Effect of graphite shape

In so called “grey irons” the graphite is present in the form of flakes, hence their name: flake graphite irons (sometimes called lamellar graphite irons), by concentrating abnormal stresses at certain points, each of these flakes may initiate cracking.

Metallurgists have there fore sought to diminish, or eliminate, this effect by changing the size or distribution of the flakes.

In a first stage, the adoption of the centrifugal process to cast flake graphite iron pipes (so called grey iron pipes), led to an appreciable improvement, by producing very fine graphite flakes.

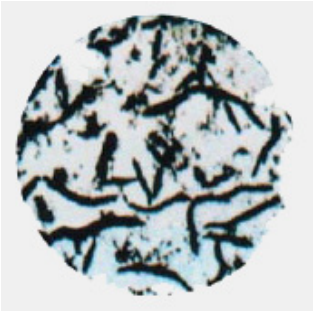
A decisive advance was the made in 1948, when research in both the U.S.A and Great Britain led to the discovery of spheroidal graphite iron, more commonly known as ductile iron.

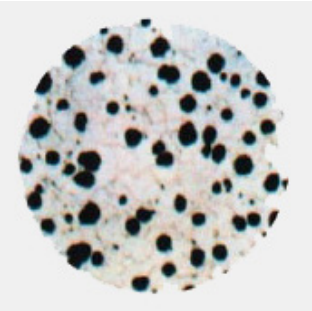
The graphite no longer exists in flake form but precipitates in a spherical form. The possibility of crack propagation lines is therefore eliminated.

Graphite precipitation in spheroidal form is obtained by the controlled addition of a small amount of magnesium to the previously desulfurized base iron.

This kind of iron, has almost got the mechanical properties of steel, but maintaining an excellent behaviour against corrosion.

Spheroidal graphite iron properties





Ductile iron owes its remarkable mechanical properties to the spheroidal shape of its graphite:

· Tensile strengthMechanical properties
· Impact resistance
· High elastic limit (yield strength)
· Good elongation

These properties are further enhanced by control of the chemical analysis and heat treatment after the manufacture of the pipe.

Ductile iron maintains the traditional qualities of cast irons, resulting from the high carbon content:

· Compression strength
· Castability
· Abrasion resistance
· Machinability
· Fatigue strength

Standards

All Mafusa pipes and fittings are manufactured from spheroidal graphite iron, complying with Standards:
ISO 2531-2009 / EN 545-2010 / EN 598-2009

Specifications		EN 545 / ISO 2531	Fábrica
Minimum tensile strenght RM (Mpa)	Pipes / Fittings	420 / 400	≥400
Minimum elastic Rp 0.2 (Mpa)	Pipes / Fittings	300* / 300	300
Minimum elongation after fracture (A en %)	Pipes / Fittings	≥ 10% DN ≤ 1000 / 7% DN > 1000	/ ≥5% (pieces)
Maximum hardness HB	Pipes / Fittings	< 230 / < 250	

ISO 2531-2009 / EN 545-2010 / EN 598-2009 permits values between 270 to 300 Mpa when:
A ≥ 12% for DN ≤ 1000 – A ≥ 10% for DN > 1000

Remarkable Mechanical Properties

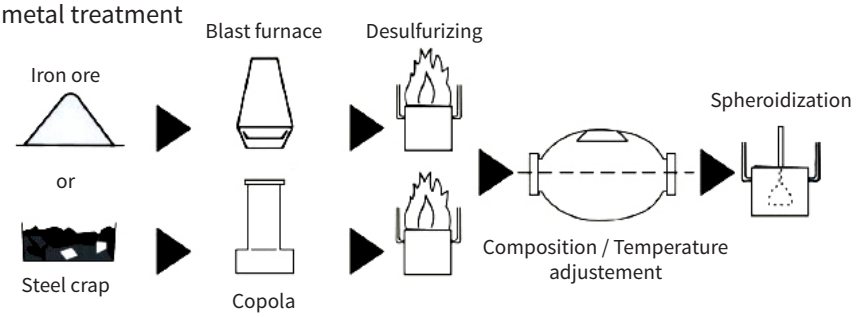
	Ductile iron pipe	Grey cast iron pipe	Steel pipe
Tensile strenght (N/mm^2)	Min. 420	150 - 260	Min. 400
Yield strenght (N/mm^2)	300	-	-
Bending strenght (N/mm^2)	Min 590	200 - 360	Min. 400
Elongation (%)	DN 100 - 1000 ≥ 10% DN 1200 - 2200 ≥ 7%	Negligible	Min.18%
Module of elasticity (N/mm^2)	Aprox. 16 x 10^4	Aprox. 16 x 10^4	Aprox. 16 x 10^4
Hardness (HB)	Máx. 230	Máx. 230	Aprox. 140

Relevant study documents on the efects of earthquakes in the sanitary water net show: The damage rate per kilometre for ductile iron mains is ¼ times of that for grey iron and 1/30 times of some other materials of pipes.

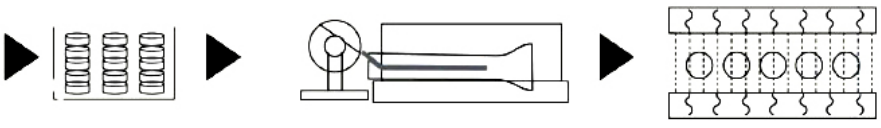
Manufacture of pipe and fittings

Three stages are involved in the manufacture of pipes and fittings:
· Metal preparation: blast furnace, cupola, metal treatment
· Pipe spinning/foundry casting
· Finishing/coatings

Metal preparation



Foundry casting

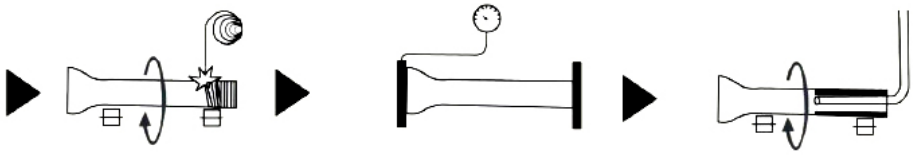


Manufacture of cores to cast the sockets

Cnetrifugal casting

Annealing

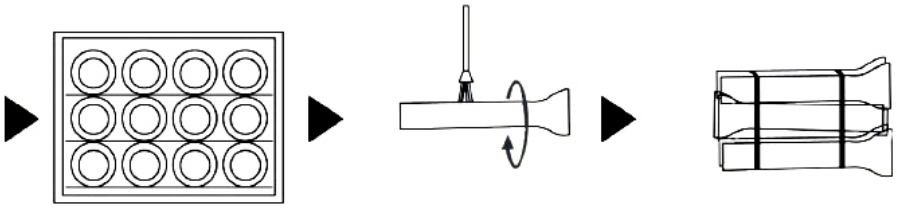
Finishing / Coatings



Zinc coating

Hydraulic testing

Cement mortar lining



Curing of cement

Bituminous coating

Packing Storage

Pipe manufacture

Metal preparation

Molten metal can be obtained directly by reduction of iron ore in a blast furnace, or by melting pig iron and scrap in a cupola (or electric furnace). In all cases the materials have to be selected and cheched carefully, in order to produce a very high purity base metal suitable for the treatments described below.

After desulfurization, the iron temperature is adjusted in an electric furnace, to provide the optimum casting temperature. At this stage, corrections can be made to the chemical composition by additions of scrap metal, or specific ferro-alloys. Magnesium is introduced into the molten metal, to render it ductile. (See DUCTILEIRON).

Foundry casting

The pipe spinning process consists of deposition of a layer of molten iron inside a rapidly rotating cylindrical mold, and solidification of the metal by continuous mold cooling.
The principal methods is used is the “LAVAUD” .
In this process, molten metals is poured into an uncoated steel mold and is subjected to rapid cooling.
A graphitizing, then ferritizing heat treatment is necessary to obtain pipes with the required structure and mechanical properties.

Finishing / Coatings

· ZINC
On leaving the heat treatment furnace, the pipes receive an external coat of pure metallic zinc, applied by electric arc melting of zinc wire and spraying with compressed air (or the combination of some metals, p.e.2n + Al)
Many types of inspections and tests to guarantee quality are carried out: checking the structure and mechanical properties of the metal, visual inspection, dimensional checks, individual hydrostatic tests.
Particular attention is paid to spigots and sockets because of their importance in joint sealing.

· CEMENT MORTAR
The mortar lining is centrifugally applied. It is poured into the pipe and then spun at high speed, which has the effect of giving the lining good compaction.
The cement mortar is then cured under controlled temperature and humidity conditions.

· PAINT
After the mortar has cured, the pipes move on to the coating lines. A layer of bituminous paint is then applied by spraying on top of the zinc.
It’s posible the application of different kind of paint (bituminous, epoxy, polyurethane, acrylic, etc.)
The pipes are then bundled (DN ≤300) and put into stock to await dispatch.

Fittings manufacture

Production of ductile iron fittings and accessory items follow the same pattern (metal preparation, casting, finishing and coating), except for the fact that sand castings do not require heat treatment.

Casting

In the fittings manufacture, we use the system “Loast Foam” where the positive of the piece is previously builded by polyurethane. That provides a brilliant final result of the finished piece.

On leaving the casting shop, the castings have their running systems removed, tehn are shotblasted and fettled. Finally they are air tested before being given a dipped or sprayed bituminous coating.

Finishing / Coatings

The purpose of an external coating is to provide a durable protection against corrosive soils.
Mafusa offers a complete range of external coatings to meet all cases of corrosive soils.

The external coatings of MAFUSA pipes and fittings for potable water supply and irrigation can be divided into three catergories according to the chemical nature of the soil:

· Standards coatings, suitable for the vast majority of soils
· Supplementary protections, for highly corrosive soils
· Special coatings, for extremely corrosive environments

The purpose of an internal protection is to:

· Guarantee that the hydraulic performance of the pipe is maintained long term.
· Prevent any risk of internal attack by the waters carried. We can offer a complete range of internal protections to meet types of water carried.
· Avoid alteration of the organoleptic qualities of the transported water.

The linings and internal coatings of MAFUSA pipes and fittings can be divided into three categories, according to the aggressivity of the waters carried:

· Standard coatings, suitable for the vast majority of raw and potable waters,
· Reinforced protections, for waters aggressive to ordinary cement (soft and acidic waters, highly abrasive waters…)
· Special coatings, offered for very special cases of water corrosivity (industrial effluents…)

External coatings	Pipes	Fittings
Standard coating	Metallic Zinc + bituminous paint or Zn + Al + paint	Bituminous paint
Supplementary coating	Zinc metálico + bituminous paint + polyethilene sleeving (applied on site)	Bituminous paint + polyethilene sleeving (applied on site)
Special coatings	Consult us (polyurethane, epoxy, etc.)	Consult us

Internal coatings	Pipes	Fittings
Standard coating	Ordinary cement mortar (ISO 2531 / EN 545)	Ordinary cement mortar / Epoxy
Supplementary coating	High alumina cement mortar (EN 598)	High alumina cement mortar / Epoxy
Special coatings	Consult us	Consult us

Mafusa examines water quality on request, in order to recommend the most suitable protection.

Marking

Pipes

Marking	Position	Nature
Socket pipes DN / Tipo de enchufe / Material (ductile iron) D.I./ Fábrica / Year of manufacture/ Logo		Cast on Painted on the barrel
Flanged pipes Fábrica / DN / PN / Longitud útil / Material (ductile iron) D.I. / Year of manufacture		Painted on the barrel (welded flanged) or Cast on (integrally cast flanges)

Fittings

Marking	Position	Nature
Socket fittings DN / Tipo de enchufe / Material (ductile iron) D.I. / Fábrica / Year of manufacture / PN / Ángulo	 + EN545 - 2010	Cast on / Label

Packing

Pipes with DN < 300

Pipes bundled, fittings packed on pallets. Small diameter pipes are delivered from our works in bundles. The bundles are designed to facilitate and speed up pipe handing

Pipes with DN > 300

Pipes and fittings unpacked.