

The remarkable properties of ADI are developed by a closely controlled heat treatment operation (austempering) which develops a unique matrix structure of bainitic ferrite (60%) and retained (high carbon) austenite.

The retained (H.C.) austenite is thermally stable to extremely low temperatures but is work hardenable and will locally transform to martensite under suitable conditions of stress. Advantage of this feature of ADI is taken by allowing the service loading stresses to work harden the load bearing services. Alternatively, surface stresses can be deliberately imposed prior to service, e.g. by shot peening of gears or fillet rolling of crankshafts in order to achieve significant improvements in wear resistance and fatigue life.

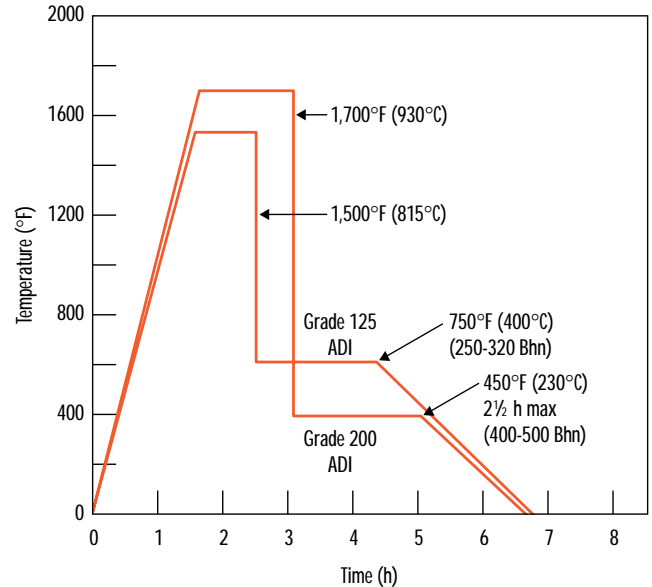
Presently there are no accepted standard specifications for ADI, but proposals for five grades of ADI have been made which form the basis for discussion and material selection between designers and foundrymen.

**Current ASTM A897  
ADA Specifications**

Tensile Strength		Yield Strength		Percent Elongation	Charpy (unnotched) (ft. lb.) (J)	BHN Hardness Range*	
(KSI)	(MPa)	(KSI)	(MPa)				
125	850	80	550	10	75	100	269 - 321
150	1050	100	700	7	60	80	302 - 363
175	1200	125	850	4	45	60	341 - 444
200	1400	155	1100	1	25	35	388 - 477
230	1600	185	1300	-	-	-	444 - 555

\*not part of specification

The heat treatment necessary to produce ADI is essentially a two-stage operation:



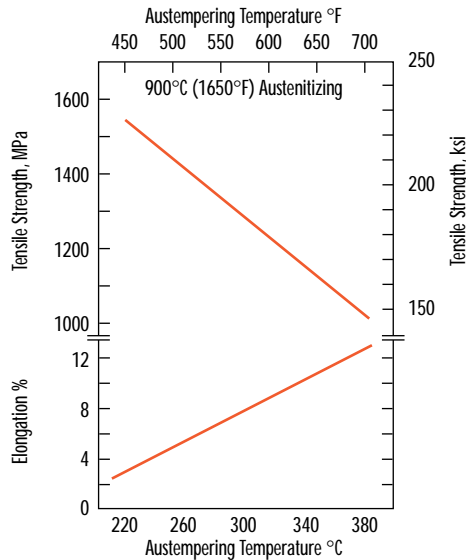
Typical Austenitizing & Austempering Cycles

**Stage 1**

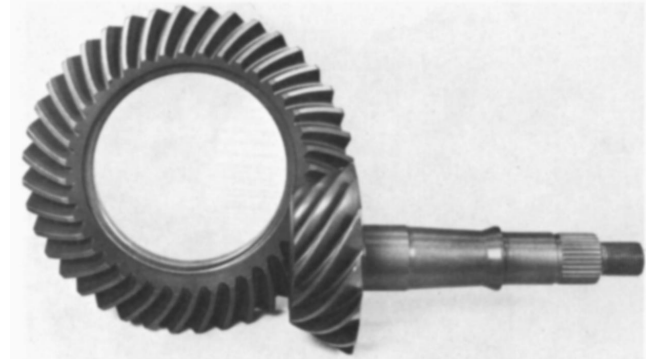
Austenitizing in the range 1500-1700°F (815-920°C). The specific austenitizing temperature selected is related to the subsequent austempering temperature and the grade of ADI required. Once selected, the austenitizing temperature must be closely controlled ( $\pm 10^\circ\text{F}$ ).

## Stage 2

Rapid transfer of the castings to the austempering furnace (usually a salt bath) where the castings are held isothermally at the selected austempering temperature. Austempering temperatures are in the range 450-750°F (230-400°C) according to the properties required in the castings (ADI grade). Close control over temperature and time of austempering is essential.

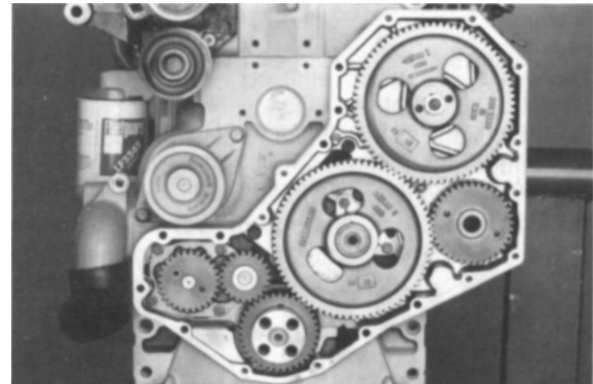


ADI is well established as a gear material replacing forged steel with major production cost savings, quieter operation and reduced weight. By machining the gears before the austempering heat treatment, major savings in machining costs are achieved.

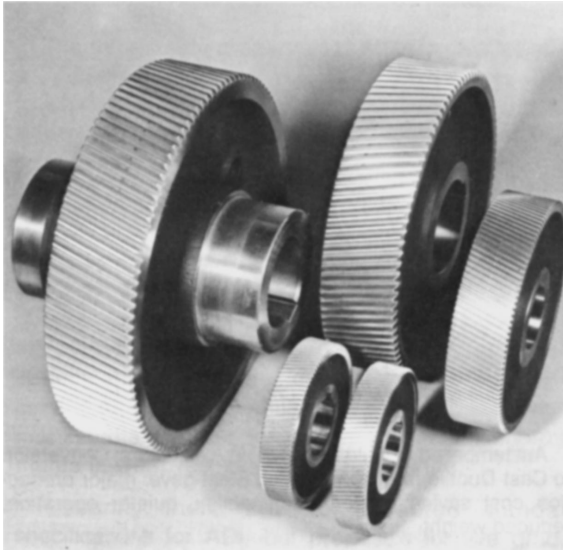


*Courtesy: General Motors Corp., Central Foundry Division, Saginaw, Michigan, USA*

Austempered Ductile Iron Hypoid Axle Gears: Conversion to Cast Ductile Iron from Forged Steel gave major production cost saving, better machinability, quieter operation, reduced weight.



ADI Timing Gears for Cummins B-Series diesel engines. Replaced forged and case carburised 1022 steel with 30% cost saving.



*Courtesy: Hogfors Industries Ltd., Finland*

Austempered Ductile Iron gears to patented specifications K9805.

Other examples of the use of ADI castings include truck spring supports, railroad axle-box spring adaptors, crankshafts, connecting rods, agricultural plough shares, etc.



ADI Crankshaft for Ford turbo-charged engine—ADI capable of meeting fatigue strength requirements at much lower cost than forged steel.

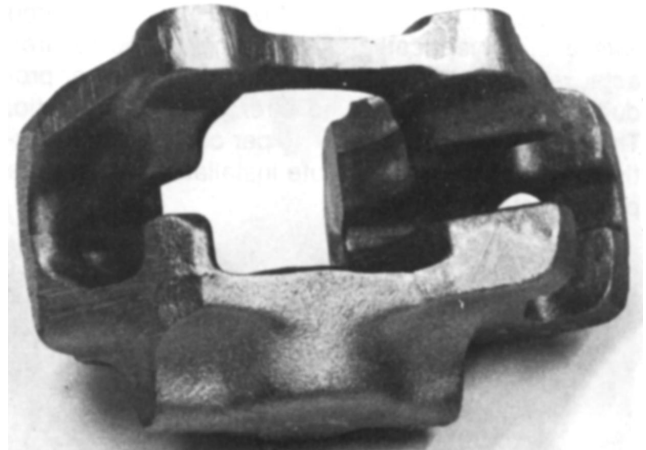
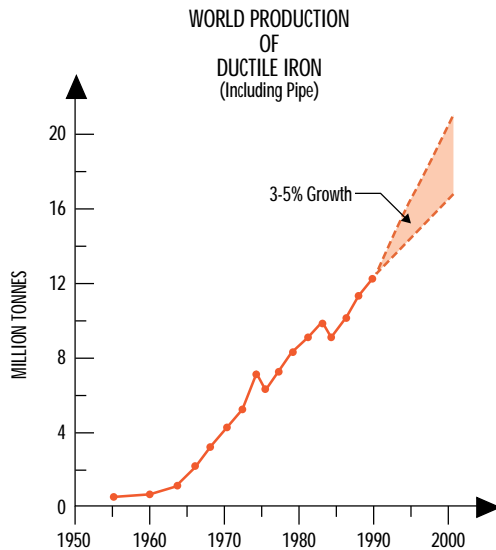
Success in consistently achieving the optimum properties and performance of ADI requires high quality, careful selection and control over the base Ductile Iron, and heat treatment parameters. This necessitates material of high nodule count which is free from carbides, inclusions and shrinkage and of a composition which minimizes the dangers of alloy segregation.

This brief summary about the **DUCTILE IRON FAMILY** is based on metallurgy, rather than on standard specifications. A chart showing the properties of most of the Ductile Iron grades is enclosed on the inside back cover of this publication. All properties are primarily determined by chemical composition, cooling (solidification and solid cooling rate) and matrix structure.

## DUCTILE IRON—“MORE STRENGTH FOR LESS EXPENSE”

Ductile Iron appears to have been invented (1948) with the designer in mind. The tensile strength, proof stress, and elongation combinations obtainable in Ductile Iron exceed those for ANY OTHER cast ferrous alloy, including steel and malleable iron.

Since its introduction, the growth of Ductile Iron applications has exceeded all expectations. World-wide production is approximately 12 million tons and is expected to reach 20 million tons by the turn of the century. The application of Ductile Iron is a notable engineering achievement of our age.

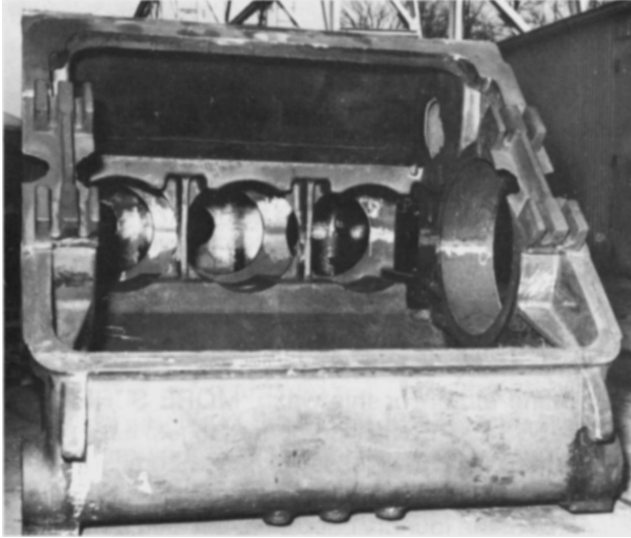


DISK BREAK CALIPER

Whether in an automobile component, as shown above, a water pipe, plow, or a “robbery-proof” parking meter box, Ductile Iron has made major inroads to the casting market in every industrially developed country. There can be little doubt, that the major motivating factor for this was **“MORE STRENGTH FOR LESS EXPENSE”** compared to just about every other cast alloy. The lesser expense comes not only from the readily available raw materials and the efficiencies of the foundry operation, but also from reduced cleaning and machining costs of Ductile Iron castings.

The following pages present a variety of Ductile Iron case histories from around the world. Many more examples could have been added. The Ductile Iron alloys are versatile and appear to find unlimited applications.

The original design of the 1,000 H.P. pump frame was a steel fabrication. Converting to Ductile Iron achieved more uniform stress distribution, lower production cost and improved strength-to-weight ratio. The weight was reduced by 46 percent, which is particularly important for remote installations where the parts must be airlifted.



*Courtesy: Gardner Denver Co., USA*

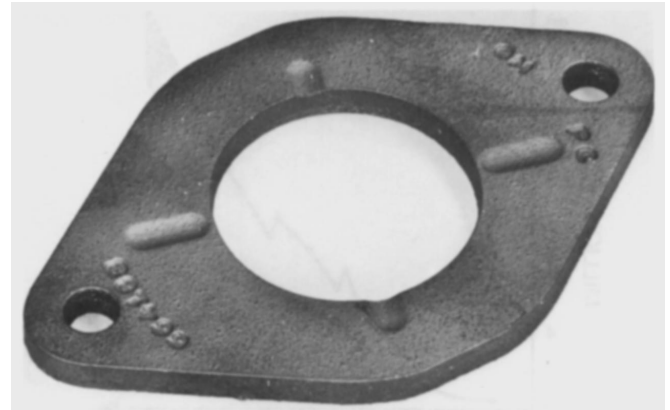
A camshaft thrust plate is exposed to severe abrasive wear. The reason for selecting Ductile Iron was to combine wear resistance with machinability. →

For break-in, this casting is phosphate-coated.



*Courtesy: Fichtel & Sachs, Germany*

↑  
Ductile Iron can readily be surface hardened to 55 Rc, which provides for the superior performance of this catch-sleeve.



*Courtesy: Dana Corp., USA*