ACMECAST®

Steel, Stainless Steel, High & Super Alloy-
Heat, Wear, Abrasion, Pressure & Corrosion Resistant
Castings, Spares, Replacement Parts, Custom-Made Components
Manufacturer-Supplier to OEM's, Plants, & Process Industry
Machined, Proof-Machined, CNC/VMC Precision Machined Components
Conversion to Castings from Fabrications, Forgings & Welded Assemblies
Engineering, Materials & Metallurgical Consulting

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High (-Si, -Cr, -Ni) Alloyed Cast Irons

Corrosion, wear, abrasion and heat resistance of alloyed cast irons, depends on principally their chemical composition and microstructure. The dominating factors are the chemical composition and the structure of the matrix. The three distinct groups of the alloyed cast irons, which have enhanced heat and corrosion resistance for specific environment, are

1. **High-Silicon Cast Irons (Silal)**
2. **High-Chromium (Ni-Hard) Cast Irons**
3. **High-Nickel (Ni-Resist) Cast Irons**

Heat-resistant alloy gray and ductile irons are Fe-C-Si alloys with additions of silicon (above 3%), chromium, nickel, molybdenum, or aluminium to improve their high-temperature properties.

At temperatures above 425°C, the mechanical properties of cast irons gradually decrease as the temperatures rises and the iron undergoes the chemical change during growth as well as oxidation. Growth is a permanent increase in volume that occurs at elevated temperatures in some cast irons, gray cast irons in particular. It is attributed to the expansion that accompanies the reaction of Fe_3C changing to graphite and iron; and the oxidation of the iron after graphite is oxidized away as carbon mono-oxide. Oxidation also can occur on the cast-iron castings surface after sufficient exposure to high temperatures. If the surface oxide scale is porous or flakes off at high temperatures, combined oxidation of the metal will occur. Eventually the strength of the material will decrease due to loss of the material in scaling.

Classification of special high-alloy cast irons

Graphite Free

Pearlitic Iron	Wear Resistant	ASTM A 532
Martensitic White Iron (Ni-Hard)	Wear Resistant	ASTM A 532
High-Chromium Iron (11-28%Cr)	Wear, Corrosion, and Heat Resistant	ASTM A 532

Graphite Bearing

Ferritic	5% Si Iron (Silal)	Heat Resistant	
	High (15%) Silicon Iron	Corrosion Resistant	ASTM A 518, A 518M
Austenitic	18% Ni (Ni-Resist)	Corrosion and Heat Resistant	ASTM A 439
	18% Ni, 5%Si Nicrosilal	Heat and Corrosion Resistant	ASTM A 439
Acicular	High Strength	Wear Resistant	

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High-Silicon Cast Irons

The principal alloying element is 12% to 18% silicon with more than 14.2% silicon needed to develop corrosion resistance. In addition, chromium and molybdenum are also used in combination with silicon to develop excellent corrosion resistance to specific environments. High-silicon cast irons represent the most universally corrosion-resistant alloys available at moderate cost.

When silicon level exceeds 14.2%, high-silicon cast irons exhibit excellent corrosion resistance to H_2SO_4, HNO_3, HCl, CH_3COOH and most mineral and organic acids and corrosives. These materials display good resistance in oxidizing and reducing environments affected by concentration or temperature.

Exceptions to universal resistance are hydrofluoric acid (HF), fluoride salts, sulphurous acid (H_2SO_3), sulphite compounds, strong alkalis and alternating acid-alkali solutions.

With high silicon content of from 12% to 18%, cast irons become very resistant to corrosive acids. With a content of 14.5% or higher, these cast irons have very high resistance to boiling 30% H_2SO_4. High-silicon irons with 16.5% silicon are resistant to boiling sulphuric acid and nitric acids at almost all concentrations. However, because of their high silicon content, they have poor mechanical properties such as low thermal and mechanical shock resistance, and are difficult to cast and are practically un-machinable due to high brittleness.

Silicon contents of less than 3.5% increase the rate of growth of gray cast iron by promoting graphitisation. However, silicon contents of 4% to 8% greatly reduce both oxidation (scaling) and growth. Silicon increases the scaling resistance of cast iron by forming light surface oxide that is impervious to oxidizing atmospheres. Silicon also raises the ferrite-to-austenite transformation temperatures to about 900°C so that the expansion and contraction due to the phase transformation can be avoided up to 900°C.

ASTM Standard Specification: **ASTM A 518/ 518 M** **Grade: 1, 2, & 3**

High-Chromium Cast Irons (Ni-Hard)

These are essentially white cast irons alloyed with 12% to 18% chromium and are popularly known as Ni-hard. Chromium imparts abrasion resistance to oxidation. High-chromium cast irons are resistant to oxidizing acids, particularly nitric acid and are useful for work with weak acids under oxidizing conditions with many organic acid solutions and with salt solution.

When the chromium levels exceed 20% high-chromium cast irons exhibit good resistance to oxidizing acids, particularly nitric acid (HNO3). High-chromium cast irons are resistant to reducing acids. They are used in saline solutions, organic acids, marine and industrial atmospheres. These materials exhibit excellent resistance to abrasion and with proper alloying additions, they can also resist combinations of abrasion and liquids including some dilute acid solutions.

The mechanical properties of high-chromium cast irons are better than those of the high-silicon cast irons. The high-chromium cast irons respond to heat treatment when the carbon and chromium contents are appropriately adjusted. However, machining of these alloys is very difficult and exhibit poor welding ability.

Chromium is added to heat-resistance cast irons because it assists in stabilizing carbides and forms a protective oxide on the metal surface. Even small additions of chromium (0.5% to 2.0%) reduce growth in gray irons subjected to cyclic heating at 800°C. After extended high-temperature service, the pearlitic matrix of as-cast 0.8% Cr heat-resistant cast irons is transformed to ferrite and its cementite is spheroidized in structure. Higher chromium additions of 15% to 35% provide excellent oxidation and growth resistance for temperatures up to 980°C. However, these high-

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chromium irons have a white-iron structure. Even though they have good strength properties, they also have limited machinability. They can be machined with expensive CBN (Cubic Boron Nitride) and PCBN Inserts.

ASTM Standard Specification: **ASTM A 532/ 532M**

Class	Type	Designation
I	A	Ni-Cr-Hc
I	B	Ni-Cr-Lc
I	C	Ni-Cr-GB
I	D	Ni-HiCr
II	A	12% Cr
II	B	15% Cr-Mo
II	D	20% Cr-Mo
III	A	25% Cr

High-Nickel Cast Irons (Ni-Resist)

These materials contain large percentage of nickel and copper and are resistant to such acids as concentrated sulphuric acid (H_2SO_4) and phosphoric acid (H_3PO_4) at slightly elevated temperatures, hydrochloric acid (HCl) at room temperature and such organic acids as acetic acid, oleic acid and stearic acid. When nickel exceeds 18% austenitic, cast irons are mainly immune to alkali or caustics, although stress corrosion cracking (SCC), a particular form of corrosion, may occur.

High-nickel cast irons are widely used and are generally known as Ni-Resist cast irons. Austenitic gray cast irons containing 14% to 30% nickel are resistant to mildly oxidizing acids, including sulphuric acid at room-temperature. High-nickel cast iron is most resistant to alkalis than unalloyed cast irons. Ni-Resist is particularly useful for high temperatures. High-nickel cast irons, because of their austenitic matrix, are the toughest of all cast irons with flake graphite. They have excellent machinability and good foundry properties, although their tensile strengths are relatively low due to the flake graphite. High-nickel ductile irons have higher strength and ductility because they have nodular graphite.

Austenitic cast irons containing 18% or more nickel up to 7% copper, and 1.75%-4% carbon is used for applications where both heat and corrosion resistance are required. The Ni-Resist cast irons have good resistance to high-temperature scaling and growth up to 815°C for most oxidizing atmospheres. In sulphur-containing atmospheres, however, the nickel content of these alloys limits their use to temperatures below 500°C. The austenitic nickel cast irons have considerably greater toughness and shock-resistance than other heat-resistant silicon and chromium alloy irons. The high-nickel cast irons with nodular graphite microstructure are considerably stronger and have higher ductility than the flaked-graphite nickel alloy irons. Ni-Resists are both machinable and weldable.

ASTM Standard Specification: **ASTM A 436/ 436M**

Type 1, 1b
Type 2, 2b
Type 3
Type 4
Type 5
Type 6

ASTM A 439/ 439M

Grade: D-2, D-2B, D-2C
Grade: D-3, D-3A
Grade: D-4
Grade: D-5, D-5B, D-5S