transmitting large volumes of gas from the point of discovery to the vicinity of the end user. High strength steel pipelines are used for this activity and will continue to do so for the foreseeable future.

When "transmission pipelines reach populated areas, commonly referred to as city gates, the pressure is significantly reduced at regulator stations and the gas "distributed" throughout the community to the consumers or end-users of the gas. This article addresses the distribution side of the natural gas business.

INTRODUCTION

The natural gas distribution network in the United States is one of our largest, most complex and vital infrastructures. From the very beginnings in the late 1700's with Benjamin Franklyn's gas lights to today's sophisticated gas turbine generators, natural gas is providing light, heat and power to millions of American homes and enterprises.

This network of pipes, valves and fittings extends throughout every major city and town in America. Today it consists of over six (6) billion feet of gas distribution mains in the United States.

Natural gas serves over 100 million homes, businesses, factories, churches, malls, arenas and other structures of every shape and size with clean, reliable and affordable energy.

Natural gas is delivered safely and reliably to these various consumers via a network of underground pipe, valves and fittings. The earliest distribution pipes were made of whatever material was available including lead and wood. Some wood pipe was still in service well into the 20th century. As the distribution network grew, cast iron was commonly used for mains and copper or steel used for individual services that took gas from the main into a home or business.

Although cast iron, copper and steel are still in service, they present a number of major issues that discouraged their continued use and expansion.

1. For safety purposes, cast iron and ductile iron is normally limited to very low pressures in the range of 5 psi or sometimes as low as inches of water column pressure. However , there are a few gas distribution companies that operate systems from 15 to 25 psi. This low pressure means a very large diameter pipe is required to provide an adequate volume of gas to the various consumers along the path of the pipeline. In some cases, potential customers were not able to be served simply because the existing cast iron pipeline did not have adequate capacity.
2. These large cast iron pipes are no longer than 16 feet in length; therefore, a joint and potential leak path exists every 16 feet within the network. Over time, due to ground movement, external forces and corrosion, leakage at the joints has become a major concern and most utilities now have multi-year programs underway to replace all of their cast iron mains.
3. Installation of cast iron and most steel pipe requires an open trench along the entire length of the pipeline. Excavation, installation and road repair are expensive, time consuming and complex projects.
4. Cast iron and steel works best when used in straight lines thus other utilities such as electric, water and cable lines often must be moved to clear a path for the iron pipe.
5. The disruption and/or closing of major streets and associated detours within populated areas are both a major expense and public relations problem for the utilities.

For all of these reasons and many more, natural gas utilities clearly recognized the need for a better distribution pipeline material and to borrow a phrase from a popular commentator, Paul Harvey, the following is “the rest of the story”.

DISCUSSION

Recognizing the limitations of cast iron piping, most utilities began using steel pipes and continue to do so, especially for distribution systems with pressures above 125 psi up to about 700 psi. Steel will continue to serve these applications although a plastic pipe has recently been approved for use up to 200 psi.

Most gas distribution systems operate at 60 psi or less and at these lower pressures the strength of steel cannot be fully exploited. Further, steel pipe is expensive, difficult to install and will corrode over time.

The cost and performance limitations of cast iron and steel motivated the utilities to seek out alternative pipe material for their low pressure systems. Plastic pipe seemed like a logical choice. Plastic pipe was first installed in a natural gas distribution system in the 1950's. Various materials were tried including acetal, PVC and polypropylene but polyethylene quickly became the material of choice because of its toughness, durability, low cost and ease of installation.

In the 1950's and '60's, "plastic" was associated with cheap toys and a popular joke from the movie "The Graduate'. It was not considered a viable engineered product and the long-term durability of plastic was unknown. It was with a very healthy dose of skepticism that natural gas utilities began to evaluate plastic pipe, and in particular, polyethylene pipe for their gas distribution systems.

It was recognized quite early in the 1960's that no significant usage of polyethylene pipe in natural gas service would occur without a valid industry-recognized standard for the product. ASTM and its consensus-driven standards development process was the answer. Engineers and others who belonged to ASTM D-20, Plastics, undertook the responsibility for developing the first consensus standard for plastic pipe specifically for natural gas service. Their work resulted in the initial publication in 1966 of ASTM D-2513 "Standard Specification for Plastic Gas Pressure Pipe, Tubing and Fittings".

The work of improving D-2513 and its companion standards eventually grew to the point where it made sense to separate this activity from general plastic concerns and have a separate committee dedicated to plastic pipe. In 1973, ASTM formed F-17 "Plastic Piping Systems" and D-2513 and related standards were transferred to this new committee. Subcommittee F17.60 "'Gas" was given the specific responsibility within F17 for D-2513 and it remains the responsibility of F17.60 to this date.

Committee F17 currently has more than 400 dues-paying members and its main and subcommittees are 'in-balance", meaning the User/General Interest members outnumber the Producer member. It is well represented with utility users, government interests, consultants, producers and general interest personnel. A number of highly experienced PhD's are active as well as scientists and engineers from all the major disciplines. More than half of F17's members have contributed ten (10) or more years of volunteer service to ASTM F17. Committee F17 members may be unique in their willingness to volunteer to lead Task Groups to initiate the standards writing or revision process; and, share unselfishly their particular expertise for the mutual benefit of the entire industry.

The wording of the Scope of D-2513 has been revised several times over the past 43 years but its focus has always been on plastic pipe, tubing and fittings for use with fuel gas mains and services in buried service. Today's Scope reads, in part, "This specification covers requirements and test methods for material, dimensions, tolerances, hydrostatic burst strength, chemical resistance and impact resistance of plastic pipe, tubing and fittings for use in fuel gas mains and services….The pipe and fittings covered by this specification are intended for use in the distribution of natural gas..".

It is important to note that the Scope and focus of D-2513 remains on products intended for the distribution of natural gas. Over the years, the acceptance and reputation of D-2513 has grown to the point that many companies seek inclusion of their products in D-2513 even though they are not intended for gas distribution service. The Subcommittee F17.60 insists that all new products proposed for inclusion in D-2513 satisfy its Scope and the subcommittee resists all such non-gas inclusions and this has proven to be a wise decision.

As mentioned above, natural gas utilities were not ready to commit to plastic pipe without a product standard such as D-2513; but, more importantly, they needed confidence that products that satisfy D-2513 also satisfy their needs. For over 40 years the focus has been on satisfying gas industry needs.

This focus on the gas industry is accomplished in several unique ways:

1. The chairperson of F17.60 Gas has almost always been a gas utility engineer (User), not a Producer or General Interest member. He or she continues to monitor all proposed additions or changes to the standard to insure it is both applicable to and a benefit to the industry. Many times a proposed project to update D-2513 is accelerated because the resulting benefits are apparent to the Users.
2. The American Gas Association, Plastic Materials Committee (PMC) has technical members participating from a significant number of utilities. They bring to the attention of the industry their concerns about the need for improving D-2513. They also recommend and monitor specific research and/or test programs to insure the best possible products, processes and practices are employed by the industry. Their concerns and recommendations are brought directly to F17.60 for inclusion into D-2513. This is an ongoing activity as shown by the fact that over the years, D-2513 has been revised, i.e., improved, 55 times. Not once has D-2513 gone through the simple R & R (review and reissue) process because changes are always forthcoming.
3. The Plastic Pipe Institute (PPI) oversees the Hydrostatic Stress Board (HSB) that develops and specifies the testing protocols required to obtain a Hydrostatic Design Basis (HDB) for a piping material. The materials' HDB, in turn, determines the long-term pressure rating of the plastic material. The gas utilities use the HDB of the material as the basis for designing the pressure capability of their distribution piping systems. PPI maintains a listing of the HDB values it has approved and all materials claiming compliance with D-2513 must have a valid HDB listing. To maintain a HDB listing with PPI, the material supplier must retest his material on an ongoing basis.
4. Organizations such as the Gas Research Institute, Southwest Research, Battelle Institute, the University of Pennsylvania and others have done extensive research on the behavior of plastic pipes and quantified the improvements achieved over the years. One test in particular, called the PENT Test, measure the resistance of the material to slow crack growth, the most likely cause of pipe failure long-term. The higher the resistance, or longer time to failure during this test, the better the material for resistance to slow crack growth. Early materials developed in the 60's

and early ‘70s had a PENT test result of 1 hour or so. Today’s “high performance” polyethylene pipe material must have a PENT value > 500 hours and some exceed 2,000 hours or more. This 500 + hour PENT result equates theoretically to an in-service life in excess of 100 years. Our great-grandkids will have to tell us how well we’ve done.

5. D-2513 is not just a pipe standard but rather s piping system standard. Pipe alone is worthless unless you can connect a source to one end and a customer to the other end and maintain control in between. Thus, D-2513 not only addresses the specific requirements for plastic pipe, but it also addresses the requirements for all valves and fittings used in plastic natural gas piping systems. D-2513 includes mandatory requirements for valves and various fittings by specific reference to the appropriate product standards for these various items. When D-2513 changes impact another product standard, this standard is then updated as well to maintain the overall harmony of all related standards. With control over all aspects of the plastic gas distribution system, weak links are eliminated and confidence in the performance of the overall system is achieved.
6. This standard D-2513 is so highly regarded that it has become the law of the land. Natural gas safety is regulated by the U.S. Department of Transportation, Office of Pipeline Safety. Regulations are written and contained in the United States Code of Federal Regulations, Part 192: “Transportation of Natural and Other Gas By Pipeline: Minimum Federal Safety Standards”. This regulation contains a requirement that states that all thermoplastic plastic pipe in natural gas service be in accordance with D-2513.
7. State regulators such as the various state Public Utility Commissions rely on D-2513 for guidance when overseeing and enforcing gas distribution system design, installation and maintenance.

BILLION DOLLAR SAVINGS

Now the really good stuff. As you can see, it is no accident that natural gas utilities have such faith in D-2513. They and a host of support experts have been working to improve it for more than 40 years and 55 revisions to the standard are proof of the work done. This confidence in plastic pipe produced to D-2513 has led to its increased usage. Utilities wisely started small with service line applications and mains through 2”, then 4” in size. Not too many years ago a manufacturer of polyethylene products through 4” size has a “complete” product line.

As confidence grew, so did the plastic natural gas line sizes. Polyethylene pipe up thru 12” ips is now very common and a fair amount of 18” and 20” polyethylene gas pipe has been successfully installed.

Today, polyethylene pipe represents:

32 million feet of gas main (50.1% of all gas main in the U.S.)
41 million individual gas services (63.4% of all gas services in the US)
3 billion feet of pipe in service
97% or more of all new distribution pipe today is polyethylene (PE).

The two primary savings associated with the use of polyethylene pipe are:

1. Installed Costs including the opportunity for alternative installation methods
2. Reduced maintenance (corrosion) costs

Since 1960 polyethylene pipe has evolved into the dominant material used in the gas distribution industry and yearly over 32,000 miles of PE pipe are installed.

INSTALLED COST SAVINGS:

Average Cost per ft. to Install Gas Distribution Mains[1]

Pipe Size	PE cost/ft. ($)	PE Average Cost/ft ($)	Steel cost/ft. ($)	Steel Average Cost/ft. ($)
2” ips	4.00 – 9.32	6.66	12.00 – 35.00	23.5
4” ips	8.00 – 15.56	11.78	16.00 – 32.00	24.00
6” ips	10.00 – 32.00	21.00	33.00 – 75.00	54.00

Table 1

From Table 1, the least difference in average installed cost is with the 4” size pipe where the average cost difference is (24.00 – 11.78) = $ 12.22 per foot.

Average Material Cost Comparison

		2"	4"	6"	8"	12"
Steel Main	pf	*$3.09*	*$10.86*	*$22.19*	*$22.10*	*$29.00*
PE MAIN	pf	$0.64	$2.06	$4.53	$7.71	$14.73
Difference	pf	79.44%	81.02%	79.60%	65.09%	49.19%

Table 2

Material savings alone range from $2.45/ft for 2” diameter pipe to $17.66/ft for 6” diameter pipe. This is almost a 80% savings in material alone.

If all 3 billion feet of polyethylene pipe currently installed enjoyed that same savings difference, the total savings would be in the range of $36 billion.
It’s true that much of the installed PE pipe is smaller than 4” and the 1” and under size pipe may not enjoy the exact same savings. However, even if we discount the overall savings by 50%, we are still saving $18 billion; and we’re just getting started!

[1] Tubbs, 43rd Annual Pipe Report – “Gas Demand, Maintenance Projected to Drive Distribution Spending”, Pipeline Gas Journal, December 2008

MAINTENANCE (CORROSION PREVENTION) COST SAVINGS

Installation of steel pipe brings with it the requirements of Part 192 , Transportation of Natural Gas and Other Gas by Pipeline , Minimum Federal Safety Standards . Beginning 1971 all underground steel pipe installed must be **cathodically protected, monitored, and records kept.** These are not trivial requirements.

Annual Operating and Maintenance costs associated with steel piping for the U.S. is estimated to be $2.2 billion. This is the annual cost of maintaining 475,000 miles of corrosion protected steel main and 15.3 million corrosion protected services. These costs ultimately get passed on to the consumer in the price they pay for natural gas. If not for the use of polyethylene pipe to D-2513, this maintenance cost would be over $4 billion, each year. As one can see, preventive maintenance costs associated with steel pipe is very expensive.

With polyethylene pipe these maintenance and monitoring costs go away, saving literally billions of dollars per year and contributing to more value for the consumer.

OTHER BENEFITS

In addition to the obvious dollars saved with the use of plastic pipe, there are at least two significant non-quantitative benefits resulting from the usage of plastic pipe:

1. Reduced carbon footprint
2. Emergency Response

CARBON FOOTPRINT

An additional and increasingly more important benefit of polyethylene pipe is the smaller carbon footprint it produces. Technology related to trenchless excavation (insertion thru existing mains), directional drilling, use of coiled piping, and other insertion techniques all contribute. Significantly less trucking, less time-consuming detours, less disposal of excavated materials, and less paving restoration is realized with the use of polyethylene pipe made to D-2513.

EMERGENCY RESPONSE

The ability to act quickly in an emergency situation is priceless. Protecting life and property are fundamental in the operation of a gas distribution infrastructure. Polyethylene allows for quicker shutoff with its squeeze off capabilities. Repairs can usually be made quicker, allowing for more timely restoration of service and greater customer satisfaction. Savings – Priceless !

CONCLUSION

The title and headline of this report refers to D-2513 as a $10 billion dollar standard but it may be more accurate to say “tens of billion” dollar standard. It has had that much of an impact on the installation and maintenance practices of the natural gas distribution industry in the United States. ASTM D2513 is a standard to be proud of. It touches many and contributes to a higher quality of life .

As Walter Cronkite closed his News casts – “and that’s the way it is”.