History of Steel Water Pipe
Its Fabrication and Design Development

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PART I. HISTORY
INTRODUCTION

The Age of Iron began about 1000 B.C. The Old Testament mentions iron 90 times. The Romans used iron throughout their empire and built the first Roman aqueduct in 312 B.C. requiring a considerable distribution system. Many years before, men had first learned the secret of conducting water through crude pipes. Even prior to the birth of Christ, the Chinese transported water through bamboo; a Babylonian king who reigned 4500 years ago had a bathroom with tile drain pipes; and a municipal reservoir served Carthage about 800 B.C.

The first water works system in America was constructed at Boston in 1652, however the principal water works development in the United States took place after 1850, at which time there were 83 water works in existence.

This paper presents the history and heritage of steel water pipe primarily in this country during its dynamic role as a servant and builder of numerous water projects for the benefit of our citizenry.

Iron, although used to a limited extent in cast form, could not be economically employed until the development of a practical process for the manufacture of welded wrought-iron pipe early in the nineteenth century. In 1812 machinery was invented in England for welding barrels for firearms and other cylindrical articles. Three years later William Murdock, a Scot, employed old musket barrels discarded after the Napoleonic wars to make gas pipe to light some of the gloomy streets of London. In 1824 James Russell, an Englishman, invented a process for the welding of tubes, with or without a mandrel, by a combination of tilt hammer and rolling operations. The following year Cornelius Whitehouse conceived a method of manufacturing pipe by drawing long, flat strips of hot metal, known as skelp, through a die or bell, forming a whole length of pipe in one operation. Then, for the first time, man had the basis for making strong pipe rapidly and economically.

FOUR MAJOR DEVELOPMENT STAGES

Five years after the Whitehouse invention (1830), the first furnace in the United States for making wrought iron pipe was built by Morris, Tasker, and Morris in the basement of a Philadelphia shop. In 1836 this firm erected a large mill and machine shop, and in 1849 a still larger building was constructed by the company to house nine pipe-welding furnaces. Gradually other pipe mills came into being in the United States, and the services of this useful product were greatly expanded.

Variations of the Russell and Whitehouse methods for making pipe from hot metal in the mills, either butt or lap welded, continue to this day; first from wrought iron, then wrought steel and presently various grades of carbon steel.

Early transmission lines made use of this pipe but due to diameter limitations, it is now used in the water industry almost exclusively in pumping and distribution service.

Between 1850 and 1860 the Age of Steel was really born, making possible the second development stage, that of producing large diameter water pipe by cold forming of sheet or plate. This was due to the invention of the Bessemer process for making steel. Until then, steel had been available only by the pound. This new process, followed shortly by the open hearth furnace, made steel available by thousands of tons. It provided the steel needed for the development of railroads, factories, tools, equipment, ships, skyscrapers, structural steel, penstocks, steel pipe for water as well as gas and oil service.

Five years after the historic 1849 Gold Rush in California, the Francis Smith Company established a shop in the mining town of Grass Valley, California, to produce water pipe for the gold miners. The pipe was made from thin English sheet iron riveted at the seams with cold rivets. It was transported by mule back to the mine sites for hydraulic operations. The pipe was laid by slipping the sections together like stove pipe. A water line of this material (22″ to 11″ diameter x 16 ga.) was laid at Railroad Flat, California in 1858 and has been in use almost continuously since that time. Then from 1863 to 1878, ten other riveted wrought steel water lines were installed in California and Nevada.

In 1887, near Riverside, California, about 45,000 feet of 24″ diameter riveted steel water pipe was installed. Most of this line was still in service in the 1950's, but was finally removed due to obsolescence.

In 1878, the Weigle Pipe Works in Denver, Colorado began the manufacture of riveted steel pipe for placer mining, irrigation, power, and municipal service. It was made of copper bearing steel, and was laid with slip joint ends.

The small plant which formed the nucleus of the many enormous works of the National Tube Company was established in East Boston in 1868.

It should be observed that during the period of 1858 to 1900, nearly all of the water pipe made was fabricated of riveted construction; at least two million feet had been installed by the end of that period, (Appendix A) presently 71 to 113 years in age.

Most of this pipe had meager protective coating, such as bitumen, asphalt, mineral rubber, galvanizing, or was just bare.

A third major development stage started at the turn of the century and lasted until about 1930. In 1905 the East Jersey Pipe Company began fabrication of Lock-Bar steel pipe in 30′ lengths with a new seam considered 100% efficient. Since single riveted seams were only 45% and double riveted seams 70% efficient, the new method made rapid inroads in the marketplace. Furthermore, the interior of this new pipe was smooth permitting 10% to 15% greater carrying capacity over riveted steel pipe and also superior to the latter as regards durability and cost.

During these three decades riveted steel pipe installation declined, especially after 1915, due to the development of Lock-Bar and later electric welding processes. However, a considerable quantity of riveted steel pipe was still being produced and a partial tabulation of installations from 1900 to 1915 indicates that about 3,000,000′ of this type of pipe 20″ and larger was manufactured and from 1916 to 1930 approximately 1,500,000′ more for an overall 30 year total of 4,500,000′ (Appendix A) as compared to 3,300,000′ of Lock-Bar pipe for the same period (Appendix B).

Also during this same time, there were several other types of steel pipe manufactured.

National Tube Company for example produced Matheson joint pipe of lap welded construction in sizes of 2″ to 30″ diameters x .095″ to .432″ wall thickness in 20′ sections. The field joints consisted of a bell and spigot into which lead was poured. The steel had a tensile strength of 52,000 psi and a yield point of 30,000 psi. The interior of the pipe was smooth, and therefore had greater carrying capacity than the same size of riveted pipe. National Tube also produced standard weight lap welded steel pipe of 2″ to 30″ diameters; and hammer welded steel pipe of 20″ to 96″ diameters x 1/4″ to 1-1/2″ thickness; and seamless steel pipe up to 26″ diameter.

In the 1920's, Taylor Forge & Pipe Works produced a spiral riveted steel pipe in sizes of 3" to 42" diameters; and Naylor Pipe Co. made a spiral lap welded line pipe in sizes of 4" to 12" in 20' sections using Toncan iron for the pipe shell.

The fourth stage started in the 1920's when automatic electric welded steel water pipe was developed. A partial tabulation of all sizes of this type produced during this decade indicates a total of about 1,700,000' (Appendix C). The first major electric welded steel water pipe line on the West Coast consisted of 116,000' of 24" and 22" diameter installed for the City of Vallejo, California in 1924. Also, during 1924, the East Bay Municipal Utility District (Oakland, California) started construction of the first unit of its Mokelumne aqueduct, which consisted of about 80 miles of 54" diameter electric welded steel pipe with heads up to 500'.

There were 10 major welded steel water pipelines produced in the 1920's, being the forerunners of this modern method of manufacture which has progressively improved to the present day.

During the Depression Years of the thirties, great progress was made in the technique of automatic welding with fluxes and the present day plasticized coal tar enamel was introduced. About 7,000,000' of pipe 20" and larger was produced in the period of 1922 to 1940 as well as an additional 15,000,000' of 4" to 20".

Although A. O. Smith of Milwaukee started the production of flash welded pipe for oil and gas transportation late in this decade, the development of automatic fusion welding in the water industry spread to the petroleum industry becoming a major impetus in the vast quantities produced immediately after World War II. The high working pressures required for gas transportation resulted in the production of higher strength steels than had ever been used in water transmission. In turn such steels up to 50,000 psi yield strength were then adopted for the water industry.

In 1939, a group of men representing steel pipe manufacturers known as the "Steel Water Pipe Manufacturers Technical Advisory Committee" was formed under the sponsorship of the American Water Works Association. This group (SWPMTAC) has prepared AWWA standards on riveted steel pipe, Lock-Bar steel pipe, welded steel pipe, coal tar enamel coatings, cement mortar coatings, field welding of steel pipe, steel flanges, steel pipe fittings, and a steel pipe design and installation manual (AWWA M11). This committee still exists, and keeps all of the standards and manual updated for the benefit of the water works industry.

During the first half of the 1940's, production of steel water pipe was held to a minimum because of the restrictive allotment system of war requirements. However a number of straight seam resistance and fusion welded, as well as spiral fusion welded, facilities developed for water pipe production manufactured over 8,000 miles (more than 40,000,000') of highly portable aboveground utility pipe (water, gasoline and oil). Both the U. S. Army Corps of Engineers and the U. S. Navy bought this type of pipe in sizes ranging from 3" to 12" with wall thickness ranging from 14 ga. to 10 ga.

When steel was difficult to get from the mills during the war for non-military purposes, several major water utilities solved this problem by purchasing old existing steel water pipelines, removing them, transporting them to their new location, rehabilitating them, and relaying them complete. This illustrates the salvageability of steel water pipe on an economical basis.

In spite of the limited steel availability for four years, well over 2,000,000' of large diameter water pipe was produced in this decade as evidenced by a partial tabulation in Appendix C. This was influenced considerably by extreme population growth in certain areas of the country as well as delay of normal waterworks growth due to the war.

Then the decade of the fifties began the era of even larger diameter and longer transmission lines (see Appendix C), a period in which over 5,400,000' was produced in the larger sizes.

During the early forty war years, concrete pipe was available and this industry received wide acceptance in lower working pressures and particularly for its low cost and simple field joints with permissible leakage factor. Up to this time steel pipe had always been joined in the field by flanges, riveting, welding or by use of patented type couplings.

Not long post war, several steel pipe firms developed O-ring gasketed joints for small diameter pipe and by the early fifties the principle was applied to large diameters up to 9 feet. Today considerable steel pipe with this joint has been installed in the 10 to 14 foot diameter range.

The last decade of the sixties has produced welded steel water pipelines of giant sizes, and fabricated from many new types of steel developed during this period for special services.

PART II. FABRICATION AND DESIGN DEVELOPMENT OF STEEL WATER PIPE

By the mid-1820's two methods of making wrought iron pipe from hot metal in the producing mills were developed; however it was not until the early 1850's that water pipe manufactured from sheet and plate was first rolled and riveted. This method of fabrication, well suited to production of pipe to economically meet the requirements of individually designed projects, continued with improvements into the 1930's. Pipe wall thicknesses could be readily varied to fit the different heads of a pipeline profile.

Because the early steels were of relatively low tensile strength and because the efficiency of cold riveted seams and riveted or drive stovepipe joints was also low, engineers of that day set a safe design stress at a low point of 10,000 psi. Their reasoning was probably also affected by the fact that there had been little experience with protective coatings to prevent corrosion, with of course, no anticipation of the highly efficient present day coatings complemented with cathodic protection.

Over the years as this method of fabrication improved and higher strength steels were developed, design stresses progressed generally on a 4 to 1 safety factor of tensile from 10,000 psi to 12,500, to 13,750, to 15,000, but in the instance of riveted pipe were adjusted to the particular seam efficiency. This type of pipe was furnished in sizes ranging from 4" through 144" and in thickness from 16 ga. to 1¼". Fabrication methods consisted of single, double, triple and even quadruple riveted seams varying in efficiency from 45% to 90% dependent on design.

The general method of fabrication was to roll and rivet cans of 4' to 8' lengths, then assemble in longer sections with riveted round seams into lengths up to approximately 30'. One firm however developed a method of spirally forming and riveting steel pipe in sizes from 3" through 42".

Lock-Bar pipe introduced in 1905 nearly supplanted riveted pipe by 1930. Fabrication consisted of first planing 30′ long plates to proper width, then after upsetting the longitudinal edges, rolling into half circle troughs 30′ long. H shaped bars of special configuration were then applied to the mating edges of two 30′ troughs making a full circle pipe section which was then clamped into position. This unit was then passed into a hydraulic pressing machine where the H bars were locked over the upset edges under a force of 350 tons per lineal foot of pipe.

Following the general procedure of the times, a 55,000 tensile steel was used which, with a 4 to 1 safety factor resulted in a 13,750 psi design stress. Lock-Bar pipe however had numerous advantages over riveted; it had only one or two straight seams and no round seams. These straight seams were considered as 100% efficient as compared to the generally 45% to 70% efficiency of riveted and then were smooth permitting 10% to 15% greater carrying capacity. Due to highly mechanized methods and fewer pieces to handle, production costs were somewhat lower.

Manufactured in sizes from 20″ through 74″ from plate ranging in thickness from 3/16″ to 1/2″, Lock-Bar took an increasingly greater part of the market until the advent of automatic electric welding in the mid-1920's. By the early 1930's both riveting and Lock-Bar methods gradually passed out of the picture.

Fabricators of automatic electric fusion welded pipe follow somewhat the same production sequences as for Lock-Bar. Through the thirties and into the forties, 30′ plates were used; however by the fifties some firms had obtained 40′ rolls and a few formed 40′ lengths in presses. Plates are longitudinally edge prepared depending on thickness by planing square, single bevel or double bevel, followed by pressing or rolling a narrow portion of the edges to the desired pipe radius before forming into full circle in drop-end pyramid rolls or for larger diameters to half circle. These latter are then fitted up in jigs for tackwelding prior to entering automatic welding machine track and pipe support frames where the smooth efficient seams are accomplished. In the early days welding was accomplished by flux coated rod from reels with an open arc, however it was soon found to be more efficient to use bare rod covering the weld position with about an inch of bulk flux.

A successful alternative method to the above is to weld two (or more depending on diameter) plates together in the flat and rolling to full circle in pyramid rolls prior to the final weld.

The obvious advantages of welding: fewer pieces, fewer operations, faster production, smaller seam protrusion, and equal 100% seam efficiency soon permitted welded pipe to dominate the field.

Several other forming methods and types of welding are prominent in the waterworks field. Spirally formed and welded pipe was developed in the early thirties and was used extensively in diameters from 4″ through 36″. Welding was by the electric fusion method. After World War II, German machines were imported and subsequently domestic ones were developed that can spirally form and weld through 96″ diameter.

Although some water pipe was manufactured by a firm that press formed and flash welded 30′ lengths, this method was used almost exclusively for high pressure service.

Another important method developed for the smaller diameter ranges to 20″ was that of forming from coils through continuously reducing rolls feeding into a resistance welding machine. This method is fast, efficient and can fabricate from 14 ga. through 3/8″ thicknesses.

During the thirties, the developing decade of welding, a new approach was taken to design stresses. Whereas prior to this time it was common practice to work with a 4 to 1 safety factor of the tensile strength, the concept of using 50% of the yield was generally accepted. Shortly after World War II, when higher yield steels were being used by the gas and petroleum industries, the use of steels up to 50,000 yield was accepted by the waterworks industry with resultant design stresses up to 25,000 psi. In some instances 60% and 65% of yield were used in the 42,000 psi and under yields.

There are three other important factors that are considered in the design of steel water pipe lines; types of field joints, corrosion prevention and external loading.

Various field joints are available to suit any construction condition and all are bottle tight not requiring a permissible leakage rate per hour or day as for other types of pipe. The most popular are O-ring gasket joints either formed on the pipe ends or the Carnegie gasket retainer welded to the spigot end, both good for operating pressures up to 350 psi. Either can be used in dry trench work or with proper harness for underwater installations.

Of the several welded joints, the most popular is the lap joint due to its ease of fit-up and because a single round seam fillet weld has been proven sufficiently strong to meet the pressure requirements of the pipe. Welding is of particular value for the higher pressures.

Mechanical couplings of the collar and ring or the clamp type as well as flanged joints find their use in special conditions such as make-up sections, attachment to pumps or special fittings, or temporary lines that might be moved with relative ease at some future time.

Concerning corrosion, recognized in the Bible by the use of the word rust, it is no longer a problem if the proper inexpensive preventive methods are taken. Some of the earliest fabricated water pipe was protected by coating with asphalt derivatives mostly by the hot dip method. In some cases in the past, designers added a rule-of-thumb percentage of thickness to the steel for further protection. Today this is very definitely a waste of good steel and money. In the late nineteen-twenties, variations of coal tar enamel came on the market several of which were applied by the hot dip process until application of lining by spinning the pipe was developed, giving a more uniform and smooth surface. The exterior coat and wrap was applied by rotation of the pipe generally at a slower peripheral speed. One company has developed equipment to line, coat and wrap simultaneously. With the development of plasticized enamels and vastly improved primers, this product today is the most widely used whether on water, gas and oil lines or many other steel products coming in contact with soil such as liquid storage, sewage treatment and other pollution control tanks.

Another protective coating popular in some sections of the country is cement mortar applied on the interior by the spinning method, on the exterior by gun application or cast over rod wrapping or wire mesh. The lining can also be applied in a pipeline after installation and numerous steel water pipelines are protected on the exterior with highly dielectric coal tar enamel impervious to water seepage and with field applied mortar lining.

To thoroughly complete corrosion protection in areas where soil conditions are extreme, the addition of cathodic protection is the answer. To many, these words have been a bug-a-boo in the past. Today it is a simple and inexpensive application well worth proper investigation. Numerous installations prove that it generally costs in the neighborhood of less than half of one percent of the price of the pipe delivered to the site, and if the impressed current method is used, the power cost is insignificant.

The next and very important design consideration to be considered is that of external loading. Pound for pound, steel has more strength than any other pipe material. As a result, very often internal pressure is not the controlling factor in determining wall thickness. This has been recognized for some time by engineers and there are those who have thought it necessary to answer the problem by rigidity. This approach is certainly not the answer as steel is a very strong, flexible material with a fine memory up to its yield point which is well above any working pressure.

Steel water pipe should be designed on a basis of economy and security without sacrificing quality or good performance. The generally accepted current criteria for the proper design of large diameter welded steel water pipelines as based on sound and economical engineering judgment and practice is as follows:

Determine the diameter, the head involved, and the depth of cover, if buried.

Then select the type of steel plate best suited for the service conditions. For low heads (under about 350′), use ASTM A283 C or D steel plate, and for high heads, use the ASTM A572 series of steels. (Special cases should consider other types of steel as indicated in Appendix E.)

Then for *buried* pipe, determine the wall thickness required for internal water pressure from the Barlow Hoop Tension Formula –

$$t = \frac{PD}{2S}$$

S is the design stress in the shell plate based on a value of at least 60% of the yield point, or 1/3 of the ultimate tensile strength, whichever is lowest. (Some major water utilities use a value of 65% of the yield point.)

Then determine the D/t ratio. If this ratio is less than 300, there is no danger of buckling. If this ratio is greater than 300, consideration should be given to using stulls in the pipe until the backfilling has been completed.

Then determine the deflection of the buried pipe from the Spangler or Watkins formula based on the thickness obtained for internal pressure, and the depth of cover using an 85% minimum compaction value for the backfill. Considering the most recent work of Dr. Watkins, an E′ of 1500 is recommended. If the calculated deflection is less than 5% of the pipe diameter, the design is safe and sound. If the deflection should be greater than 5%, it can be reduced to proper limits by ellipsing the vertical diameter with stulls in the amount of the excess deflection. After the backfilling has been completed, the stulls can be removed, and the pipe will assume its proper position.

If the pipe will be laid above the ground, it can be supported by cradles or by ring girders. If the D/t ratio is less than 300, there is no danger of buckling; and if the D/t ratio is less than 158, there is no danger of pipe collapse from full vacuum. If the D/t ratio is greater than 300, consideration should be given to using some stiffener rings on the outside of the pipe.

When designing steel water pipelines, reference should be made to the latest edition of AWWA steel pipe standards, and good use can be made of the Steel Plate Fabricators Association's Welded Steel Water Pipe Manual and Federal Specification WW-P-1432 all readily obtainable.

PART III. APPENDICES

APPENDIX A – Service life tabulation of riveted steel water pipe installations from 1858 to 1900; and tabulation of riveted steel water pipe installations from 1901 to 1933.

APPENDIX B – Tabulation of Lock-Bar steel water pipe installations from 1905 to 1932.

APPENDIX C – Tabulation of welded steel water pipe installations from 1922 to 1970 by decade periods:

1922 to 1930
1931 to 1940
1941 to 1950
1951 to 1960
1961 to 1970

APPENDIX D – Summary of Appendices A, B and C.

APPENDIX E – Types of steel available for steel water pipe service.

APPENDIX F – Long major aqueducts tabulation.

APPENDIX G – Steel water pipeline field joints.

APPENDIX H – Steel water pipe specifications.

APPENDIX I – Types of steel water pipe.

APPENDIX A

SERVICE LIFE OF STEEL WATER PIPE

Partial Tabulation of Steel Water Pipe Installations
(Prior to 1900 including some early wrought iron pipe)

Year Installed	Location	Diameter Inches	Thickness	Footage Feet	Type
1858	Railroad Flat, California	22 - 11	16 Ga.	—	Riveted
1860	New York, New York	90	1/2"	1,000	Riveted
1863	San Francisco, California	37 - 30	1/4"	27,280	Riveted
1868	Humbug, California	26	16 Ga.	—	Riveted
1868	San Francisco, California	30	12 Ga.	80,000	Riveted
1870	San Francisco, California	30	12 Ga.	42,240	Riveted
1870	Magalia, California	30	10 Ga.	—	Riveted
1870	Pioche, Nevada	5	14 Ga.	8,000	Riveted
1871	Lawrence, Massachusetts	77	3/8"	—	Riveted
1871	San Francisco, California	22	9 Ga.	2,105	Riveted
1871	North Bloomfield, California	14 - 10	—	—	Riveted
1873	Santa Rosa, California	11 - 9	16 Ga.	10,000	Riveted
1873	Virginia City, Nevada	12	5/16" - 1/16"	37,000	Riveted
1874	Carson City, Nevada	12 - 7	16 Ga.	10,000	Riveted
1874	Pittsburgh, Pennsylvania	50	—	2,900	Riveted
1874	Rochester, New York	36	—	50,000	Riveted
1875	San Francisco, California	22	9 Ga.	12,226	Riveted
1875	Oakland, California	24	3/16"	—	Riveted
1876	Rochester, New York	24	—	10,451	Riveted
1878	Texas Creek, California	17	9 - 14 Ga.	4,000	Riveted
1880	Los Angeles, California	44	1/8"	17,000	Riveted
1880	San Fernando, California	8	—	—	Riveted
1881	Lawrence, Massachusetts	77	3/8"	—	Riveted
1882	San Francisco, California	30 - 22	1/4" - 1/8"	14,000	Riveted
1882	Longmont, Colorado	6	—	23,000	Riveted
1882	Holyoke, Massachusetts	103	—	—	Riveted
1883	Fort Collins, Colorado	10	3/16"	18,000	Welded
1883	San Francisco, California	30	3 Ga.	3,480	Riveted
1884	San Francisco, California	33	1/4"	2,409	Riveted
1885	San Francisco, California	44 - 30	1/4" - 6 Ga.	103,409	Riveted
1886	Lawrence, Massachusetts	84	—	—	Riveted
1886	San Francisco, California	30	3 Ga.	4,513	Riveted
1887	Alhambra, California	10 - 4	16 Ga.	3,200	Riveted
1887	Riverside, California	24	—	45,000	Riveted
1887	San Francisco, California	36	9 Ga.	100,000	Riveted
1887	Pasadena, California	6	—	—	Riveted
1888	San Francisco, California	22	—	12,000	Riveted
1888	Pasadena, California	22	14 Ga.	18,000	Riveted
1888	Sierra Madre, California	6 - 4	16 Ga.	15,000	Riveted
1888	Altadena, California	8	16 Ga.	1,200	Riveted
1888	Redlands, California	24	11 Ga.	2,200	Riveted
1888	Chula Vista, California	6	12 Ga.	—	Riveted
1889	Nephi, Utah	3	16 Ga.	1,500	Riveted
1889	Alhambra, California	7	16 Ga.	900	Riveted
1889	San Francisco, California	44	3 Ga.	4,878	Riveted
1889	Pasadena, California	13	14 Ga.	6,000	Riveted
1890	San Jose, California	18	12 Ga.	31,000	Riveted
1890	Santa Cruz, California	14	9 Ga.	—	Riveted
1890	Detroit, Michigan	72	—	—	Riveted
1890	Redlands, California	8	—	6,000	Riveted
1890	Walla Walla, Washington	20 - 6	7 - 14 Ga.	100,000	Riveted
1891	Newark, New Jersey	48	3/8" - 1/4"	111,800	Riveted
1891	Newark, New Jersey	36	1/4"	23,980	Riveted
1891	Pittsburgh, Pennsylvania	50	5/8"	3,600	Riveted
1891	The Dalles, Oregon	10	10 Ga.	8,000	Riveted
1891	Pocatello, Idaho	12	16 Ga.	6,000	Riveted
1892	Pasadena, California	20 - 4	14 Ga.	5,000	Riveted
1892	Butte, Montana	20	—	3,114	Riveted
1893	Syracuse, New York	54	3/8"	6,500	Riveted
1893	Rochester, New York	38 - 36	5/16"	136,000	Riveted
1894	Portland, Oregon	42 - 33	5/16" - 6 Ga.	132,000	Riveted
1894	Passaic Valley, New Jersey	30	5/16"	12,300	—
1895	Whittier, California	10	10 Ga.	15,000	Riveted
1895	National City, California	24	11 Ga.	26,000	Riveted
1895	Altadena, California	12	14 Ga.	5,000	Riveted
1895	Pasadena, California	8	14 Ga.	1,200	Riveted
1895	Vancouver, British Columbia	22 - 16	12 Ga.	52,000	Riveted
1895	San Francisco, California	30	1/4"	4,090	Riveted
1895	Kearney, New Jersey	42	—	8,800	Riveted
1895	Colorado	8 - 6	16 Ga.	42,700	Riveted
1895	Cambridge, Massachusetts	42	—	20,000	—
1896	Minneapolis, Minnesota	48	—	31,680	Riveted
1896	Newark, New Jersey	48 - 42	1/4"	126,000	Riveted
1896	Passaic Valley, New Jersey	42	3/8" - 1/4"	8,700	Riveted
1896	New Bedford, Massachusetts	48	5/16"	42,000	Riveted
1896	Bayonne, New Jersey	30	—	44,000	—
1896	New Westminster, British Columbia	14	—	70,000	Riveted
1896	New York, New York	72	—	—	Riveted
1897	Minneapolis, Minnesota	50	7/16" - 5/16"	16,605	Riveted
1897	Ogden, Utah	72	11/16" - 3/8"	4,600	Riveted
1897	Patterson, New Jersey	42	5/16"	40,000	Riveted
1897	Jersey City, New Jersey	48	1/2"	—	Riveted
1897	Colorado	18 - 6	6 - 16 Ga.	4,400	Riveted
1898	Red Bluff, California	7	14 Ga.	9,000	Riveted
1898	Duluth, Minnesota	42	1/2" - 1/4"	30,500	Riveted
1898	Allegheny, Pennsylvania	50	—	—	Riveted
1898	Albany, New York	48	—	8,000	Riveted
1899	Colorado	18 - 10	14 - 16 Ga.	22,000	Riveted
1899	Little Falls, New Jersey	66 - 36	—	—	—
1899	Lawrence, Massachusetts	108	3/8"	154	Riveted
1899	Los Angeles	44	—	—	Riveted
1899	Passaic Valley, New Jersey	51	7/16" - 1/4"	44,600	Riveted
1899	Seattle, Washington	42	1/4"	32,000	Riveted
1899	Kern, California	60 - 48	1/2" - 12 Ga.	5,000	Riveted

APPENDIX A (Cont'd.)

Year Installed	Location	Diameter Inches	Thickness	Footage Feet	Type
1899	Newark, New Jersey	51 - 48	1/4"	47,000	Riveted
1899	Pittsburgh, Pennsylvania	48	–	4,400	–
1900	Redlands, California	4	14 Ga.	3,000	Riveted
1900	San Francisco, California	36	7 Ga.	420	Riveted
1900	Victor, Colorado	29	3/16"	2,500	Riveted
1900	Marquette, Michigan	42	–	600	Riveted
1900	Butte, Montana	26	–	33,910	Riveted
1900	Montebello, California	16	10 Ga.	5,000	Riveted
1900	Colorado	17	4 - 8 Ga.	1,920	Riveted
1900	Passaic Valley, New Jersey	42	5/16"	18,600	Riveted

APPROXIMATE TOTAL FOOTAGE = 2,000,000

Partial Tabulation of Riveted Steel Water Pipe Installations
1901 to 1933

Year Installed	Location	Diameter Inches	Thickness	Footage Feet
1901	Pittsburgh, Pennsylvania	50 - 42	3/8"	17,000
1901	Atlantic City, New Jersey	30	1/4"	27,000
1901	Niagara, New York	84	–	6,500
1901	Seattle, Washington	42	–	61,000
1902	Montebello, California	20	12 Ga.	–
1902	Jersey City, New Jersey	72	11/16" - 5/16"	93,000
1903	Boston, Massachusetts	90	7/16"	4,000
1903	Pittsburgh, Pennsylvania	48	1/2"	4,000
1903	Sacramento, California	24	1/4"	9,000
1903	Newark, New Jersey	60 - 48	5/16"	40,000
1903	Jersey City, New Jersey	72	11/16" - 5/16"	–
1903	Kansas City, Missouri	36	–	35,000
1903	Troy, New York	33	3/8"	35,000
1903	Schenectady, New York	36	–	23,716
1904	Bayonne, New Jersey	30	3/8" - 1/4"	4,000
1904	Astoria, New York	60	–	15,000
1904	Erie, Pennsylvania	60	–	7,920
1904	Toronto, Ontario	72	–	6,000
1904	Red Bluff, California	12	10 Ga.	1,600
1904	San Bernardino, California	20	10 Ga.	16,800
1905	Troy, New York	33	–	35,780
1905	Los Angeles, California	98 - 16	1/2" - 3/16"	1,108,000
1905	St. Louis, Missouri	84	1/2"	18,960
1905	Cincinnati, Ohio	84	–	1,521
1905	Springfield, Massachusetts	54 - 42	–	63,500
1905	Los Angeles, California	24 - 16	3/16"	13,200
1906	Brooklyn, New York	72	–	42,300
1906	Pittsburgh, Pennsylvania	72 - 30	3/8" - 1/4"	47,000
1906	Fair Oaks, California	28 - 24	12 Ga.	14,210
1906	San Francisco, California	36 - 30	9 - 7 Ga.	139,400
1907	Pittsburgh, Pennsylvania	36	3/8"	3,700
1907	Niagara, New York	108	5/16" - 1/4"	564
1907	St. Louis, Missouri	84	–	20,000
1907	Kern, California	84 - 60	1-3/8" - 5/16"	4,175
1907	Philadelphia, Pennsylvania	48 - 36	–	54,000
1908	Canyon, California	36	12 Ga.	2,450
1908	Passaic Valley, New Jersey	30	1/4"	15,400
1908	Philadelphia, Pennsylvania	132	–	1,590
1908	Colorado	34	8 - 16 Ga.	31,910
1909	Seattle, Washington	51 - 48	3/8" - 5/16"	10,700
1909	Boulder, Colorado	60	1/2"	2,640
1909	Erie, Pennsylvania	56	–	5,280
1909	Vancouver, British Columbia	24	1/4" - 3/16"	73,000
1910	New York, New York	36	3/16"	11,000
1910	New York, New York	135 - 114	3/4" - 7/16"	33,000
1910	Montrose, California	36 - 26	–	5,200
1910	Pittsburgh, Pennsylvania	24	–	5,000
1910	Brooklyn, New York	48	–	16,200
1910	Paterson, New Jersey	42	5/16"	2,000
1911	Pasadena, California	30	10 Ga.	10,297
1911	Calgary, Alberta	144 - 114	1/2"	516
1911	Tacoma, Washington	46 - 39	1/2" - 1/4"	7,300
1911	New York, New York	66	–	8,510
1911	Medford, Oregon	60 - 48	3/8" - 1/4"	1,093
1911	Verdi, Nevada	78	3/8" - 1/4"	790
1912	Juneau, Alaska	42 - 30	1/4" - 3/16"	1,655
1912	Alaska	40 - 30	1/2" - 1/4"	9,000
1912	Los Angeles, California	68 - 64	3/8" - 5/16"	28,940
1912	Pittsburgh, Pennsylvania	30	1/2"	5,300
1912	Seattle, Washington	42	–	13,243
1912	Pittsburgh, Pennsylvania	72 - 60	1/2" - 3/8"	5,280
1912	Altman, New York	138 - 96	5/8"	2,000
1912	Belleville, Ohio	168	–	2,920
1912	Montclair, New Jersey	24	–	7,343
1912	Chihuahua, Mexico	102	–	1,400
1913	Los Angeles, California	72	–	–
1913	Los Angeles, California	84	1/2" - 3/8"	1,378
1913	Baltimore, Maryland	120	7/16"	2,465
1913	Murray City, Utah	26 - 22	7 Ga.	3,882
1913	Vancouver, British Columbia	36 - 26	3/8" - 1/4"	46,250
1913	Kansas City, Missouri	48	–	1,220
1913	Cleveland, Ohio	48	1/4"	2,265
1913	Falls Village, Connecticut	108	3/8" - 5/16"	826
1913	Niagara, New York	96 - 72	5/8" - 5/16"	3,400
1913	Lock Raven, Maryland	120	7/16"	2,464
1913	Ocoe, Tennessee	96	5/8"	1,320
1913	Croghan, New York	114	–	2,555
1913	Altman, New York	138	5/8"	1,194
1913	Los Angeles, California	132 - 90	1-1/8" - 1/4"	49,575
1914	Pittsburgh, Pennsylvania	48 - 42	–	3,060
1914	Butte, Montana	24	–	12,950

APPENDIX A (Cont'd.)

Year Installed	Location	Diameter Inches	Thickness	Footage Feet
1914	Baltimore, Maryland	120	7/16"	–
1914	Tacoma, Washington	30	1/4"	550
1914	Springfield, Massachusetts	42	–	–
1914	Fremont, Ohio	168	–	2,861
1914	Cleveland, Ohio	48	–	1,320
1914	Massena, New York	24	3/8" - 1/4"	22,000
1914	Miami, Arizona	152	–	1,670
1914	Riverside, California	30 - 20	–	40,400
1914	Niagara, New York	120	1/4"	1,106
1914	Cleveland, Ohio	72 - 66	–	3,960
1915	Baltimore, Maryland	84	7/16"	4,000
1915	Pittsburgh, Pennsylvania	48	1/2"	3,900
1915	Greeley, Colorado	20	–	5,280
1915	Massena, New York	24	3/8" - 5/16"	5,000
1915	Ogden, Utah	24	–	17,250
1915	San Bernardino, California	20	3/16"	3,500
1915	Victoria, British Columbia	36	3/8" - 5/16"	56,677
1915	Placerville, California	30	1/2" - 3/16"	915
1916	Follansbee, West Virginia	30	–	288
1916	Minneapolis, Minnesota	48 - 40	–	6,555
1916	Painesville, Ohio	54	–	1,320
1916	Braden Copper Company	80	–	4,134
1917	Terra Bella, California	36 - 20	14 Ga.	200,000
1917	Lindsay-Strathmore, California	36	10 Ga.	1,200
1917	Everett, Washington	28	1/4"	20,300
1917	Minneapolis, Minnesota	48	–	835
1917	Olmstead, Utah	90 - 72	5/8" - 1/2"	4,580
1917	Portsmouth, Ohio	48	1/4"	880
1917	Talluha Falls, Georgia	60	–	1,224
1917	Oakland, California	24	–	4,130
1917	Georgia Railway Company	156	–	680
1918	Salinas, California	34	3/16"	3,362
1919	Butte, Montana	26 - 24	–	33,485
1920	Wessels, Duval Company	60 - 42	11/16" - 1/4"	3,781
1920	J. G. White Company	36 - 30	3/8" - 1/4"	23,000
1920	Spring Valley, California	30 - 22	5/16"	–
1921	Sacramento, California	30	3/8" - 1/4"	7,964
1922	Sacramento, California	60 - 42	3/8" - 5/16"	1,819
1922	Bay City, Michigan	38 - 26	–	31,800
1922	Honolulu, T.H.	30	5/16"	400
1922	Madison, Iowa	108	7/16" - 3/8"	1,037
1922	Minneapolis, Minnesota	48	–	1,320
1922	Oakland, California	30	1/4"	7,174
1922	Seattle, Washington	66 - 48	9/16" - 5/16"	29,200
1922	Shasta, California	84	5/16"	320
1922	Walla Walla, Washington	24	5/16"	11,182
1922	Georgia Railway Company	56	1/4"	128
1923	Oakland, California	24 - 20	–	18,500
1923	San Francisco, California	60	7/16" - 5/16"	100,000
1923	Covina, California	54 - 28	–	–
1923	Cleveland, Ohio	48 - 36	–	1,317
1923	Cleveland, Ohio	72	1/2"	201
1923	Florence, Alabama	108	–	1,048
1923	Longview, Washington	48	3/8"	1,158
1923	Philadelphia, Pennsylvania	48 - 30	–	2,640
1923	Phoenix, Oregon	100 - 36	–	188
1923	Portland, Oregon	100	3/8" - 5/16"	1,285
1923	Wheeling, West Virginia	31	–	26,400
1923	Cuba	57	–	1,742
1924	Gage Canal, California	62	5/16"	1,123
1924	Dominguez, California	33 - 20	–	100,000
1924	Fillmore, California	36 - 24	–	20,000
1924	Albany, New York	48 - 26	–	1,340
1924	Badin, North Carolina	180	11/16" - 1/2"	302
1924	Irvington-Niles, California	44	1/4"	21,120
1924	Irvington-Redwood, California	60	7/16" - 5/16"	102,432
1924	Oakland, California	30 - 20	3/16"	40,000
1924	Philadelphia, Pennsylvania	48 - 20	–	19,934
1924	Pittsburgh, Pennsylvania	42	1/2"	440
1924	St. Paul, Minnesota	60 - 32	–	8,300
1924	Tacoma, Washington	48 - 30	5/16" - 1/4"	2,295
1924	San Salvador, Central America	48	1/4" - 3/16"	815
1925	Providence, Rhode Island	66	3/8" - 5/16"	10,500
1925	Puente, California	20	14 Ga.	18,000
1925	Hemet, California	30	–	50,000
1925	Detroit, Michigan	44	–	21,120
1925	Flint, Michigan	50	–	16,500
1925	Philadelphia, Pennsylvania	48	–	1,200
1925	Pittsburgh, Pennsylvania	20	–	1,340
1925	Pottsdam, New York	72	1/4"	2,510
1925	St. Louis, Missouri	62 - 49	–	95,000
1926	Santa Paula, California	30 - 24	–	10,000
1926	Boston, Massachusetts	30	3/8"	7,230
1926	Brooklyn, New York	60	1/2"	13,100
1926	Detroit, Michigan	50	–	2,680
1926	Flint, Michigan	50 - 44	3/8" - 5/16"	1,385
1926	Honolulu, T.H.	20	3/16"	4,500
1926	Minneapolis, Minnesota	66 - 50	–	8,464
1926	New York, New York	30	1/2"	2,800
1926	Philadelphia, Pennsylvania	30	–	5,280
1926	Ciael Chopia	84	1/2"	413
1927	San Jacinto, California	30 - 20	–	5,000
1927	Yorba Linda, California	26	–	20,000
1927	Allen Falls, New York	84	9/16" - 5/16"	10,255
1927	New York, New York	36	1/2"	4,430
1927	Buhl, Idaho	90	1/4"	1,127
1927	Detroit, Michigan	36	3/16"	350
1927	Saginaw, Michigan	36 - 30	–	21,120

APPENDIX A (Cont'd.)

Year Installed	Location	Diameter Inches	Thickness	Footage Feet
1927	St. Louis, Missouri	60 - 48	1/2"	1,700
1928	Vancouver, British Columbia	60 - 20	9/16" - 1/4"	100,000
1928	Detroit, Michigan	96 - 48	3/4"	774
1928	Honolulu, T.H.	31	5/16"	826
1928	Kenka Lake, New York	42	1/2"	840
1928	San Francisco, California	44	1/4"	6,650
1928	New York, New York	48 - 36	1/2"	5,000
1928	Philadelphia, Pennsylvania	93 - 30	9/16" - 5/16"	38,450
1928	Pittsburgh, Pennsylvania	30 - 24	1/2"	6,000
1928	Youngstown, Ohio	88	—	548
1929	New York, New York	77 - 66	1/2"	7,210
1929	Cleveland, Ohio	48 - 30	5/8" - 1/2"	2,173
1929	Detroit, Michigan	72 - 42	5/8" - 1/2"	7,850
1929	Erie, Pennsylvania	72	1/2"	7,900
1929	Harper, Oregon	153	5/16"	3,308
1929	Kearney, New Jersey	33	5/16"	680
1929	Wanaque, New Jersey	84	9/16"	6,520
1930	Philadelphia, Pennsylvania	30 - 24	3/8"	7,120
1930	Boston, Massachusetts	48	3/4"	2,200
1930	Detroit, Michigan	72 - 48	5/8"	20,921
1930	Erie, Pennsylvania	72	—	11,695
1930	Los Angeles, California	30	3/8"	12,312
1930	New York, New York	72 - 36	1/2"	21,940
1930	Pittsburgh, Pennsylvania	84 - 72	3/8"	673
1930	Seattle, Washington	66 - 48	9/16" - 1/2"	5,635
1930	U.S.B.R. — Vale, Oregon	101	7/16" - 5/16"	7,130
1931	U.S.B.R. — Yakima, Washington	145	3/4" - 7/16"	552
1931	Detroit, Michigan	72	5/8"	2,150
1931	Los Angeles, California	48 - 45	3/8" - 1/4"	5,043
1931	New York, New York	72 - 20	1/2"	2,020
1931	Pittsburgh, Pennsylvania	84 - 72	—	673
1931	Placerville, California	30	1/4"	795
1933	New York, New York	30	1/2"	196

APPROXIMATE TOTAL FOOTAGE = 5,220,000

APPENDIX B

Partial Tabulation of Lock-Bar Steel Water Pipe Installations 1905 to 1932

Year Installed	Location	Diameter Inches	Thickness	Footage Feet
1905	Passaic Valley, New Jersey	48 - 42	1/4"	10,000
1905	Pittsburgh, Pennsylvania	50 - 30	3/8" - 1/4"	28,500
1905	Lynchburg, Virginia	30	—	11,500
1905	Wilmington, Delaware	48 - 43	—	20,000
1905	Paterson, New Jersey	48 - 42	1/4"	11,500
1906	Philadelphia, Pennsylvania	48 - 36	—	86,980
1906	New York, New York	72	7/16"	125,000
1906	Honolulu, Hawaii	30	—	8,000
1907	Wilmington, Delaware	48 - 43	7/16" - 3/8"	20,340
1907	Trenton, New Jersey	48	5/16"	7,000
1907	Lockport, New York	30	1/4"	68,640
1907	Vancouver, British Columbia	30 - 22	5/16" - 1/4"	65,000
1907	Montreal, Canada	36	—	11,000
1907	Gary, Indiana	36	1/4"	4,000
1908	Springfield, Massachusetts	54 - 42	7/16" - 1/4"	75,000
1908	Seattle, Washington	42	3/8" - 1/4"	17,394
1908	Michigan City, Indiana	30	—	4,000
1908	Montreal, Canada	36	—	25,000
1909	Springfield, Massachusetts	42 - 30	3/8"	24,290
1909	Portland, Oregon	48 - 24	1/4"	17,600
1909	Brooklyn, New York	72	—	83,000
1910	Ensley, Alabama	50	3/8" - 5/16"	8,840
1910	New York, New York	48	7/16"	16,000
1910	Pittsburgh, Pennsylvania	24	—	5,000
1910	Portland, Oregon	52 - 44	1/4"	128,000
1910	Seattle, Washington	42 - 24	1/4"	23,600
1910	Seattle, Washington	32	—	4,050
1910	Butte, Montana	42	—	1,200
1910	Washington, D.C.	30	1/4"	1,220
1910	Cuba	36 - 28	—	1,300
1911	Pennsylvania Railroad	20	—	7,770
1911	Denver, Colorado	60	3/8"	1,200
1911	Portland, Oregon	52 - 44	5/16" - 1/4"	130,000
1911	Seattle, Washington	42 - 44	1/4"	16,000
1911	Montreal, Canada	48 - 30	—	7,300
1911	Lakeland, Florida	20	—	4,000
1911	Massena, New York	24	—	1,323
1911	Marquette, Michigan	66	—	8,000
1911	Philadelphia, Pennsylvania	20	—	7,770
1912	Omaha, Nebraska	48	—	10,550
1912	Ottawa, Canada	42	3/16"	2,400
1912	Union Bay, British Columbia	50	—	1,320
1912	Rochester, New York	66	—	9,200
1912	Washington, D.C.	36 - 24	1/4"	471
1912	Winnipeg, Canada	36	—	42,500
1912	Akron, Ohio	36	7/16" - 1/4"	56,000
1912	Denver, Colorado	60		—
1913	Minneapolis, Minnesota	54 - 48	7/16" - 5/16"	39,000
1913	Montclair, New Jersey	24	1/4"	7,325
1913	Utica, New York	36	1/4"	1,000
1913	Winnipeg, Canada	36	1/4"	42,000
1913	Schenectady, New York	24	1/4"	2,420

APPENDIX B (Cont'd.)

Year Installed	Location	Diameter Inches	Thickness	Footage Feet
1913	Massena, New York	24	–	1,200
1913	Wilkes-Barre, Pennsylvania	36	–	1,335
1914	Minneapolis, Minnesota	48	1/2" - 1/4"	11,970
1914	New York, New York	66	1/2" - 7/16"	12,500
1914	Utica, New York	30	1/4"	1,000
1914	Brooklyn, New York	66	–	12,200
1914	Ottawa, Canada	51	–	15,000
1914	Schenectady, New York	36	3/8"	10,500
1914	Winnipeg, Canada	36	1/4"	21,569
1914	Essex Junction, Vermont	36	–	2,440
1914	Rochester, New York	66 - 48	–	1,120
1914	Rutland, Vermont	54	–	2,750
1915	Minneapolis, Minnesota	48	–	7,355
1915	Ottawa, Canada	51	–	15,000
1916	Seattle, Washington	42	–	2,625
1916	Ottawa, Canada	51	–	1,945
1916	Minneapolis, Minnesota	48 - 40	–	7,341
1916	Rochester, New York	37	–	50,754
1916	St. Louis, Missouri	36	–	26,700
1916	Brandon, Vermont	36	–	2,344
1916	Gary, Indiana	36	–	1,865
1917	Eastman-Kodak	42	–	7,910
1917	Rochester, New York	37	–	42,140
1917	Carnegie Gas Company	54 - 30	–	48,537
1918	Carnegie Gas Company	40	–	12,000
1919	Akron, Ohio	48	–	12,000
1919	Jersey City, New Jersey	72	–	88,000
1920	Elyria, Ohio	36	–	24,500
1920	Port Henry, Vermont	40 - 36	–	3,000
1920	Passaic, New Jersey	30	–	12,300
1920	Salt Lake City, Utah	36	–	1,200
1920	Bayonne, New Jersey	48	–	44,000
1920	Akron, Ohio	48	–	21,250
1920	Detroit, Michigan	48	–	21,930
1921	Detroit, Michigan	48	–	19,000
1921	Saginaw, Michigan	36	–	5,000
1921	Philadelphia, Pennsylvania	72 - 36	–	10,500
1922	Cleveland, Ohio	60	–	20,000
1922	Montreal, Canada	48 - 36	–	13,000
1922	Detroit, Michigan	36	–	5,000
1922	Bay City, Michigan	48	–	4,000
1923	Cleveland, Ohio	60	–	10,400
1923	Brooklyn, New York	72 - 60	–	58,230
1923	Detroit, Michigan	24	–	7,890
1923	Kearney, New Jersey	30	–	5,600
1923	Elyria, Ohio	36	–	1,400
1923	Portland, Oregon	58 - 50	5/16" - 1/4"	132,000
1924	Boston, Massachusetts	68 - 56	–	44,359
1924	Kearney, New Jersey	30	–	5,150
1924	Philadelphia, Pennsylvania	48	–	9,100
1924	Cleveland, Ohio	48 - 42	–	7,720
1924	Seattle, Washington	54 - 24	–	28,217
1925	Seattle, Washington	54 - 24	–	18,779
1925	Philadelphia, Pennsylvania	36 - 30	–	10,300
1925	New York, New York	72	–	14,360
1925	Cleveland, Ohio	48 - 36	–	19,025
1925	Tacoma, Washington	64	–	2,276
1925	Detroit, Michigan	60 - 48	–	33,686
1925	Montreal, Canada	48 - 42	–	13,583
1925	Garfield, New Jersey	30	–	7,600
1925	Omaha, Nebraska	48	–	21,970
1926	Garfield, New Jersey	30	–	7,600
1926	Seattle, Washington	54	–	8,330
1926	Portland, Oregon	40 - 24	–	22,775
1926	Tacoma, Washington	52	–	2,600
1926	Fairbanks, Alaska	56 - 46	7/16" - 1/4"	34,380
1926	San Diego, California	36	1/2" - 5/16"	88,791
1926	New York, New York	36	–	1,072
1926	Montreal, Canada	36	–	2,583
1926	Garfield, New Jersey	30	–	5,185
1926	Kearny, New Jersey	36	–	4,300
1926	Oakland, California	54	7/16"	2,448
1927	Miami, Florida	51 - 45	–	3,050
1927	San Francisco, California	54	–	55,000
1927	Kearny, New Jersey	48 - 30	–	24,287
1927	Minneapolis, Minnesota	48	–	49,130
1927	Sacramento, California	42 - 24	5/16" - 1/4"	8,700
1928	New York, New York	48 - 36	–	9,270
1928	San Francisco, California	54	7/16" - 1/4"	56,097
1928	Grove, New Jersey	54	–	3,257
1928	Kearny, New Jersey	48 - 42	–	9,670
1928	St. John, New Brunswick	36	–	5,465
1929	Wanaque Aqueduct, New Jersey	74	1/2" - 7/16"	171,500
1929	Seattle, Washington	54	–	28,000
1929	Newark, New Jersey	60	–	25,400
1929	Minneapolis, Minnesota	48	–	15,500
1929	Pittsburgh, Pennsylvania	36	–	1,100
1929	Detroit, Michigan	60 - 48	–	14,700
1930	Seattle, Washington	54 - 24	7/16" - 5/16"	34,000
1930	New York, New York	48	1/2"	8,700
1930	Minneapolis, Minnesota	48 - 42	5/16"	31,000
1930	Kearny, New Jersey	36	3/8"	9,555
1931	New Jersey	52	1/2"	30,000
1931	Minneapolis, Minnesota	60 - 50	7/16" - 3/8"	2,000
1931	Kearny, New Jersey	36	3/8"	11,100
1932	Minneapolis, Minnesota	42 - 36	–	22,000
1932	Newark, New Jersey	42	–	2,750

APPROXIMATE TOTAL FOOTAGE = 3,400,000

APPENDIX C

Partial Tabulation of WELDED Steel Water Pipe Installations – 1922 to 1970

1922 to 1930

Year Installed	Location	Diameter Inches	Thickness	Footage Feet
1922	Walla Walla, Washington	24 - 20	3/16″	6,108
1922	Spokane, Washington	30 - 24	1/4″ - 7/32″	3,030
1923	Astoria, Oregon	22	1/4″	39,510
1923	Banta, California	48	3/16″	4,000
1923	Tacoma, Washington	30	1/4″	1,159
1924	Vallejo, California	24 - 22	1/4″ - 3/16″	116,160
1924	Oakland, California	54	3/8″ - 1/2″	435,000
1925	Oakland, California	42	1/4″	4,210
1925	San Francisco, California	30	3/16″	4,500
1925	Stockton, California	36	3/16″	1,128
1926	Laguna Beach, California	30	3/16″	43,442
1926	San Rafael, California	30 - 26	1/4″	37,400
1926	Roseville, California	25 - 22	3/16″	8,212
1926	Bakersfield, California	30	3/16″	17,000
1926	Bunker, California	48	1/4″	470
1926	Newark, California	60 - 48	3/8″ - 1/4″	577
1926	Pacific Grove, California	22	3/16″	2,500
1926	San Francisco, California	36 - 20	3/16″	10,700
1926	Storrie, California	36 - 20	1/4″ - 3/16″	42,240
1926	La Mesa, California	24	10 Ga.	21,120
1927	Oakland, California	54 - 20	1/2″ - 3/16″	4,400
1927	Santa Cruz, California	24 - 20	3/16″	1,015
1927	Springfield, Massachusetts	72 - 36	1/2″ - 5/16″	37,000
1927	Yakima, Washington	24	1/4″ - 3/16″	17,903
1928	Everett, Washington	30	–	115,000
1928	Boston, Massachusetts	30	3/8″	19,000
1928	Mt. Clemens, Michigan	30	–	5,000
1928	Tacoma, Washington	51 - 48	5/16″	1,650
1928	New York, New York	60 - 36	1/2″	25,390
1928	Oakland, California	20	3/16″	1,200
1928	Pacific Grove, California	30	1/4″	12,890
1928	San Francisco, California	24 - 20	1/4″ - 3/16″	31,760
1929	Boston, Massachusetts	60 - 36	1/2″	8,800
1929	Cleveland, Ohio	36 - 30	1/2″	1,340
1929	Detroit, Michigan	66 - 48	1/2″	26,237
1929	Honolulu, T.H.	30	3/16″	351
1929	Madera, California	30	1/4″	12,829
1929	Kansas City, Missouri	54	7/16″	1,114
1929	San Francisco, California	30 - 20	1/4″ - 3/16″	35,400
1929	Linden, New Jersey	28	1/4″	340
1929	Monroe, Michigan	36	3/8″	5,200
1929	Oakland, California	54 - 36	7/16″ - 5/16″	3,906
1929	New York, New York	60 - 36	1/2″	18,525
1929	Oakland, California	54 - 24	3/8″ - 1/4″	2,198
1929	Youngstown, Ohio	48 - 24	3/8″	134,590
1929	Los Angeles, California	24	5/16″	22,000
1930	Boston, Massachusetts	60	1/2″	5,400
1930	Clyde, California	36 - 24	5/16″ - 1/4″	16,628
1930	Detroit, Michigan	48 - 24	1/2″	22,000
1930	East Chicago, Indiana	54	–	10,000
1930	Everett, Washington	52 - 24	1/2″ - 3/16″	47,000
1930	Los Angeles, California	40 - 24	3/8″	34,307
1930	New York, New York	30	1/2″	8,740
1930	Oakland, California	24 - 20	5/16″ - 1/4″	22,731
1930	Salyer, California	54 - 42	7/16″ - 3/16″	7,740
1930	San Francisco, California	24 - 20	1/4″ - 3/16″	14,080
1930	Washington, D.C.	20	8 Ga.	3,000
1930	San Diego, California	40 - 36	3/8″ - 3/16″	86,000
1930	Tacoma, Washington	52 - 42	–	20,000
1930	Vancouver, British Columbia	36 - 26	–	50,000

APPROXIMATE TOTAL FOOTAGE = 1,700,000

1931 to 1940

Year Installed	Location	Diameter Inches	Thickness	Footage Feet
1931	Boston, Massachusetts	60	1/2″ - 3/8″	54,299
1931	Cleves, Ohio	54	9/16″	332
1931	Flint, Michigan	44 - 30	5/16″	1,806
1931	Little Falls, New Jersey	90 - 30	5/8″ - 3/8″	844
1931	Los Angeles, California	144 - 24	7/8″ - 1/4″	263,000
1931	New York, New York	72 - 20	1/2″	57,000
1931	Oakland, California	24	1/4″	7,310
1931	Portland, Maine	36	3/8″	3,584
1931	San Francisco, California	75 - 36	1/2″ - 1/4″	464,000
1931	San Leandro, California	30	1/4″	23,000
1931	Vancouver, British Columbia	36 - 20	–	35,000
1931	Vancouver, British Columbia	70	3/4″ - 11/16″	4,700
1931	Anacortes, Washington	24	3/16″	29,416
1931	Seattle, Washington	66 - 48	–	85,307
1931	Everett, Washington	52 - 48	3/8″ - 1/4″	52,000
1932	Panther Valley, Pennsylvania	30	–	50,000
1932	Boston, Massachusetts	60 - 20	1/2″	10,785
1932	Los Angeles, California	84 - 24	3/8″	86,000
1932	St. Louis, Missouri	36 - 28	5/8″ - 7/16″	17,000
1932	San Francisco, California	66 - 56	1/2″ - 5/16″	2,408,000
1932	Wilmette, Illinois	33	–	2,980
1933	Ft. Wayne, Indiana	42	–	13,000
1933	City of Los Angeles, California	94 - 80	1-1/16″ - 3/8″	18,000
1933	Auburn, New York	30	3/8″	10,000
1933	Vancouver, British Columbia	60	3/4″ - 9/16″	4,000
1933	Washington, D.C.	48	9/16″	35,000
1934	City of San Francisco, California	66	1/2″ - 3/8″	80,000
1934	Seattle, Washington	78	5/16″	29,500

APPENDIX C (Cont'd.)

Year Installed	Location	Diameter Inches	Thickness	Footage Feet
1934	St. Louis, Missouri	60 - 48	7/16"	67,670
1934	Hamilton, Ohio	24	1/4"	33,450
1935	Fort Smith, Arkansas	27	–	118,800
1935	Owyhee, Oregon	126 - 108	13/16" - 3/8"	2,530
1935	Tacoma, Washington	63 - 42	3/8" - 5/16"	35,785
1935	Creede, California	84	3/8" - 1/4"	10,000
1935	Boston, Massachusetts	48 - 36	1/2"	22,000
1935	New Brunswick, New Jersey	24	5/16"	6,000
1935	New York, New York	48 - 20	1/2"	39,000
1935	Diamond Alkali Company	60	9/16"	3,200
1936	City of San Francisco, California	60	3/8"	82,000
1936	Birmingham, Alabama	60 - 24	–	147,000
1936	Malheur, Oregon	80	9/16" - 1/4"	23,178
1936	Metropolitan Water District	138 - 116	1" - 1/2"	55,000
1936	Metropolitan Water District	120 - 72	–	6,000
1936	Elyria, Ohio	30	–	18,480
1936	Buffalo, New York	36	1/2"	10,000
1936	City of Los Angeles, California	40 - 24	–	124,000
1936	St. Louis, Missouri	60	9/16" - 1/2"	46,917
1937	Denver, Colorado	57 - 36	–	19,440
1937	San Gabriel Dam, California	120 - 51	–	5,000
1937	Salem, Oregon	36 - 27	–	60,000
1937	Everett, Washington	52 - 30	7/16" - 1/4"	102,000
1937	City of San Francisco, California	60	3/8"	24,620
1938	Grand Coulee, Washington	72	9/16" - 3/8"	955
1938	Metropolitan Water District	55 - 51	15/32" - 3/8"	90,000
1938	City of Los Angeles, California	36 - 24	–	13,000
1938	Lorain, Ohio	30	7/16"	20,000
1938	City of New York, New York	60	–	14,510
1938	Cleveland, Ohio	36 - 24	–	29,323
1938	Grand Rapids, Michigan	54	9/16"	5,980
1938	Grand Rapids, Michigan	42 - 36	–	21,000
1939	Polson, Montana	48	3/8" - 1/4"	1,260
1939	Spartanburg, South Carolina	24 - 20	1/4"	65,000
1939	Metropolitan Water District	36 - 21	3/8" - 5/16"	38,000
1940	Colorado Springs, Colorado	24	1-1/8" - 5/16"	15,624
1940	City of Los Angeles, California	78 - 36	1/2" - 3/8"	100,000
1940	Montebello, Maryland	147	1/2"	11,625
1940	Bremerton, Washington	24	1/4"	14,725

APPROXIMATE TOTAL FOOTAGE = 5,300,000

1941 to 1950

Year Installed	Location	Diameter Inches	Thickness	Footage Feet
1941	Toledo, Ohio	78 - 42	9/16"	90,000
1941	Georgetown, South Carolina	24	–	36,000
1941	Bastrop, Louisiana	28	–	12,780
1941	Birmingham, Alabama	42	–	16,700
1942	Decatur, Georgia	30	–	44,000
1942	City of New York, New York	48 - 36	–	5,400
1942	Camp Hahn, California	24 - 20	5/16" - 3/16"	40,000
1942	Springfield, Massachusetts	51	3/8"	12,500
1944	Longmont, Colorado	30	1/4"	18,000
1944	Greeley, Colorado	38 - 24	5/16" - 3/16"	190,000
1944	Richland, Washington	42	17/32" - 5/16"	117,964
1945	U. S. Engineers	60	3/4" - 5/8"	20,000
1946	Tacoma, Washington	48	5/16"	11,053
1946	Monterey, California	30 - 24	1/4" - 3/16"	10,000
1946	Grand Coulee, Washington	144	1" - 7/16"	9,373
1946	U. S. Navy (San Diego, California)	48	13/16" - 7/16"	9,400
1946	Oakland, California (E.B.M.U.D.)	30	3/16"	13,000
1946	Sacramento, California	42 - 24	3/8" - 1/4"	35,220
1946	City of San Francisco, California	60 - 36	1/2" - 3/16"	23,000
1947	Seattle, Washington	48	3/8"	13,800
1947	Oakland, California (E.B.M.U.D.)	69	1/2" - 3/8"	171,000
1947	Salem, Oregon	30	1/4"	8,000
1947	City of New York, New York	36 - 30	–	50,000
1947	Saginaw, Michigan	66	–	10,427
1947	Philadelphia, Pennsylvania	60 - 48	1/2" - 7/16"	–
1947	Syracuse, New York	54	7/16"	4,264
1947	Longmont, Colorado	30	3/8" - 3/16"	20,000
1948	Metropolitan Water District	46	3/8"	34,670
1948	Savannah, Georgia	48 - 36	–	73,000
1948	Macon, Georgia	30	–	19,200
1948	Seattle, Washington	48	–	13,740
1948	Salem, Oregon	24	1/4"	30,000
1948	Springfield, Massachusetts	48	7/16" - 3/8"	26,000
1948	City of San Francisco, California	60	7/8" - 3/8"	15,000
1948	City of San Francisco, California	62	9/16" - 1/2"	113,000
1948	California (Imperial Valley)	186	1/2"	720
1948	Philadelphia, Pennsylvania	48 - 24	1/2" - 5/16"	–
1948	Jersey City, New Jersey	48	3/8"	12,000
1948	Boston, Massachusetts	36 - 30	1/2"	4,450
1948	Syracuse, New York	49	5/16"	–
1948	Toledo, Ohio	24	1/4"	13,148
1948	Sterling, Colorado	24	1/4" - 3/16"	7,500
1948	Seaside, Oregon	24	5/16"	11,280
1949	City of New York, New York	85 - 48	1/2"	–
1949	Tulsa, Oklahoma	30	5/16"	1,476
1949	Golden, Colorado	20	1/4" - 3/16"	–
1949	City of Los Angeles, California	67 - 58	1/2" - 3/8"	4,915
1949	City of San Francisco, California	73	1/2" - 3/8"	91,000
1949	New Orleans, Louisiana	50	3/8"	33,030
1949	Seattle, Washington	66	–	36,296
1950	Medford, Oregon	30 - 20	1/4" - 3/16"	162,434
1950	San Francisco, California	62	1/2" - 7/16"	35,600
1950	Seattle, Washington	42	–	10,521

Year Installed	Location	Diameter Inches	Thickness	Footage Feet
1950	Tulsa, Oklahoma	36	5/16"	9,100
1950	Portland, Oregon	36	–	23,400
1950	Cincinnati, Ohio	49	1/2"	8,400
1950	Syracuse, New York	49	5/16"	8,350
1950	Wilkinsburg, Pennsylvania	36 - 30	3/8" - 5/16"	13,550
1950	Boston, Massachusetts	36	1/2" - 7/16"	27,100
1950	Greeley, Colorado	27	3/16"	75,000
1950	Allentown, Pennsylvania	36 - 30	3/8"	16,000
1950	Cleveland, Ohio	48 - 24	9/16" - 3/8"	33,500

APPROXIMATE TOTAL FOOTAGE = 2,000,000

1951 to 1960

Year Installed	Location	Diameter Inches	Thickness	Footage Feet
1951	Hollywood, California	83 - 66	1/2"	236
1951	City of San Francisco, California	72	1/2" - 5/16"	90,000
1951	City of Los Angeles, California	69	11/16" - 1/2"	23,902
1951	City of Los Angeles, California	67 - 61	3/8"	32,200
1951	City of Los Angeles, California	69	2" - 5/8"	4,400
1951	City of Los Angeles, California	60	7/16"	900
1951	City of Los Angeles, California	36	3/8"	3,000
1951	Hamilton, Canada	48 - 20	3/8"	38,000
1951	Denver, Colorado	54 - 36	1/4" - 3/16"	7,400
1951	Pueblo, Colorado	30 - 21	1/4" - 3/16"	35,000
1951	Englewood, Colorado	27 - 18	–	30,000
1951	Cleveland, Ohio	48	–	15,000
1951	Tullahoma, Tennessee	60	7/16"	–
1951	Philadelphia, Pennsylvania	54 - 48	1/2"	9,000
1951	Cincinnati, Ohio	48	1/2"	10,200
1952	New Jersey	72	–	25,000
1952	City of Los Angeles, California	61	1/2" - 3/8"	5,420
1952	Williamsport, Pennsylvania	24	1/4"	1,600
1952	Omaha, Nebraska	48 - 36	3/8"	11,700
1952	Pueblo, Colorado	30 - 21	1/4"	36,000
1952	San Jose, California	30 - 18	5/16" - 10 Ga.	60,000
1952	Atlanta, Georgia	48	7/16"	6,000
1952	New Orleans, Louisiana	30 - 24	5/16" - 1/4"	–
1952	Santa Clara, California	30	1/4"	15,000
1952	Brazil	48 - 44	7/16"	2,060
1952	Wheaton, Maryland	31	3/8" - 5/16"	27,000
1952	Boulder, Colorado	24	1/4"	6,360
1952	Metropolitan Water District	61 - 46	1/2" - 3/8"	51,000
1952	City of Los Angeles, California	69 - 36	1/2" - 3/8"	7,923
1953	Portland, Oregon	66 - 56	1/2" - 5/16"	133,000
1953	Metropolitan Water District	73 - 43	11/16" - 3/8"	86,477
1953	Eastern Mun. Water District - California	39 - 36	3/16"	38,510
1953	City of Los Angeles, California	69 - 36	5/8" - 3/8"	23,658
1953	City of Riverside, California	42 - 36	3/16"	9,977
1953	Houston, Texas	37	7/16"	37,929
1953	Syracuse, New York	49	5/16"	7,300
1953	Tullahoma, Tennessee	84 - 30	5/8" - 3/8"	25,000
1953	Denver, Colorado	36	3/8"	5,300
1953	Philadelphia, Pennsylvania	43 - 30	7/16" - 3/8"	48,750
1953	Colorado Springs, Colorado	42 - 30	5/16" - 3/16"	10,000
1953	Augusta, Georgia	36	5/16"	19,600
1953	Calgary, Canada	30	3/8"	–
1953	Omaha, Nebraska	48 - 30	3/8"	2,720
1953	Fort Smith, Arkansas	30 - 22	3/16"	22,000
1953	San Jose, California	30 - 18	7 Ga. - 10 Ga.	57,000
1953	Duluth, Minnesota	30	5/16"	8,100
1953	Lethbridge, Canada	24 - 18	3/8" - 5/16"	14,500
1953	Hemet, California	24 - 20	–	25,384
1953	Fallbrook, California	24	–	23,311
1953	San Francisco, California	61	7/16" - 3/8"	20,270
1954	Hemet, California	24 - 21	10 Ga. - 12 Ga.	14,100
1954	Las Vegas, Nevada	24	–	22,151
1954	Colton, California	24	10 Ga.	4,218
1954	Covina, California	25	10 Ga.	8,310
1954	City of Los Angeles, California	60	–	12,000
1954	La Habra, California	20	10 Ga.	16,000
1954	City of Los Angeles, California	26 - 24	9/32" - 1/4"	5,500
1954	Cincinnati, Ohio	42	1/2"	11,800
1954	Spartanburg, South Carolina	30 - 24	1/4"	48,980
1954	Syracuse, New York	39	3/8"	5,600
1954	Pasco, Washington	36 - 20	1/4" - 3/16"	13,850
1954	Regina, California	36	5/16" - 1/4"	190,000
1954	Atikokan, Canada	42 - 36	5/8" - 3/8"	61,000
1954	Beaver Falls, Alaska	48 - 24	–	3,800
1954	Nictaux, Nova Scotia	66	5/8" - 3/8"	3,312
1954	Omaha, Nebraska	48 - 36	3/8"	9,700
1954	Rifle, Colorado	42 - 18	3/16"	3,844
1954	Tuscaloosa, Alabama	36 - 24	1/4"	26,900
1954	Camino, California	48 - 36	1/4"	29,712
1954	City of New York, New York	72	–	21,000
1954	Colorado Springs, Colorado	30	1/2" - 1/4"	87,603
1954	Tacoma, Washington	78	–	56,000
1954	Muskegan Heights, Michigan	30	5/8"	4,500
1954	Sparrows Point, Pennsylvania	96	5/8" - 1/2"	23,800
1954	City of Los Angeles, California	71	1/4"	1,000
1954	City of Riverside, California	36	1/4" - 3/16"	21,800
1954	Tucson, Arizona	36	1/4"	50,810
1954	Las Vegas, Nevada	39 - 36	3/16"	100,000
1954	Metropolitan Water District	109 - 37	23/32" - 3/8"	102,250
1954	City of Los Angeles, California	96 - 49	3/8" - 1/4"	18,940
1954	Metropolitan Water District	120	3/4" - 3/8"	6,000
1954	Santa Paula, California	60	1/2"	800
1954	La Canada, California	39 - 36	7/32" - 3/16"	6,741

Year Installed	Location	Diameter Inches	Thickness	Footage Feet
1955	Tacoma, Washington	216	1" – 3/4"	950
1955	Santa Paula, California	42 - 24	7 Ga. - 12 Ga.	50,000
1955	Pasadena, California	24	3/16"	5,600
1955	Puente, California	28	.21" - .13"	20,000
1955	Worcester, Massachusetts	36 - 30	–	34,300
1955	Garden Grove, California	28 - 21	6 Ga.	50,000
1955	Beverly Hills, California	24	9 Ga.	15,000
1955	Metropolitan Water District	79 - 55	23/32" - 7/16"	124,410
1955	New Orleans, Louisiana	30	–	25,000
1955	City of Los Angeles, California	61 - 36	13/32" - 1/4"	26,938
1955	Riverside, California	36	1/4"	2,772
1955	San Francisco, California	91	3/8"	5,105
1955	San Francisco, California	61	7/16" - 3/8"	6,000
1955	Colorado Springs, Colorado	24	3/8" - 1/4"	49,000
1955	Wanship, Utah	85	–	–
1955	Cucamonga, California	24 - 21	3/16" - 12 Ga.	20,000
1955	San Bernardino, California	30	1/4"	1,800
1955	Long Beach, California	24	5/16"	1,204
1955	Casper, Wyoming	24	1/4"	9,000
1955	Reading, Pennsylvania	36 - 30	5/16" - 9/32"	33,000
1955	Seattle, Washington	30	1/4"	5,300
1955	Caracas, Venezuela	49	1" - 3/8"	90,000
1955	Tulsa, Oklahoma	48	1/2"	33,000
1955	Philadelphia, Pennsylvania	48	7/16"	1,475
1955	Loveland, Colorado	34	1/4"	10,000
1955	Crossett, Arkansas	30 - 24	1/4"	40,800
1955	Syracuse, New York	39 - 26	3/8" - 5/16"	4,502
1955	Richmond, Virginia	66	1/2"	2,000
1955	Shiprock, New Mexico	40	1/4"	8,695
1955	Denver, Colorado	67	7/16"	4,000
1955	Richmond, British Columbia	30 - 24	1/4"	30,000
1956	Elsinore, California	33 - 20	10 Ga.	48,000
1956	Lancaster, Pennsylvania	42	5/16"	55,500
1956	Monrovia, California	24	11 Ga.	24,000
1956	City of Los Angeles, California	116 - 49	3/8" - 1/4"	23,925
1956	Pomona, California	42	3/8" - 3/16"	19,578
1956	Metropolitan Water District	73	31/32" - 7/16"	116,685
1956	Westwood, Massachusetts	36 - 30	1/4"	4,430
1956	Oakley, California	24	–	14,500
1956	Oakdale, California	96 - 48	1-3/16" - 5/8"	–
1956	San Rafael, California	24 - 20	1/4" - 3/16"	12,900
1956	Pueblo, Colorado	42 - 24	3/8" - 1/4"	12,010
1956	Seattle, Washington	48	5/16" - 1/4"	8,585
1956	Littleton, Colorado	36	1/2"	5,640
1956	Winter Park, Colorado	84	1/2" - 5/16"	3,960
1956	Portland, Oregon	36	1/4"	8,000
1956	Duluth, Minnesota	36	5/16"	11,120
1956	Aurora, Colorado	27 - 12	1/4" - 10 Ga.	70,000
1956	Omaha, Nebraska	54 - 48	–	–
1956	Lenoir, North Carolina	20	1/4"	53,000
1956	Rupert, Idaho	78	–	1,500
1956	North East, Pennsylvania	24 - 18	1/4"	9,550
1956	Monrovia, California	24	11 Ga.	24,120
1956	San Bernardino, California	20	1/4"	4,300
1956	San Luis Obispo, California	24	3/16"	12,000
1956	Elsinore, California	21	12 Ga.	3,882
1956	Carlsbad, California	27 - 20	7/32" - 12 Ga.	40,000
1956	City of Los Angeles, California	67 - 60	3/8"	1,920
1956	City of Los Angeles, California	30	1/4"	17,580
1956	Long Beach, California	21	–	7,590
1956	Chino, California	24 - 20	12 Ga.	25,900
1956	Newport Beach, California	24	–	2,820
1957	Metropolitan Water District	162 - 49	1-1/8" - 3/8"	227,703
1957	City of Los Angeles, California	61 - 36	3/8" - 5/16"	14,220
1957	San Diego Aqueduct	76 - 73	1-1/8" - 3/8"	56,950
1957	City of San Diego, California	36	3/16"	25,865
1957	Ventura, California	39	1/4" - 10 Ga.	17,260
1957	Newport Beach, California	30	3/16"	13,000
1957	San Francisco, California	79	3/8"	7,400
1957	City of Los Angeles, California	22	3/8"	36,000
1957	Englewood, Colorado	24	–	12,000
1957	Monta Vista, Colorado	84	3/8" - 1/4"	8,108
1957	Gramercy, Louisiana	54	5/16" - 1/4"	4,400
1957	Cleveland, Ohio	54	11/16" – 9/16"	–
1957	Philadelphia, Pennsylvania	36	3/8"	3,160
1957	Brighton, Colorado	24 - 16	3/16" - 7 Ga.	12,900
1957	Grand Junction, Colorado	20	7 Ga.	10,800
1957	Medford, Oregon	24	7 Ga.	7,500
1957	Colton, California	30 - 20	10 Ga.	8,521
1957	Torrance, California	24	–	6,800
1957	Camarillo, California	30 - 20	3 Ga. - 3/16"	16,000
1957	San Bernardino, California	30	–	3,405
1957	Statesville, North Carolina	24	1/4"	28,000
1957	Jefferson Co., Colorado	54	3/8"	5,300
1957	Aberdeen, Washington	28-1/2	1/4"	13,474
1957	Atlanta, Georgia	36	5/16"	4,900
1957	Colorado Springs, Colorado	24	1/4"	57,000
1957	Longmont, Colorado	27 - 24	3/16"	55,300
1958	St. Paul, Minnesota	90 - 60	7/16" - 3/8"	64,000
1958	Phoenix, Arizona	48 - 45	5/16" - 1/4"	36,879
1958	City of Los Angeles, California	49 - 37	11/32" - 1/4"	45,918
1958	Oceanside, California	24	3/16" - 10 Ga.	30,000
1958	San Diego Co. Water Authority	75 - 66	5/8" - 5/16"	184,914
1958	Metropolitan Water District	76	7/8" - 7/16"	31,315
1958	San Bernardino, California	36	1/4"	480
1958	City of Los Angeles, California	61	5/16"	2,220
1958	City of Los Angeles, California	24 - 20	5/16" - 1/4"	4,500
1958	San Rafael, California	27 - 24	–	5,430

APPENDIX C (Cont'd.)

Year Installed	Location	Diameter Inches	Thickness	Footage Feet
1958	Riverside, California	30 - 20	3/16" - 10 Ga.	5,700
1958	Fallbrook, California	20	–	13,000
1958	El Segundo, California	28	10 Ga.	1,300
1958	San Francisco, California	90 - 80	1-5/8" - 3/4"	7,028
1958	Orange, California	24	–	3,688
1958	Colton, California	30	–	3,500
1958	Carlsbad, California	20	10 Ga.	6,120
1958	Vernon, California	24	10 Ga.	2,654
1958	Oceanside, California	24	3/16" - 10 Ga.	30,000
1958	San Diego Co. Water Authority	75 - 66	5/8" - 5/16"	184,914
1958	Metropolitan Water District	76	7/8" - 7/16"	31,315
1958	San Bernardino, California	36	1/4"	480
1959	Los Banos, California	63 - 54	5/16"	12,000
1959	Santa Monica, California	36	3/16"	7,639
1959	City of Los Angeles, California	70 - 36	15/32" - 3/16"	43,550
1959	San Diego, California	36	3/16"	6,461
1959	Metropolitan Water District	67 - 37	7/8" - 3/8"	76,580
1959	Phoenix, Arizona	60 - 54	11/32" - 5/16"	20,530
1959	Long Beach, California	36	10 Ga.	1,272
1959	Terra Bella, California	54	5/16"	26,000
1959	San Diego Co. Water Authority	69 - 66	15/16" - 3/8"	72,231
1959	Wahluke, Washington	186	1-1/16" - 3/16"	8,500
1959	Atlanta, Georgia	36 - 30	5/16"	9,116
1959	Green Springs, Oregon	48 - 32	–	9,600
1959	City of Los Angeles, California	73 - 61	3/8" - 5/16"	8,400
1959	City of Los Angeles, California	67 - 31	5/16" - 1/4"	4,500
1959	City of Los Angeles, California	30 - 24	5/16" - 3/16"	16,000
1959	Ontario, California	24 - 20	8 Ga. - 10 Ga.	3,750
1959	Terra Bella, California	36 - 20	3/16" - 10 Ga.	30,000
1959	Monrovia, California	24	12 Ga.	3,235
1959	Pomona, California	20	11 Ga.	3,850
1959	Weston, Massachusetts	48 - 36	–	13,315
1960	City of Los Angeles, California	73 - 41	9/16" - 9/32"	15,575
1960	Metropolitan Water District	61	3/4" - 3/8"	20,325
1960	California Electric Power	60	1/4"	3,300
1960	Phoenix, Arizona	54 - 36	1/2" - 1/4"	83,565
1960	City of San Diego, California	51	1/2" - 5/16"	7,666
1960	Anaheim, California	36	3/16"	5,214
1960	Camarillo, California	54 - 36	1/4" - 3/16"	17,980
1960	Metropolitan Water District	85 - 37	7/16" - 3/8"	905
1960	San Bernardino, California	36	9/32" - 11 Ga.	28,070
1960	Ontario, California	25	8 Ga.	3,400
1960	Riverside, California	24	–	1,287
1960	Hemet, California	25 - 21	10 Ga.	10,600
1960	Ventura, California	24	–	18,610
1960	Chino, California	30	–	28,150
1960	San Bernardino, California	30	–	9,917
1960	Navajo Dam, New Nexico	110	–	–
1960	Santa Cruz, California	36 - 18	–	13,025
1960	Bellingham, Washington	40	–	50,000
1960	Fremont, California	30 - 18	–	13,460
1960	San Rafael, California	33	–	32,300
1960	Oakland, California	91-1/2 - 55	5/8" - 1/2"	4,921

APPROXIMATE TOTAL FOOTAGE = 5,400,000

1961 to 1970

Year Installed	Location	Diameter Inches	Thickness	Footage Feet
1961	Toronto, Canada	96	3/8"	4,150
1961	Boston, Massachusetts	52 - 36	–	16,000
1961	Spartanburg, South Carolina	30	–	14,250
1961	San Jose, California	48	1/4"	12,000
1961	Seattle, Washington	34	–	25,000
1961	City of Los Angeles, California	61 - 37	9/16" - 1/4"	23,873
1961	Santiago Aqueduct, California	54 - 39	7/16" - 3/16"	62,905
1961	Calleguas, California	48	13/32" - 1/4"	31,091
1961	El Segundo, California	61	9/16"	3,009
1961	San Diego, California	118	3/4"	13,000
1961	Metropolitan Water District	145 - 97	1"	3,911
1961	San Diego, California	42	3/8" - 9/32"	23,575
1961	Tri-Cities, California	45 - 39	5/16" - 1/4"	30,520
1961	Long Beach, California	42 - 36	3/16"	16,076
1961	Sacramento, California	30 - 18	–	21,574
1961	Novato, California	30	–	53,900
1961	Santa Maria, California	30 - 20	–	30,275
1961	City of Los Angeles, California	36 - 20	7/16" - 1/4"	16,030
1961	Nevada (Aetron)	42	7/16" - 1/4"	6,507
1961	County of Los Angeles, California	30	.225"	81,745
1961	Calleguas, California	30 - 24	3/16" - 8 Ga.	17,000
1961	Pasadena, California	24	3/16"	1,310
1961	Carpinteria, California	30 - 24	5/16" - 3/16"	1,640
1961	Riverside, California	24 - 20	10 Ga.	13,700
1961	Fruitvale, California	24	.281"	2,374
1961	Santa Fe Irrig. District, California	20	10 Ga.	9,600
1961	Hemet, California	24 - 21	10 Ga.	15,600
1962	Wisconsin Rapids, Wisconsin	20	1/4"	11,800
1962	Rochester, New York	60 - 48	–	30,000
1962	High Point, North Carolina	36 - 18	–	11,287
1962	St. Louis, Missouri	42 - 36	–	15,000
1962	Las Vegas, Nevada	36	3/16"	21,335
1962	La Mesa, California	60 - 36	1/4" - 3/16"	3,164
1962	Calleguas, California	54 - 48	9/16" - 1/4"	153,000
1962	Metropolitan Water District	79 - 55	31/32" - 3/8"	125,360
1962	Perris, California	42 - 36	3/16"	15,000
1962	Oakland, California	27 - 24	–	21,370
1962	Oakland, California	87 - 65	1/2" - 5/16"	188,000

APPENDIX C (Cont'd.)

Year Installed	Location	Diameter Inches	Thickness	Footage Feet
1962	San Francisco, California	24	–	23,025
1962	Alameda County, California	24	–	9,565
1962	San Rafael, California	24	–	7,600
1962	Burlingame, California	34	–	6,188
1962	San Bernardino, California	20	3/16"	9,407
1962	Rainbow, California	36 - 20	1/4" - 12 Ga.	17,000
1962	Rialto, California	24	–	7,700
1962	Anaheim, California	24 - 21	–	13,260
1962	City of Los Angeles, California	24	5/16"	10,000
1962	Oceanside, California	42 - 24	3/16" - 12 Ga.	57,000
1962	Hemet, California	42 - 27	3/16" - 10 Ga.	47,000
1962	Santa Ana, California	33 - 30	3/16" - 8 Ga.	29,650
1962	El Toro, California	24 - 21	8 Ga. - 10 Ga.	12,690
1962	City of Los Angeles, California	60	7/16"	790
1962	San Diego, California	36	3/16"	7,988
1962	Long Beach, California	36	1/4" - 3/16"	2,243
1963	Sacramento, California	60 - 48	–	–
1963	Nevada	88 - 36	3/4" - 5/8"	10,236
1963	Oakland, California	78	–	1,700
1963	Pasadena, California	24	3/16"	7,170
1963	Las Vegas, Nevada	24	–	15,825
1963	Fullerton, California	24	–	4,120
1963	Los Alisos, California	27 - 21	–	5,100
1963	San Diego, California	36	1/4" - 3/16"	42,361
1963	Metropolitan Water District	49 - 43	17/32" - 3/8"	40,400
1963	Calleguas, California	54 - 39	15/32" - 3/16"	92,538
1963	Tucson, Arizona	48 - 36	1/4" - 3/16"	50,925
1963	City of Los Angeles, California	66 - 41	1/2" - 1/4"	6,320
1963	Costa Mesa, California	42 - 36	5/16" - 3/16"	29,477
1963	West Orange, California	36	3/16"	13,500
1963	Glendale, California	48	1/4"	850
1963	Phoenix, Arizona	66	1/4"	13,149
1963	County of Los Angeles, California	45	3/8" - 3/16"	23,621
1963	Birmingham, Alabama	60	–	180,000
1963	San Francisco, California	79-1/2	1/2" - 3/8"	110,000
1963	Ramona, California	20 - 18	–	35,380
1963	Ambridge, Pennsylvania	24	5/16"	9,717
1963	DeKalb County, Georgia	30	.281"	150,000
1963	Reading, Pennsylvania	36 - 30	–	31,000
1963	Seattle, Washington	66 - 60	–	15,000
1963	South Bay Aqueduct, California	90 - 72	15/32" - 3/8"	120,000
1963	Denver, Colorado	96	1/4"	–
1963	Norfolk, Virginia	36	–	1,600
1964	Colorado Springs, Colorado	36	1/4"	60,000
1964	St. Louis, Missouri	60 - 36	–	50,000
1964	Flagstaff, Arizona	36	3/16"	19,270
1964	Calleguas, California	48 - 36	1/4" - 3/16"	84,000
1964	San Diego Co. Water Authority	66	1" - 5/16"	40,090
1964	Redlands, California	20	12 Ga.	8,400
1964	Long Beach, California	24	5/16"	9,000
1964	Las Vegas, Nevada	24	–	57,569
1964	Fullerton, California	24	–	5,710
1964	Los Angeles County, California	27	10 Ga.	24,016
1964	Huntington Beach, California	30	–	18,200
1964	Tempe, Arizona	36 - 24	–	7,690
1964	Brushy Creek, California	63	3/4" - 1/4"	4,000
1964	Buena Park, California	36	3/16"	7,835
1964	Anaheim, California	36	3/16"	1,720
1964	San Diego, California	36	3/16"	6,088
1964	Oxnard, California	45 - 36	1/4" - 3/16"	35,686
1964	City of Los Angeles, California	36	3/8"	8,350
1964	La Mesa, California	36	3/16"	1,085
1964	Los Banos, California	210 - 84	1-3/8" - 1-3/16"	9,300
1965	Martinez, California	36 - 18	–	18,085
1965	Houston, Texas	60	3/8"	9,300
1965	Riverside, California	42	3/16"	3,292
1965	City of Los Angeles, California	77	3/4" - 3/8"	54,300
1965	Washington, D.C.	66 - 36	–	4,400
1965	Delta, California	180	–	2,800
1966	City of Los Angeles, California	88	7/16" - 3/8"	46,222
1966	City of Los Angeles, California	54	11/32" - 3/8"	13,340
1966	City of Los Angeles, California	54	5/16"	8,747
1966	Metropolitan Water District	151-1/2	1-1/4" - 1/2"	10,500
1966	Metropolitan Water District	85 - 79	29/32" - 17/32"	70,000
1966	Olean, New York	20	–	6,620
1967	Metropolitan Water District	85 - 79	1-3/16" - 1/2"	82,795
1967	Metropolitan Water District	201	–	411
1967	City of Los Angeles, California	54	3/8" - 11/32"	7,268
1967	Metropolitan Water District	79	7/8" - 21/32"	25,965
1967	Las Vegas, Nevada	60 - 48	1/4"	20,476
1967	Bethlehem, Pennsylvania	42 - 36	–	51,000
1967	Bronx, New York	48	–	16,000
1967	Houston, Texas	60	–	10,000
1967	City of San Francisco, California	60	3/8" - 5/16"	23,000
1967	Buena Vista, California	108	1/2" - 5/16"	4,673
1967	Wind Gap, California	109	1/2" - 3/16"	10,000
1967	Oso, California	109	3/8"	9,000
1967	Wheeler Ridge, California	109	9/16" - 5/16"	10,000
1967	Tehachapi Lift, California	168 - 150	2-1/2" - 1/2"	16,000
1968	Pastoria, California	192	5/8" - 9/16"	1,642
1968	Las Vegas, Nevada	60 - 42	1/4" - 3/16"	32,725
1968	Little Lake, California	78	15/16" - 3/8"	104,897
1968	Jawbone, California	85 - 82	1-1/8" - 3/8"	154,708
1968	Metropolitan Water District	100	3/4" - 9/16"	23,300
1968	Metropolitan Water District	89	1" - 1/2"	26,235
1968	Metropolitan Water District	121-1/2	11/16"	5,270
1968	Alexandria, Virginia	72	–	3,800

APPENDIX C (Cont'd.)

Year Installed	Location	Diameter Inches	Thickness	Footage Feet
1968	San Francisco, California	79-1/2	1/2" - 3/8"	250,000
1968	Washington, D.C.	60	–	23,000
1969	Bethlehem, Pennsylvania	42 - 30	–	46,644
1969	San Francisco, California	96 - 90	–	180,000
1969	City of Los Angeles, California	162 - 90	1-7/8" - 7/16"	6,000
1969	City of Los Angeles, California	103	5/8" - 1/2"	3,000
1969	Pearblossom, California	103	11/16" - 5/8"	610
1970	Metropolitan Water District	97 - 94	1-1/16" - 25/32"	26,310
1970	Henderson, Nevada	90 - 66	9/16" - 1/4"	74,640
1970	San Diego Co. Water Authority	97	1" - 1/2"	59,295
1970	Stanislaus River, California	276 - 72	1-1/4" - 5/16"	6,260
1970	Rialto, California	137 - 122	1-1/4" - 1/2"	45,210

APPROXIMATE TOTAL FOOTAGE = 4,500,000

APPENDIX D

SUMMARY OF APPENDICES A, B AND C

The tabulations in Appendices A, B and C covering installations of riveted, Lock-Bar and welded steel water pipe from 1858 to 1970 are only partially complete, but do include most of the major installations known at this time. Except for the portion of Appendix A covering riveted steel water pipe installations up to 1900, all other tabulations include pipe sizes of 20" diameter and larger, and do *not* include any penstocks.

All of the tabulations include 311 installations of riveted steel pipe, 150 Lock-Bar steel pipe installations; and 563 welded steel pipe installations; or a grand total of 1,024 installations. Of the installations prior to 1900, most of them are still in service, and will reach a useful service life of at least 100 years. Six installations have already reached the 100-year mark.

The grand total footage of all of these installations amounts to almost 30,000,000′ of 20″ diameter and larger. The breakdown by types and periods is as follows:

Period	Riveted	Lock-Bar	Welded
1858 - 1900	2,000,000′	–	–
1901 - 1930	5,220,000′	3,400,000′	1,700,000′
1931 - 1940	–	–	5,300,000′
1941 - 1950	–	–	2,000,000′
1951 - 1960	–	–	5,400,000′
1961 - 1970	–	–	4,500,000′
TOTALS	7,220,000′	3,400,000′	18,900,000′
GRAND TOTAL	29,520,000′		

APPENDIX E

TYPES OF STEEL AVAILABLE FOR STEEL PLATE WATER PIPE

ASTM Specification	Quality	Min. Tensile Strength PSI	Min. Yield Point PSI	Recommended Design Stress PSI	Remarks
A36	ST.	58,000	36,000	19,300	Economical strength. Down to 5°F. temp.
A131A	ST.	58,000	32,000	19,300	Down to 5°F. temp.
A131B	ST.	58,000	32,000	19,300	Down to -25°F. temp. to 1/2" plate.
A131C	ST.	58,000	32,000	19,300	Down to -25°F. temp. to 1" plate.
A283B	ST.	50,000	27,000	16,665	Economical low cost steel.
A283C	ST.	55,000	30,000	18,300	Economical low cost steel.
A283D	ST.	60,000	33,000	20,000	Economical low cost steel.
A285B	P.V.	50,000	27,000	16,665	Individual plate test.
A285C	P.V.	55,000	30,000	18,300	Individual plate test.
A441	ST.	70,000	50,000	25,000	Good strength and corrosion resistance above ground.
A514	ST.	115,000	100,000	50,000	High strength. Q&T. Notch toughness. Fine grain.
A516-Gr. 60	P.V.	60,000	70,000	20,000	Down to -25°F. temp. to 1" plate.
A516-Gr. 70	P.V.	32,000	38,000	23,300	Down to -25°F. temp. to 1" plate.
A517	ST.	115,000	100,000	50,000	Killed steel. Fine grain. High strength. Q&T.
A537A	P.V.	70,000	50,000	25,000	Normalized. Fine grain.
A537B	P.V.	80,000	60,000	30,000	Fine grain. Q&T.
A572-Gr. 42	ST.	60,000	42,000	21,000	Good strength.
A572-Gr. 45	ST.	60,000	45,000	22,500	Good strength.
A572-Gr. 50	ST.	65,000	50,000	25,000	Good strength.
A572-Gr. 55	ST.	70,000	55,000	27,500	Good strength.
A572-Gr. 60	ST.	75,000	60,000	30,000	High strength.
A572-Gr. 65	ST.	80,000	65,000	32,500	High strength.
A573-Gr. 65	ST.	65,000	35,000	21,665	Fine grain.
A573-Gr. 70	ST.	70,000	38,000	23,330	Fine grain.
A588A	ST.	70,000	50,000	25,000	Fine grain. High corrosion resistance above ground.

APPENDIX F

42 Major Aqueducts Longer Than 20 Miles Including Pipelines, Pump Lifts, Tunnels, Canals, Grade Conduits

Overall Length Miles	Location	Year Installed
600	Feather River Aqueduct – California	1972
351	Coolgardie – Australia	1902
340	Los Angeles Aqueduct – California – First	1913
266	Apulian Aqueduct – Italy	1915
242	Colorado River Aqueduct – California	1939
154	Hetch Hetchy Aqueduct – California – First	1931
154	Hetch Hetchy Aqueduct – California – Second	1949
154	Hetch Hetchy Aqueduct – California – Third	1968
120	New York City Aqueduct	1906
100	Los Angeles Aqueduct – California – Second	1968
98	Winnipeg, Canada	1918
90	Mokelumne Aqueduct – California – First	1924
90	Mokelumne Aqueduct – California – Second	1947
90	Mokelumne Aqueduct – California – Third	1962
65	Newark, New Jersey	1891
60	San Diego Aqueduct – California – First	1946
60	San Diego Aqueduct – California – Second	1958
60	San Diego Aqueduct – California – Third	1971
60	Tulsa, Oklahoma	1928
44	Birmingham, Alabama – First	1936
44	Birmingham, Alabama – Second	1963
38	Victoria, British Columbia	1915
36	Adelaide, Australia	1951
36	Vancouver, British Columbia	1909
32	Phoenix, Arizona	1928
30	Medford, Oregon	1950
27	Butte, Montana	1914
26	Rochester, New York	1893
26	Philadelphia, Pennsylvania	1906
25	Denver, Colorado	1927
25	Portland, Oregon – First	1895
25	Portland, Oregon – Second	1910
25	Portland, Oregon – Third	1923
25	Portland, Oregon – Fourth	1953
24	Springfield, Massachusetts	1905
23	Fort Smith, Arkansas	1935
22	Everett, Washington – First	1928
22	Everett, Washington – Second	1937
22	Vallejo, California	1924
20	Pittsburgh, Pennsylvania	1895
20	Norfolk, Virginia	1925
20	Portsmouth, Virginia	1927

APPENDIX G

STEEL WATER PIPELINE FIELD JOINTS

Steel water pipe sections can be connected together in the field by various types of joints as indicated below:

1. Riveted
2. Drive
3. Mechanical couplings
4. Threaded
5. Flanged
6. Butt-welded, single or double
7. Butt-strap
8. Bell and spigot for calking
9. Slip bell for lap welding
10. Bell and spigot O-ring rubber gasket

Riveted Joints

Used now primarily for large diameter steel pipe having thick plate walls.

Drive Joints

Used for light gage steel pipes having asphalt or coal-tar enamel coatings, and operating under relatively low pressures. Ends of a section are slightly belled and tapered so as to fit tightly when driven together for several inches.

Mechanical Couplings

Represented by sleeve and clamp type couplings, They provide flexibility, ease of installation, and permanent watertightness. They avoid field welding and permit a certain amount of expansion and contraction movement. Sleeve couplings have been used since 1891. Clamp couplings are used generally on smaller sizes of steel pipe, and require a groove or bar at the ends of the pipe sections in order to house the rubber gasket tightly. An advantage of this joint is its portability for aboveground construction water lines.

Threaded Joints

Used primarily in small diameters of mill steel pipe, where sections can be connected with threaded couplings for use in water service lines or industrial piping.

Flanged Joints

AWWA Standard C 207 gives the proper design of flanges for steel water pipe. Flanges are not used generally for field joints on large diameter steel pipe because of their high cost and lack of flexibility. They are advantageous, however, for special conditions, such as connections to flanged gate valves, meters, bridge crossings, pumps, industrial piping, etc.

Butt-Welded Joints

These joints develop full strength, but will require more care in fitting up in the field.

Butt-Strap Joints

They are advantageous where ease in fitting up butt-welded joints is desired. The strap acts as a back-up bar. These joints are expensive for general use.

Bell and Spigot Joints for Calking

These joints have bell and spigot formed ends, which are calked together with dry pack neat cement. They are easy to install, and can be used on steel pipe sizes up to 48 inches diameter, where internal pressure does not exceed 200 psi. The inside pipe lining remains unaffected by the assembly of this joint.

Slip Bell for Lap Welding

This joint is widely used because of its flexibility, ease in forming, ease in laying, simplicity, and its absolute watertightness. Small angle changes up to about 4° can be made in each joint. It possesses high strength, and will resist settlement, shocks, washouts, etc. A single fillet weld inside or out is sufficient to maintain full pipeline integrity.

Bell and Spigot Rubber Gasket Joints

This latest type of O-ring joint has become very popular for steel water pipelines because of its great flexibility, watertightness, rapid installation, and economical cost without any field welding or damage to the inside lining. It will permit deflection angles in alignment up to at least 4° dependent on diameter.

Field joints in steel water pipelines are always completely watertight, and there are fewer of them because of the longer lengths of pipe sections obtainable. They lend themselves to good work organization, provide uniform quality and trouble-free performance.

APPENDIX H

STEEL WATER PIPE SPECIFICATIONS

There are a number of specifications that provide for high quality, modern welded steel water pipe, or the steel material used in its manufacture. The American Water Works Association has developed the best and most up-to-date standards for this product. They are as follows:

AWWA STANDARD C 201 for *Fabricated* Electric Fusion Welded Steel Pipe.

AWWA STANDARD C 202 for *Mill* Type of Steel Pipe.

AWWA STANDARD C 203 for Coal Tar Enamel Protective Coatings for Steel Pipe.

AWWA STANDARD C 205 for Cement Mortar Protective Coatings for Steel Pipe.

AWWA STANDARD C 206 for Field Welding of Steel Pipe Joints.

AWWA STANDARD C 207 for Steel Pipe Flanges.

AWWA STANDARD C 208 for Dimensions of Steel Water Pipe Fittings.

AWWA STANDARD C 602 for Cement Mortar Protective Lining of 16" size and larger Steel Pipe *in place.*

AWWA STANDARD C 201 accepts the following types of steel material:

ASTM A 245 Grade A (Light Gage Structural Quality Flat Hot-Rolled Carbon Steel. Yield Point = 25,000 psi).

ASTM A 283 Grades, B, C, or D (Low and Intermediate Tensile Strengths of Carbon Steel Plate for Structural Quality. Yield Points = 27,000; 30,000; and 33,000 psi respectively).

API Standard 5LX Grade X-42 Steel Plate (for high pressure water lines. Yield Point = 42,000 psi).

AWWA STANDARD C 202 accepts the following types of steel material:

Grade A	(30,000 psi yield point.)
Grade B	(35,000 psi yield point.)
Grade X-42	(42,000 psi yield point.)

Other Specifications used for Steel Pipe are as follows:

ASTM A 53 Welded and Seamless Steel Pipe up to 24 in. size

Grade A	(30,000 psi yield point.)
Grade B	(35,000 psi yield point.)

ASTM A 120 Welded and Seamless Steel Pipe for Ordinary Uses up to 12 in. size

Grade A	(30,000 psi yield point.)
Grade B	(35,000 psi yield point.)

ASTM A 134 Electric Fusion Welded Steel Plate Pipe Size 16 in. and over.

ASTM A 135 Electric Resistance Welded Steel Pipe Size 30 in. and under.

Grade A	(30,000 psi yield point.)
Grade B	(35,000 psi yield point.)

ASTM A 139 Electric Fusion Welded Steel Pipe Sizes 4 in and over.

Grade A	(30,000 psi yield point.)
Grade B	(35,000 psi yield point.)

ASTM A 211 Spiral Welded Steel or Iron Pipe Sizes 4 in. to 48 in.

API 5L Line Pipe – Sizes up to 24 in.

Grade A	(30,000 psi yield point.)
Grade B	(35,000 psi yield point.)

API 5LX High-Test Line Pipe – Sizes up to 48 in.

Grade X-42	(42,000 psi yield point.)
Grade X-46	(46,000 psi yield point.)
Grade X-52	(52,000 psi yield point.)
Grade X-60	(60,000 psi yield point.)
Grade X-65	(65,000 psi yield point.)

FEDERAL SPEC. WW-P-1432 – Pipe, Steel, Sizes 4 in. through 144 in.

FEDERAL SPEC. SS-P-385a – Pipe, Steel, Sizes 4 in. through 42 in.

FEDERAL SPEC. WW-P-404 and 406 – Mill Steel Pipe, Sizes up to 12 in.

All of the specifications listed above are suitable for steel water pipe for their particular conditions. However, for the most up-to-date specifications on an overall basis, AWWA Standard C 201 is recommended as the most practical and modern one to use for steel water pipe service.

APPENDIX I

TYPES OF STEEL WATER PIPE

The various types of steel pipe available for water service lines are as follows:

Fusion Welded – Briefly, fusion welded steel pipe is manufactured by planing the edges of steel plates to size, forming or rolling the plates to cylindrical shape, and welding them together by means of submerged arc welding using the automatic process. It is readily possible to obtain a welded joint strength equal to that of the plate. This type of pipe is fabricated in sizes of 4" diameter to 20' diameter and in thicknesses of 14 gage to 2" and heavier. Lengths generally are 40', however quite often they are welded together in the shop and delivered to the site in 80' or 120' sections.

Resistance or Flash Welded – This type of pipe is manufactured by forming sheets or plates to cylindrical shape and fusing them together by means of pressure and of heat generated by high amperage electric current, without the addition of any electrode material. This pipe can be furnished in sizes of 4" diameter to 36" diameter and in thicknesses of 12 gage to 1/2". Lengths generally are 30' to 80'.

Spiral Welded – This type of pipe is made by forming skelp sheets spirally into cylindrical shape and either butt welding or lap welding the spiral seams together. It can be furnished in sizes of 4" diameter to 96" diameter, in thicknesses of 14 gage to 1/2", and in lengths of 30' to 40'.