Ductile Iron

DCI (A395)

FLOWSERVE

Bulletin A/6j

Ductile Iron

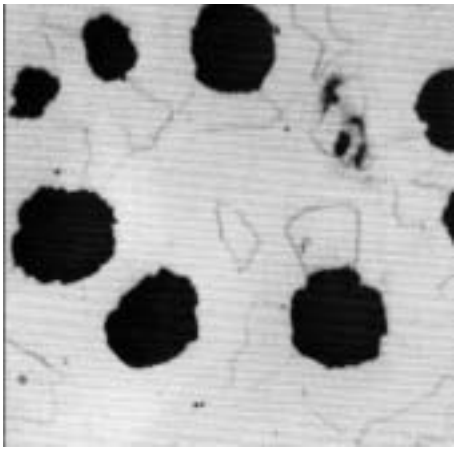
What Ductile Iron Is

Ductile iron is a family of cast graphitic irons which possess high strength, ductility and resistance to shock. Annealed cast ductile iron can be bent, twisted or deformed without fracturing. Its strength, toughness and ductility duplicate many grades of steel and far exceed those of standard gray irons. Yet it possesses the advantages of design flexibility and low cost casting procedures similar to gray iron.

The difference between ductile iron and gray iron is in the graphite formation. Ordinary gray iron is characterized by a random flake graphite pattern in the metal. In ductile iron the addition of a few hundredths of 1% of magnesium or cerium causes the graphite to form in small spheroids rather than flakes. These create fewer discontinuities in the structure of the metal and produce a stronger, more ductile iron. It is this graphite formation which accounts for the fact that ductile iron is also referred to as “nodular iron.” The ductile iron process was developed by The International Nickel Company, Inc. Flowserve Corporation produces valves, pumps, and other process equipment in ASTM A395 ductile iron.

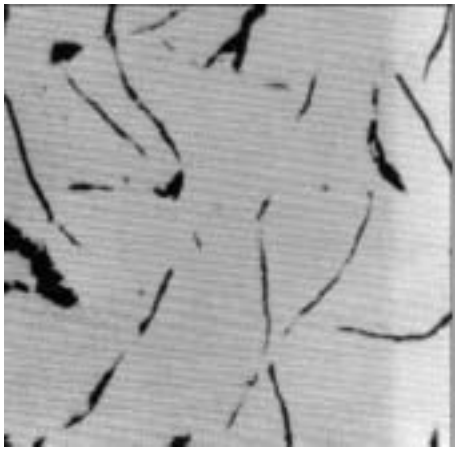
Ductile Iron

A395 material showing random graphite nodules. Etched, magnification 250x.



Gray Iron

Showing random graphite flakes. Unetched, magnification 250x.



What Ductile Iron Means to the User

With ductile iron, the safety and reliability of process equipment is improved. The improved mechanical properties increase its resistance to breakage from physical load, or mechanical and thermal shock far above that of gray iron. The corrosion resistance of ductile iron is equal or superior to gray cast iron and to cast steel in many corrosives. Its wear resistance is comparable to some of the best grades of steel and superior to gray iron in heavy load or impact load situations. Because it can be cast with the same low cost procedures used for gray iron it is considerably less expensive than cast steel and only moderately more expensive than gray iron. The substantial advantages obtained from its high yield strength and ductility make it an economical choice for many applications.

Tensile Strength	The tensile strength of ductile iron begins where gray iron stops. The as-cast tensile strength of ductile iron ranges from 60,000 to 100,000 psi. A395 material, which has the greatest ductility, has a minimum tensile strength of 60,000 psi.
Yield Strength	The yield strength of A395 ductile iron is a minimum of 40,000 psi. This is higher than grades 70-36 and 60-30 cast steel or ordinary gray iron (which has no true yield strength) and gives a high safety factor in load bearing or thermal stress situations.
Modulus of Elasticity	The modulus of elasticity of ductile iron is comparable to cast steel in that the stress is proportional to the strain up to the yield point. Ductile iron has an elastic modulus between 23 and 26 million psi, considerably higher than gray iron which has no true elastic modulus, and somewhat below that of cast steel. This, coupled with the high yield strength of ductile iron, gives a high safety factor.
Ductility	Ductility and tensile strength are the major factors in determining the impact resistance of metals. Although it is clear that the ductility of a casting may be significantly different from the conventional test piece, the measure of ductility is a good relative index of plasticity. The commonly used index of ductility is the plastic elongation of a 2" test bar. A395 ductile iron is one of the most ductile of all cast irons and shows 18% to 30% elongation on a test piece.
Pressure Tightness	The nodular graphite structure of ductile iron reduces discontinuities in the structure and prevents capillary leakage often encountered in gray cast irons. This, along with the fact that it is easily cast, makes ductile iron ideal for high pressure services.
Impact Resistance	Although all ductile irons have good impact resistance, type A395 material is the most desirable for applications subject to possible shock. Impact resistance depends on the degree of ferritization in the microstructure. Since A395 ductile iron is fully ferritic, it has high impact resistance. Charpy impact test on a standard test bar, unnotched, give readings from 60 to 115 foot pounds.
Heat Resistance	The high temperature strength of A395 ductile iron is roughly comparable to ordinary cast steel at 800°F. It has a stress rupture strength of 30-35,000 psi after 100 hours at 800°F.
Wear Resistance	Service data indicate that the wear resistance of ductile iron is equivalent to some of the best grades of cast gray iron. This has been demonstrated by in-service performance of equipment such as cylinder liners, crankshafts, metal working rolls, dies and gears.
Quality Assurance	All Flowserve ductile iron castings are rigorously inspected to assure proper graphite nodularization and an adequate ferritizing anneal heat treatment.
Corrosion Resistance	The corrosion resistance of ductile iron is equal or superior to cast steel where either is regularly used. In some applications it demonstrates a useful advantage over cast steel such as in neutral to alkaline brines. Ductile iron is also extensively used for handling concentrated sulfuric acid, caustic solutions, steam condensate and a wide variety of organic liquids.

Ductile Iron

Mechanical Properties of Ductile Iron Compared with Cast Iron, Malleable Iron and Cast Steel

	Ductile Iron ASTM A395	**Cast Iron** ASTM A48 Class 25	**Malleable** ASTM A47 Grade 32510	**Cast Steel** ASTM A216 Grade WCB
Tensile Strength, Min. psi	60,000	25,000	50,000	70,000
Yield Strength, Min. psi	40,000	*	32,500	36,000
Elongation, Min. in 2"	18%	*	10%	22%

*Cast iron shows no true yield strength and negligible elongation. Therefore, no values are listed for these specifications.

Properties and Specifications

Chemical Composition

Total carbon	3% min.
Silicon	2.75% max.
Phosphorous	0.08% max.

Mechanical Properties

Tensile Strength, psi (MPa)	60,000 min. (414 min.)
Yield Strength, psi (MPa)	40,000 min. (276 min.)
Elongation, in 2"	18% min.
Hardness, Brinell	143-187
Impact Strength, Charpy unnotched, ft.-lbs. (joules)	60-115 (81.5-156)

Physical Properties

Specific Gravity	7.1
Density, lbs. per cu. in.	0.257
Thermal Conductivity, CGS	0.0825
Coefficient of Thermal Expansion, Mean 68°-392°F., in./in./°F. (cm/cm/°C.)	6.8×10^{-6} (12.3×10^{-6})

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Printed in U.S.A.
February 2011