Dura-Bar®
Continuous Cast Iron Bar Stock

Heat Treat Guide

- Temperature Effects
- Methods and Cycle Times
- Hardenability, Growth and Wear
- Austempered Ductile Iron

Guidelines

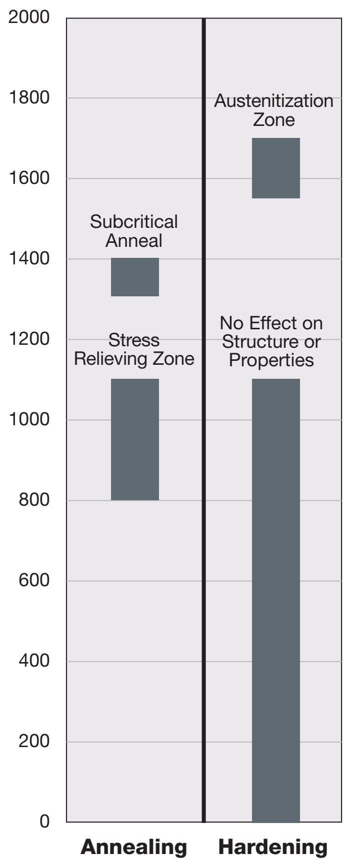
Temperature Effects

Heat treatment of Dura-Bar can be useful for extending the range of properties in the as-cast condition. Most conventional heat-treat methods that are commonly used on steel will work with Dura-Bar and because of the high carbon content, all grades have equal hardenability. Carburizing is not necessary, which can be a substantial time and cost savings.

Dimensional changes that occur during heat treating processes are predictable with minimal distortion when compared to most grades of plain carbon steel.

The guidelines for the various types of heat treating apply to standard Dura-Bar grades of gray and ductile iron.

Temperature Effects °F



Methods and Cycle Times

The following cycles are guidelines for each of the most commonly used heat treat methods. These cycles are applicable to standard Dura-Bar grades.

Stress Relieving:

Stress relieving Dura-Bar is usually not necessary. However, when extremely precise tolerances are required, stress relieving can be used to improve dimensional stability.

Type of Process	Purpose	Heat Treat Cycle	Resulting Hardness (BHN)*
Stress Relieving	Reduce thermal and mechanical stresses for dimensional stability	Heat to 800 – 1100F. Hold 1 hour per inch cross section. Furnace cool to 300F.	No Change

Annealing:

Two types of annealing processes may be used to soften Dura-Bar. Subcritical annealing is used to spherodize (soften) the pearlitic structure and full annealing transforms the matrix to all ferrite. All values are typicals.

Type of Process	Purpose	Heat Treat Cycle	Resulting Hardness (BHN)*
Subcritical Anneal	Spherodize (soften) pearlite to improve machinability	Heat to 1300 – 1400F. Hold 1 hour per inch cross section. Furnace cool to < 650F.	135 – 180
Full Anneal	Full conversion of pearlite to ferrite	Heat to 1550 – 1700F. Hold 1 hour per inch cross section. Furnace cool to < 650F.	130 – 180

Hardening:

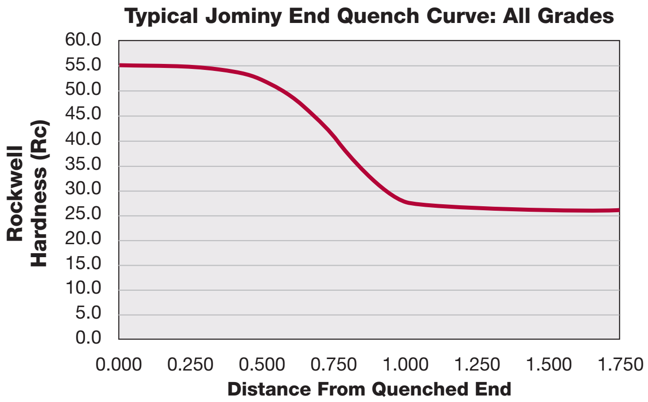
Hardening Dura-Bar is useful to improve strength and wear resistance. The most common method is quench and temper. Flame and induction hardening methods can also be used. Normalizing is used to transform the ferrite to pearlite in machined parts. Austempering requires quenching in an elevated salt bath to achieve desired results.

	Type of Process	Purpose	Heat Treat Cycle	Resulting Hardness (BHN)*
Gray & Ductile	Normalizing	Conversion of the matrix to pearlite. Effective only on machined parts or cut wafers less than 1.0" thick	Heat to 1550 – 1700F. Hold 1 hour per inch cross section. Force air or fan cool to room temperature.	241 – 302
Gray & Ductile	Quench and Temper	Full conversion of matrix to martensite	Heat to 1550 – 1700F. Hold 1 hour per inch cross section. Quench in oil or polymer. Temper to desired hardness.	Rc 35 – 55 depending on tempering temperature
Ductile	Austemper Ductile Iron (ADI)	Conversion of matrix to acicular ferrite and carbon-rich austenite ("ausferrite")	Heat to 1550 – 1700F. Hold 1 hour per inch cross section. Quench in elevated temperature salt bath.	Rc 28 – 55 depending on grade

* Resulting hardness values are for ductile iron only. Annealed gray iron values will be lower. Hardness values listed for hardening are checked using Brinell Hardness test methods and converted to Rockwell.

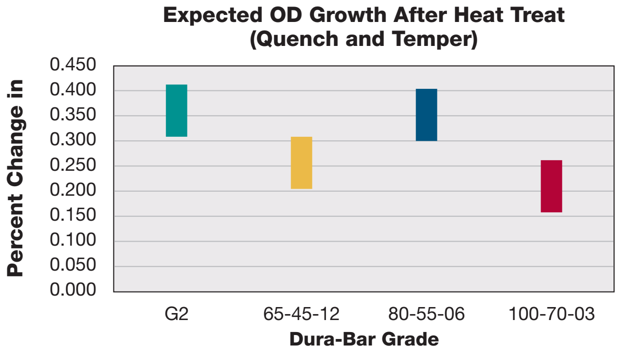
Hardenability

The starting grade or microstructures of any Dura-Bar products have little relationship to their ability to be hardened. Any grade of ductile iron can be quenched and tempered to 50 – 55 Rc, gray iron can be heat treated to Rc 45 – 50.



Expected Growth

Cast irons grow when heat treated above 1350F primarily because of the decomposition of the carbides in the pearlite. In all cases, the growth will be less than 0.4%. The following graph shows expected growth ranges for each of the Dura-Bar grades.

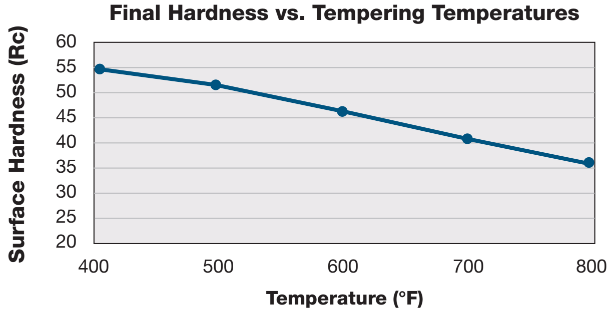


Data is based on 20 samples of each grade and the change in the outside diameter of a 1.00" machined specimen. All samples were heat treated to 1650º F, quenched in oil, then tempered to 450º F to a final hardness of Rc 50.

Tempering Temperatures

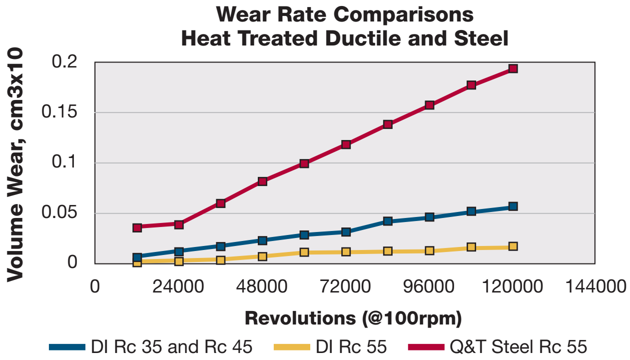
All quenched parts require tempering to soften the martensite and reduce internal stresses caused by the quench. Desired hardness after tempering ranges from Rc 35 – Rc 55 with lower hardness specified when improved machining is desired.

The following chart may be used as a guideline for predicting final hardness. Hold times depend on the size of the heat treat load and furnace size. A guideline is to hold 2X the length of time required for the parts to reach temperature.



Wear Rate Comparison

Ductile iron is heat treated to improve strength and wear. Gray iron is heat treated to improve wear, but will show little improvement in strength. Both gray and ductile iron need to be tempered (softened) after quenching. Tempering to 45 – 50 Rc will result in optimal wear resistance and material toughness. The following chart shows the wear rate comparisons for varying tempered hardnesses of ductile iron and steel. Gray iron will have wear rates similar to ductile iron.



Data is based on 3 pad specimens on 52100 hardened steel disks, dry conditions, 150 lbs force.

Austempered Ductile Iron (ADI)

ADI starts with a good quality ductile iron that the austempering process turns into a tough, high-strength material with remarkable advantages. Austempering is a two stage heat treatment process which involves austenizing at 1650F then subsequent quenching at an elevated temperature, usually between 450 – 750F depending on the desired properties. It is recommended that the machined part dimensions be reviewed with the heat-treater to determine the best starting grade, and any required alloy additions to achieve the desired results. Typically Dura-Bar 65-45-12 can be used as the starting grade.

The following properties are the ADI grades in accordance with ASTM A897.

Grade	Tensile* Strength (min ksi)	Yield* Strength (min ksi)	Elongation* (%)	Typical Hardness (BHN)
110-70-11**	110	70	11	241-302
130-90-09	130	90	9	269-341
150-110-07	150	110	7	302-375
175-125-04	175	125	4	341-444
200-155-02	200	155	2	388-477
230-185-01	230	185	1	402-512

* minimum values

** unnotched charpy impact bars, room temperature

Key Facts:

Ductile Iron Grades: All are equally heat-treatable, however in some cases 80-55-06 will respond to flame or induction hardening better than 65-45-12.

No Carburizing: Steel grades such as 8620 and 1018 must be carburized in order to harden through heat treating. None of the Dura-Bar grades require carburizing.

Minimal Growth: All Dura-Bar grades grow when heat treated, just like steel. However the growth is very minimal and very predictable.

Graphite: Heat treating does not alter the size and shape of the graphite – in either gray or ductile iron.

Temperatures: All Dura-Bar grades can be used at service temperatures up to 1100F with no effect on microstructure or properties.

Jominy End Quench: The profile will be the same for all Dura-Bar grades.

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Form: 99-75-00-04-00
Rev: July 2019