The history of pipe is the history of civilization. No other single product has contributed so much to the health and comfort of the people of the great cities of the world. Beginning with the crude clay pipe of early Babylonian days, 4000 B.C., there has been a constant effort to reach the ideal – a pipe that could be economically made and which would endure underground.

Iron was known to man in prehistoric ages, and there are many evidences of its use in early history. The earliest authentic date of the casting of iron on a major scale in Western Europe was 1313 with the manufacture of cast iron cannons in the City of Ghent, Germany. There is no documentation of the time or place of the adoption of cast iron for use in pipe-making, but it is reasonable to assume that cast iron pipe was produced coincidentally with the similar casting of the cannon.

CAST IRON PIPE THROUGH THE AGES

The first authentically recorded cast iron pipe was laid in Germany in 1455 and carried water to the Dillenberg Castle. Sometime between 1664 and 1688 the French laid an approximate 400mm diameter cast iron pipeline about 8,000m long to supply water to the City of Versailles. The first cast iron pipe to be installed in London was laid around the year 1746. In the United States, Philadelphia seems to have used the first cast iron for water pipe in 1804. Earlier pipelines were of wood. The iron pipe used in Philadelphia came from England, had bell and spigot joints, and was in 3m lengths.

From the origination of cast iron pipe, its development for underground service has shown a sure, steady growth. Today, it is found in all parts of the world. In the leading countries of Europe and in America, the larger cities contain thousands of kilometers of cast iron pipe.

The manufacture of cast iron pipe has progressed from the early crude pit cast method to the modern deLavaud centrifugal process.

The most significant event in recent pipe history was the development of ductile iron in 1948. In a relatively short time ductile iron pipe gained widespread acceptance. The specifying of ductile iron increased to where all iron piping installed for the past several years has been ductile, and gray iron pressure pipe is no longer manufactured. Improvements in casting methods, processing, and metallurgical technology are continually producing superior quality pipe, capable of satisfying the specific piping needs of the 20th century and beyond.

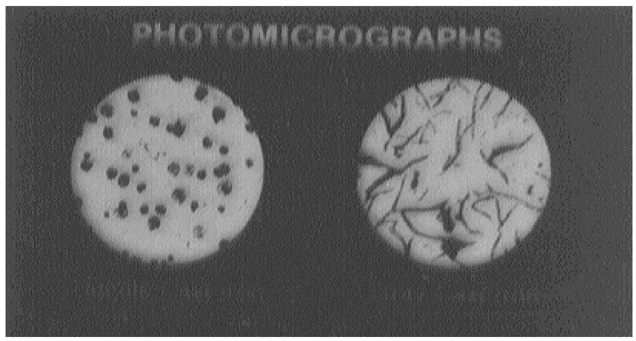
Original Cast Iron Mains Still in Operation After a Century of Service: Over 500 North American cities are currently being served by cast iron mains that were installed more than 100 years ago. At least 12 cities have cast iron pipe in service that is over 150 years old. These mains are indicative of the strength, inherent corrosion resistance, durability, and reliability of cast iron pipe. The commercial introduction of ductile iron pipe in 1955 provided the utility industry with a pipe possessing those same characteristics plus increased strength and flexibility.

Section of cast iron water main in excellent condition after serving Richmond, Virginia, since 1830.

What is ACIPCO Ductile Iron? The ideal of cast iron with ductility, long sought by metallurgists, was realized with the introduction of ductile iron in 1948. Acclaimed to be one of the most significant metallurgical developments in this century, ductile iron has had an increasing impact in many industries. Ductile iron has ductility – as the name implies – and in addition, it has strength and impact resistance far greater than that of gray iron; yet it retains the proven corrosion resistance of gray iron, thus making it an ideal piping material.

American Cast Iron Pipe Company pioneered the development of ductile iron pipe and produced experimental casts of ductile pipe and fittings as early as 1948. The first shipment of **ACIPCO** Ductile Iron pipe was made in 1955. Production of ductile iron pipe has grown steadily and it is now the predominant piping material for conveying water and other liquids.

ACIPCO DUCTILE IRON PIPE



Photomicrograph showing graphite form in ductile iron.

Photomicrograph showing graphite form in gray iron.

ACIPCO Ductile Iron Minimum Physical Properties for Ductile Iron Pipe		
AWWA C151		ISO 2531
These properties are verified by tensile samples from the wall of the pipe.	Tensile Strength……60,000 psi Yield Strength. ……..42,000 psi Elongation………………...10%	….420 N/mm² ….300 N/mm² ……..……..10%

Ductile iron is produced by treating molten low-sulfur base iron with magnesium under closely controlled conditions. The startling change in the metal is characterized by the free graphite in ductile iron being deposited in spheroidal or nodular form instead of flake form as in gray iron. With the free graphite in nodular form, the continuity of the metal matrix is at a maximum, accounting for the formation of a far stronger, tougher, ductile material exceeding gray iron in strength, in ductility, and in impact characteristics by wide margins.

EXHIBITS TREMENDOUS TENSILE STRENGTH. A pipe must be able to withstand severe stresses caused externally by shifting ground and heavy loads and internally by water pressure and water hammer. ACIPCO ISO Ductile Iron pipe has minimum strength requirements of 420 N/mm^2 tensile strength, 300 N/mm^2 yield strength and 10% minimum elongation.

HAS GREAT BEAM STRENGTH. Ductile iron will bend or give considerably before it will ultimately fail. This characteristic is what makes its ductility so desirable. Ductile iron's ability to bend under load greatly increases its resistance to beam load.

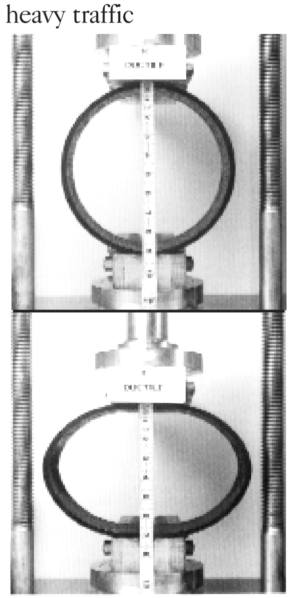
Because of ductile iron's great beam strength and durability, it is ideally suited for challenging applications such as this pipe-on-supports installation.

WITHSTANDS SEVERE CRUSHING LOADS. Extreme traffic loads, heavy backfill, or earth movements caused by freezing, thawing, and soil swell pressures impose tremendous forces on buried pipes. Beam tests, free bend tests, and – toughest of all – ring tests, which determine the pipe's ability to resist concentrated loads, all demonstrate the superiority of ductile iron pipe.

IS CORROSION RESISTANT. Numerous laboratory and field tests have proved that ductile iron's corrosion resistance is equal to or greater than that of cast iron, which has served a number of U.S. utilities for more than 150 years with no external corrosion protection. In the majority of soils, ductile iron needs no external corrosion protection. In most areas of highly corrosive soil, simple, economical polyethylene encasement has provided excellent corrosion protection for the pipe.

HAS EXTREMELY HIGH IMPACT RESISTANCE. In test after test, ductile iron has exhibited tremendous impact resistance. Ductile's toughness makes it much less vulnerable to damage from improper handling or abnormal service conditions. And it stands up under heavy traffic conditions in unstable soil environments where other materials might fail due to the stresses caused by unusual loading.

DEMONSTRATES TREMENDOUS BURSTING STRENGTH. Ductile's tremendous bursting strength makes it ideally suited for high-pressure applications. Ductile's bursting strength also provides an additional safety factor against water hammer.



Ductile iron pipe can withstand severe crushing loads. The ring test, shown at right, determines a pipe's ability to withstand load over a relatively small area, as would occur in rocky terrain where the pressure of a single rock, plus all the backfill above it, could cause weaker materials to fail. A deflection gauge on the ring-crushing apparatus has been adjusted to accurately record deflection at specified load intervals.

Bottom: This photograph was taken immediately after rupture occurred at the top of the ring. Note deflection of a full 50mm in this 200mm ductile iron pipe.

IS EASY TO INSTALL. Ductile iron is easy to install in the field. A wide variety of joints and standard fittings are available for every application. Ductile iron can be cut and direct-tapped in the field. And it requires no complex laying schedules or line-and-grade drawings.

IS VIRTUALLY MAINTENANCE-FREE. Years of experience in operating systems throughout the world have proved that, once installed, ductile iron requires little, if any, maintenance over the life of the pipeline. Ductile's longevity can be witnessed in the outstanding service records of cast iron pipe over the past 150 years.

OFFERS IMPRESSIVE ENERGY SAVINGS. Ductile's high flow coefficient (C = 140) and generally larger-than-nominal inside diameters can result in increased flow capacity, lower head loss, lower pumping costs, and significant energy savings over the life of the pipeline.

ASSURED, PROVEN LONG LIFE. Historical records document the proven service for centuries of gray cast iron pipe. Extensive laboratory and field tests conducted by many authorities under various installation conditions prove the superiority of ductile iron for soil corrosion resistance over gray cast iron. The outstanding resistance of ductile iron pipe to soil corrosion has been verified by more than four decades of service.

After receiving the full force of a 2-ton weight dropped from a height of 9m, this 800mm **ACIPCO** Ductile Iron pipe was severely deformed, but did not fail.

IRON MELTING FACILITY

At **ACIPCO**, iron for pipe production is melted in one of the world's largest cupolas which is over 3,800mm in diameter and can melt up to 90 metric tons of iron per hour. This 35m-tall furnace is completely water cooled. A computer is used to control the operation by monitoring the various operating conditions and charge components.

The latest pollution control equipment has been incorporated into this cupola. The effluent gases are cleaned in an elaborate system consisting of a high-energy wet scrubber and a waste gas burner that remove 99.5% of the particulate matter with no visible discharge. Combustion air is preheated to 642° Celsius in a recuperative type heater which burns and further cleans the effluent gases and utilizes the waste energy available.

Five 11-metric-ton coreless electric induction furnaces provide final adjustments in chemical analysis and temperature.

Iron is desulfurized to less than .01% and held in either the 1,180 metric ton or 907-metric-ton holding ladle. Iron is then transferred to five 11-metric-ton coreless electric induction furnaces where the temperature and composition are adjusted and controlled to fit the various production center demands.

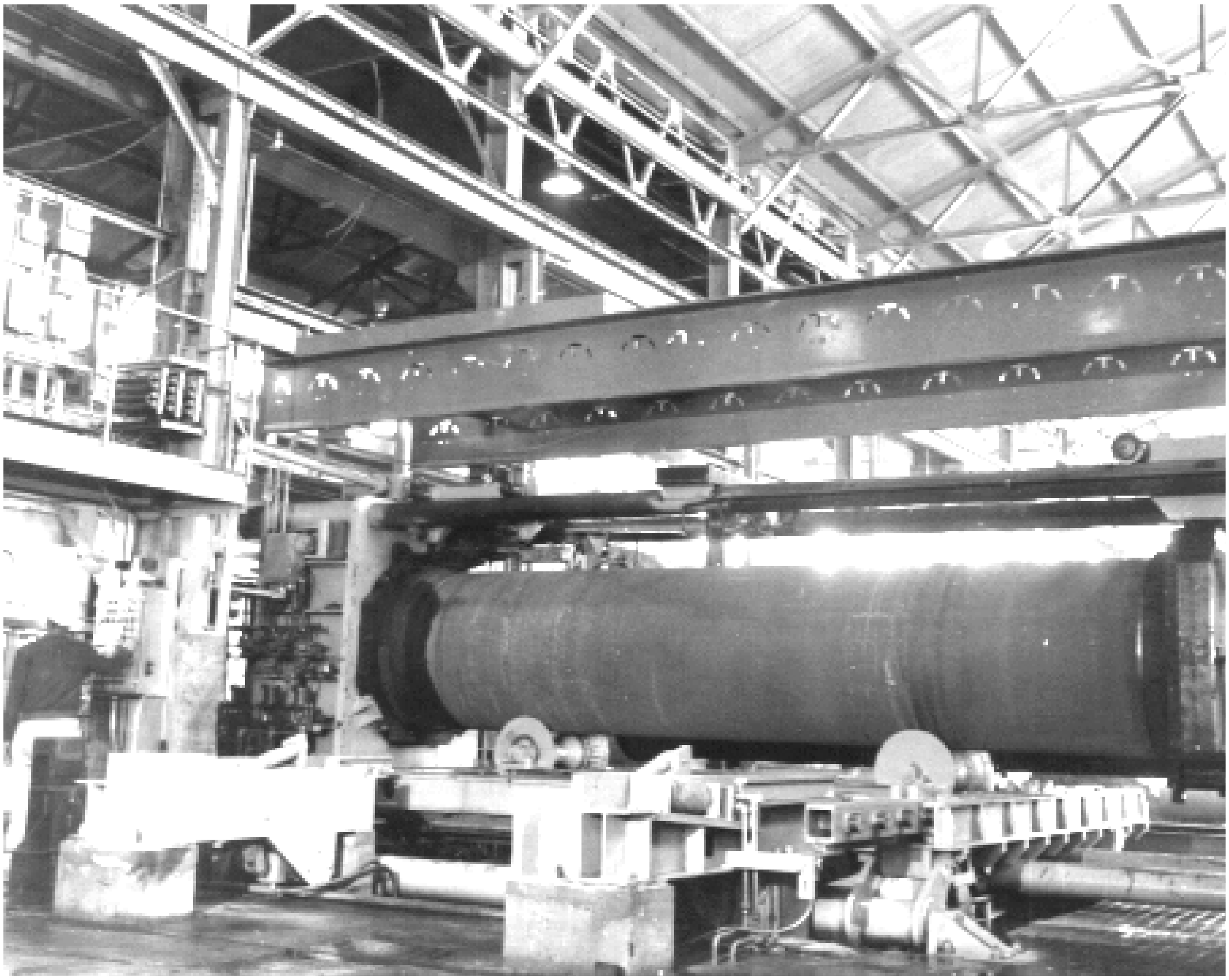
To produce nodular graphite structure for ductile iron, magnesium is immersed in the iron in pressurized ladles. The pressure ladle stations contain the smoke and ensure a controlled residual of magnesium.

The entire melting process is monitored by melting engineers who supervise methods and improvements.

Molten iron being poured into a pressure ladle where it will be treated with magnesium to produce ductile iron.

Stream of molten iron flowing continuously from the cupola into 45-metric-ton-capacity collecting ladles.

After the melting process, the ductile iron is then directed to centrifugal pipe casting machines. The newest and most modern of these machines were designed and built by **ACIPCO**. Molten ductile iron pours from the bottom of a quadrant type ladle into a rotating pipe mold inside the casting machine. A head core made of resin-coated sand serves to seal the bell end of the mold and to form the inside of the bell of the pipe for the specific joint being made.

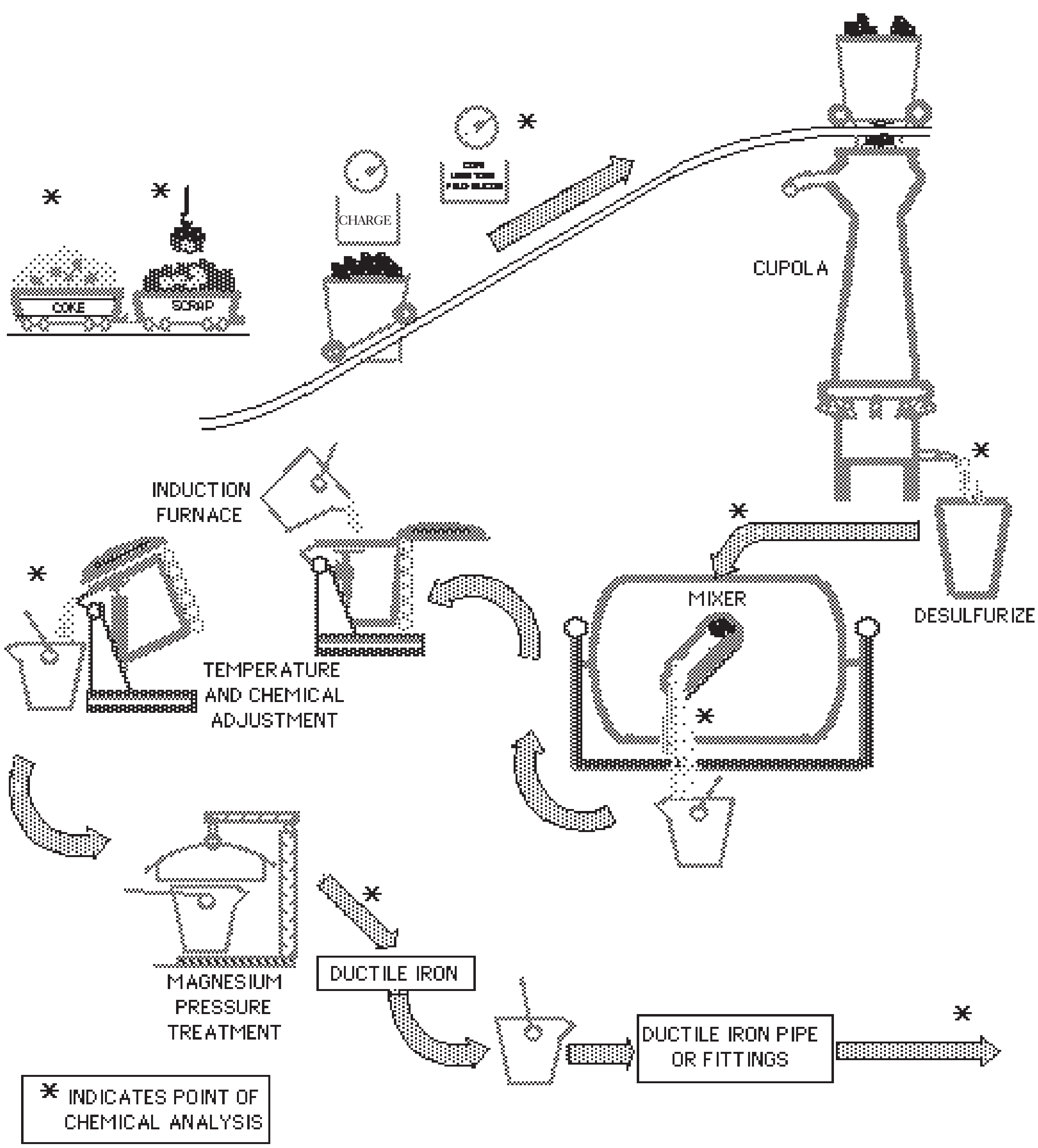


When pipes emerge from the ovens, each piece of pipe is subjected to a hydrostatic test in accordance with ISO 2531. This photograph shows a 1,200mm, class K9 pipe being hydrostatically tested to a pressure of 40 bars.

PIPE CASTING FACILITY AND PROCESS

As the mold rotates, centrifugal force distributes the metal evenly, forming the pipe wall. The newly cast pipes, up to 1,600mm in diameter, are heat treated in annealing ovens to optimize the strength and ductility of the iron.

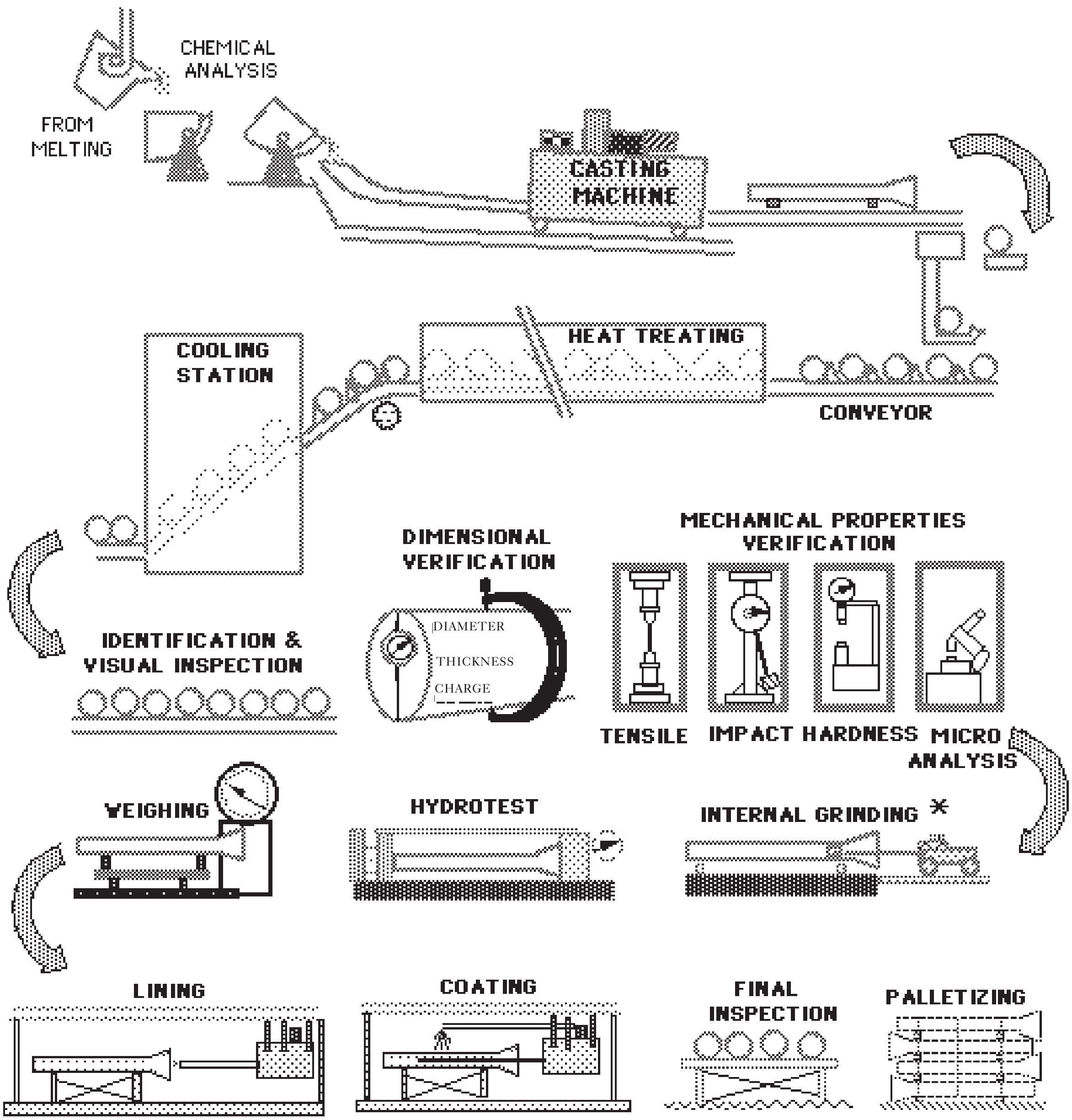
When the pipes emerge from the ovens, each piece of pipe is subjected to a hydrostatic test in accordance with ISO 2531. Further testing verifies dimensions, mechanical properties, and weight. After testing, some pipes are routed for special fabrication. Most pipes go straight to **ACIPCO**'s internal lining and external coating facility.



Melting Process

After lining and coating, the pipes are marked and taken to a curing building where the cement linings are cured for 24 hours in an environmentally controlled building.

Because of our focus on excellence, in 1994 **ACIPCO** was the first North American ductile iron pipe manufacturer to receive ISO 9000 certification for quality assurance.



*450mm - 1,600mm only

Pipe Casting Process