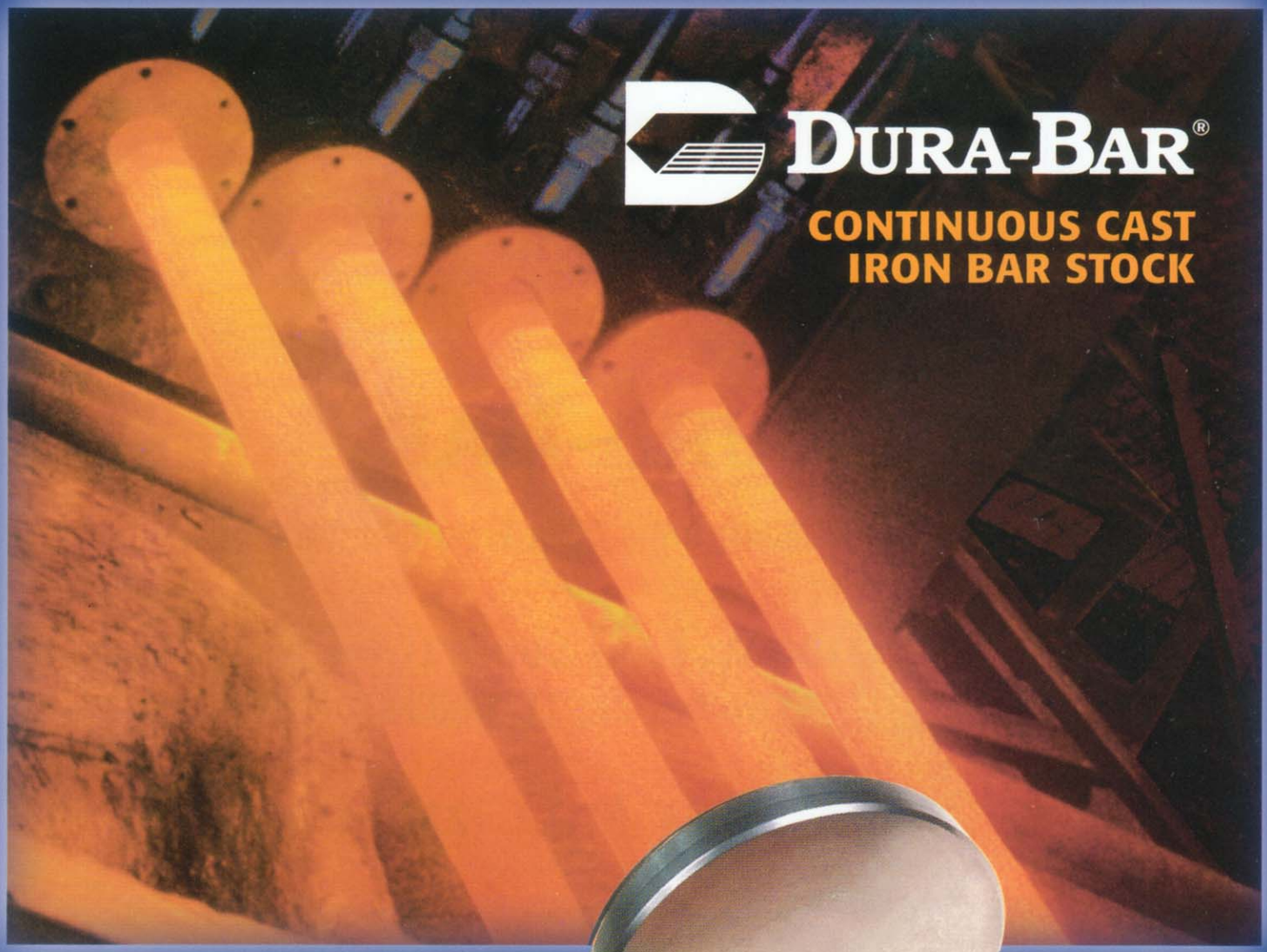


DURA-BAR®

CONTINUOUS CAST
IRON BAR STOCK

GEARS

- Low Noise
- Lower Cost

"Gearing Up For The 21st Century"

the DURA-BAR®

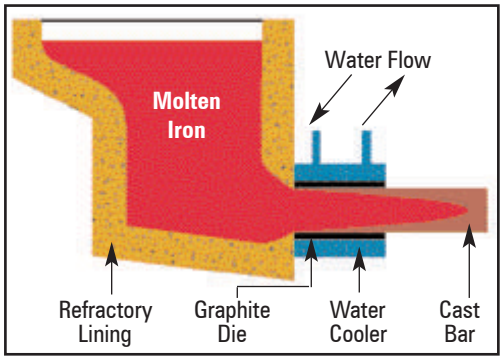
Difference

Dura-Bar is the **world's largest producer and the only manufacturer in North America of continuous cast iron bar stock** offering rounds, rectangles/squares, tubes and shapes in a large selection of sizes and grades. Continuously cast iron bars offer outstanding machinability advantages over carbon and alloy steels and can significantly **decrease the cost to manufacture machined parts** in a wide variety of applications and industries.

The key to Dura-Bar's unique properties comes from the **Continuous Casting Process**. A water-cooled graphite die that is machined to form the shape of the bar is mounted at the bottom of a bar machine crucible. Molten iron enters the die and a solid skin begins to form that takes the shape of the bar. When the bar exits the die, it consists of a solid shell surrounding a molten metal core.

As the bar is cast horizontally along the barline, iron is constantly fed into the die under the ferrostatic head pressure of the metal in the bar machine crucible. Molten iron is delivered to the bar machine at precise temperatures in regular intervals. Impurities that could form inclusions remain at the top of the molten metal bath, well away from the opening of the die.

Dura-Bar's most notable characteristic is its **extremely dense, fine grained microstructure that allows excellent surface finishes** after machining and parts are free from dross, slag and other tool wearing inclusions. Common casting defects such as porosity and shrink are virtually eliminated by the process of continuous casting.



Gears are one of the many applications that are well suited for Dura-Bar. The microstructure consists of solid graphite particles in a metal matrix making gears easier to machine and quieter in operation. Wear resistance, inherent vibration damping characteristics, weight reduction over steel and the ability to be used as-cast or heat treated to a wide variety of properties are just a few of the many benefits customers are realizing by converting their steel gears to Dura-Bar continuous cast iron bar stock.

the DURA-BAR®

Advantages

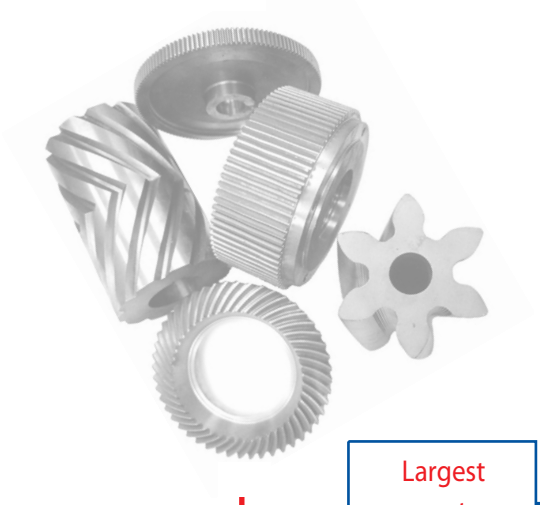
DURA-BAR vs. STEEL

- Improves machinability
- Superior vibration damping
- Higher strength-to-weight ratio
- Improves surface finishes
- Eliminates heat-treat distortion

DURA-BAR vs. CASTINGS

- Consistent quality
- Short lead times
- Optimal fatigue strengths
- Exceptional surface finishes
- Shrink-Free Material

Total Cost Savings



PROCESS & percentage of total cost	8620 Steel	DURA-BAR® Continuous Cast Iron Bar Stock
BUY MATERIAL 10%	$1.80	$2.50
CUT TO SLUGS	$0.50	$0.50
MACHINE GEAR BLANKS 15 - 20%	$2.00	$0.75
HOB TEETH 35 - 40%	$4.00	$1.38
SHAVE 15%	$1.50	$0.56
DEBURRING 0 - 30%	$1.50	$0.75
HEAT-TREAT 15%	$1.00	$1.50
GRIND 5 - 10% POLISH	$1.50	$1.50
TOTAL	$13.80	$9.44

Largest cost savings opportunity

If heat-treat distortion occurs, re-hobbing is required. (The cost will be the same as the first time.)

Clearly the use of Dura-Bar continuous cast iron bars instead of carbon or alloy steel can significantly decrease the cost to manufacture machined parts.

Gear Performance Improvements

NOISE REDUCTION

All gears make noise when they are operating. Noise comes from the design, from allowable variations in dimensional tolerances and from the material used for a gear. With everything else being equal, a set of gears made from a material that has good damping characteristics will be quieter than a set made from a material that does not.

Graphite flakes in gray cast iron will cause significantly better damping properties by comparison to any other ferrous metal. The nodules in ductile iron behave similar to the graphite flakes in gray iron, cushioning vibrations as they are transmitted through a part.

VIBRATION & NOISE REDUCTION

TYPE OF METAL	RELATIVE DECREASE IN AMPLITUDE VIBRATION / CYCLE
Steel	1.0 - 2.0
As-Cast Gray Iron	20 - 60
Heat-Treated Gray Iron	20 - 30
As-Cast Ductile Iron	3.0 - 9.4
Q & T Ductile	3.0 - 5
Austempered Ductile Iron	10 - 15

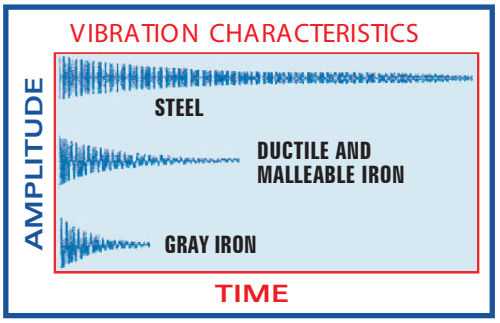
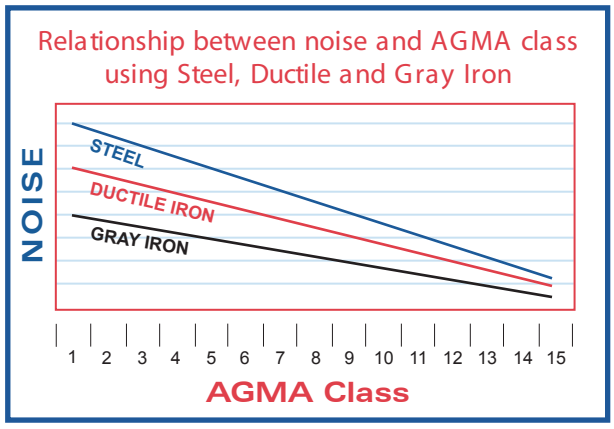


Figure 3.1

Figure 3.1 shows the relative damping capacity of as-cast and heat treated gray and ductile iron compared to steel.

The ability to dampen vibrations using Dura-Bar means that the ductile iron gears will be quieter than steel gears made to the same dimensional tolerances and have similar surface finishes. Gray iron gears will be quieter than steel or ductile iron gears and are an excellent choice for low stress applications.



Automotive balance shaft gears require high precision when made from steel in order to meet the noise standard. The tolerances are not as critical when using gray or ductile iron, which allows the gear to be made at a **lower cost**.

Figure 3.2 shows the qualitative relationship between noise level and AGMA classification using steel, ductile and gray iron.

Figure 3.2

HEAT-TREAT DISTORTION

Iron and steel grow when heat-treated because of the volume change in the atomic structure. With Dura-Bar, the growth is predictable because of the strict metallurgical process controls. Predictable growth minimizes additional processing steps after heat-treat.

Plus...

- Since Dura-Bar does not require carburizing, heat-treat distortion caused by variations in the rate of carbon diffusion into the part is eliminated.
- Due to the continuous casting process, Dura-Bar will not have residual stresses that can be present in rolled steel bars.

Machinability

Machinability Ratings and Material Selection			
MATERIAL Dura-Bar Grades	**TOOL LIFE COMPARISON at 450 SFM**	**RECOMMENDED SFM**	**Best for Applications Requiring:**
Gray Iron, Alloyed Gray Iron	100%	1100	High noise damping, moderate strength and wear, relatively low contact stresses.
65-45-12 Ferritic Ductile	260%	1400	Excellent machinability, predictable growth after heat-treat, responds well to quench and tempering and austempering.
80-55-06 Partially Pearlitic Ductile	35%	900	Good machinability, responds well to induction hardening, good noise damping.
80-55-06 Modified for Enhanced Machinability	80%	1200	
100-70-02 Pearlitic Ductile	25%	750	Used when elimination of heat-treat is a possibility, good strength and wear in the as-cast condition, good damping.
Machinability Ratings for Steel			N/A
8620 Steel	60%	350-800	
4140 Steel	65%	350-800	
1144 Steel	85%	600-1000	

COST COMPARISON

Dura-Bar's cost advantage over steel is made possible because of its ability to be machined faster, often 2 to 3 times faster than alloyed steel, which translates to more piece production per hour. Dramatic reduction in the cost of the finished part can occur by taking advantage of the free machining characteristics of the material. Deburring costs can also be reduced or eliminated.

STRENGTH

Dura-Bar is available in gray and ductile iron with tensile strengths ranging from 35,000 psi to 100,000 psi in the as-cast condition and strengths up to 230,000 when heat treated. Mechanical properties are better than those in conventionally cast parts because of the continuous casting process and strict metallurgical controls.

The highly engineered process produces the best graphite nodularity, with control over nodule size, nodule count and distribution. This means optimal strengths in tension, compression and fatigue. Selecting the right heat-treat method will produce strengths to 90% of those in 8620 carburized and hardened steel and up to 80% of those in 4140 through hardened steel.

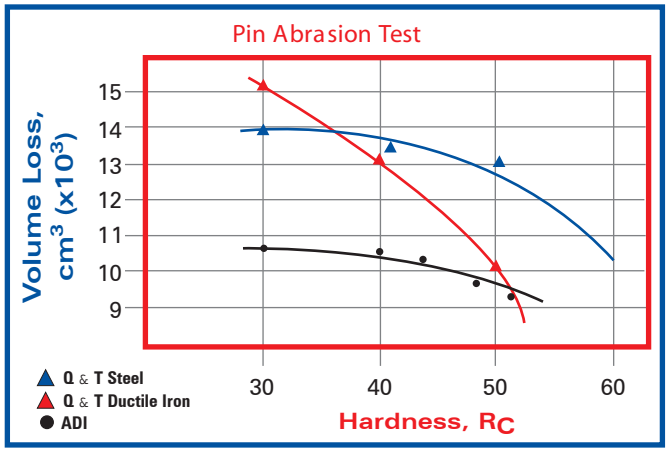
Fatigue Data for Heat-Treated Steel and Gray and Ductile Iron				
MATERIAL	**SINGLE TOOTH BENDING FATIGUE STRENGTH (psi)**	**ROTATING BEAM FATIGUE STRENGTH (psi)**	**CONTACT FATIGUE STRESS (psi)**	**OVERALL RELATIVE STRENGTH***
G2, as-cast	25,000	20,000	75,000	N/A
G2, Q & T Rc 45	30,000	25,000	80,000	N/A
65-45-12 ductile iron, as-cast	35,000	40,000	60,000	N/A
80-55-06 ductile iron, as-cast	40,000	40,000	65,000	N/A
100-70-02 ductile iron, as-cast	50,000	35,000	115,000	N/A
Ductile Iron, quenched and tempered 50Rc	60,000	45,000	225,000	90%
Grade 1 ADI	85,000	80,000	130,000	N/A
Grade 2 ADI	80,000	75,000	140,000	N/A
Grade 3 ADI	75,000	73,000	180,000	85%
Grade 4 ADI	72,000	70,000	220,000	80%
Grade 5 ADI	67,000	65,000	250,000	75%

NOTE:

*1). Based on a study conducted at the University of Dayton Research Institute on spur test gears using a specially designed fixture to test the strength in a test gear machined to specific standards.

2). All values listed are typical and not for specific design purposes.

3). Shot peening will increase fatigue strength properties up to 50%.



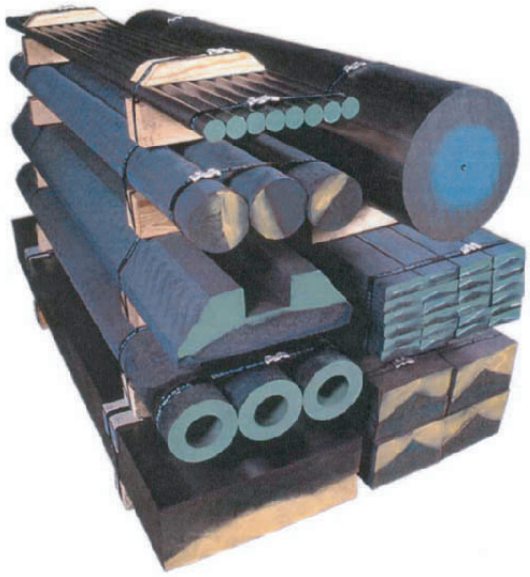
WEAR RESISTANCE

Dura-Bar resists galling and scuffing and will out perform heat treated steel in a standard pin abrasion test when it is in the quench and tempered or austempered condition (ref graph). The graphite particles prevent friction welding which causes galling. The ausferrite matrix in austempered ductile iron will strain transform when loaded and the wear resistance over a range of hardness values is virtually unchanged.

In addition to the wear resistance benefits provided by the graphite particles, localized thermal stresses are reduced because of Dura-Bar's high thermal conductivity.

Grades

- Ductile Iron
- Gray Iron
- Ni-Resist Iron
- Special Alloyed Iron



Shapes

- Rounds 5/8" - 20" diameter
- Squares/Rectangles up to 22" x 22"
- Tubes (rounds can be trepanned into tubes; contact Dura-Bar for available sizes)
- Special Shapes

As-Cast or Cold-Finished

Dura-Bar is available from a nationwide network of distributors. Contact us for the one nearest you.

DURA-BAR®

Continuous Cast Iron Bar Stock

1-800-BAR-MILL (227-6455) ◆ 815-338-7800 ◆ Fax: 815-338-1549

2100 West Lake Shore Drive, Woodstock, IL 60098-6911

Website: *www.dura-bar.com* ◆ E-Mail: *sales@dura-bar.com*

MEMBER OF AGMA

American Gear Manufacturers Association

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