Impact Strength vs. Fracture Toughness

How does Dura-Bar compare to steel in cold weather applications? Charpy Impact strength is often used as an indicator in determining materials for low temperature applications, but with ductile iron, that does not tell the whole story. Consideration should also be given to fracture toughness and to the ability of the bar producer to control chemistry.

Dura-Bar R&D sent samples to a lab in Texas to determine the ductile to brittle transformation temperature of Dura-Bar 65-45-12. The following curve was developed:

The data shows ductile to brittle transformation took place somewhere around -20 degrees F. This is consistent with findings from the Ductile Iron Society and similar to steel, which also transforms from ductile to brittle in cold environments.

When a question comes up about Charpy Impact strengths, it is important to know how to respond. Especially when you consider that carbon steel has an impact strength around 50 ft-lbs, much higher than ductile iron. (65-45-12 is around 10 ft-lbs and 80-55-06 is about 15 ft-lbs.).

Most Design Engineers use Charpy Impact strengths as a measure of toughness, which is acceptable for steel but not for ductile iron. Actually, the reasons why impacts are low for ductile do not apply to its fracture toughness.

Charpy Impact measures how easily a crack is initiated in a test specimen and how fast it propagates once it’s started. Fracture toughness measures only crack propagation – and from a design standpoint on a part that is constantly loaded, an engineer would be more concerned over crack propagation.

The Ductile Iron Society does a great job of explaining the difference between fracture toughness and impact in the orange book “Ductile Iron Data for Design Engineers" pgs 3-48 & 3-49.*

One very important point in the explanation is that even though ductile to brittle transformation temperatures are similar in Charpy tests, they are dramatically different in fracture toughness tests with ductile iron being significantly superior. In fact, 65-45-12 is considered to be sufficiently tough to resist brittle crack propagation at temperatures as low as -80F! So what does this all mean? As always, find out the application and the forces that will act on the part. If an iron casting or other non-Dura-Bar material is being used, there are other chemistry related advantages to using Dura-Bar, but that’s a topic for another technical brief.
Points to Remember:

1. The impact strength of ductile iron will be less than steel. If the part is subjected to impact loading, this is an important issue.

2. Impact strength and fracture toughness are two completely different properties. Fracture toughness should be considered if the part is subjected to constant loading.

3. Ductile irons will have lower fracture toughness compared to steel at room temperatures, but in cold environments, fracture toughness of ductile is better than steel.

4. Fatigue strength is a good measure of how a part will perform under cyclical (repeated on and off) loading and fatigue properties of ductile iron will be similar to fatigue strengths of steel.

There are excellent charts and explanations in the Ductile Iron Data for Design Engineers. Dura-Bar has copies of the book in our reference library. The book is also on-line at, Ductile Iron Society Website, * Under “Tensile Properties”, click on “Modified Charpy Test Results.”

Contact Dura-Bar today to discuss your application or any questions you may have about Dura-Bar material properties and cost-saving opportunities.