

Ductile Iron News

To Promote the production and application of ductile iron castings



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FEATURES

- [Cover Story - DIS Visits Benton Foundry](#)
- [DIS Annual Award to Kathy Hayrynen](#)
- [College Industry Conference Preview](#)
- [Nodule Count - Why and How!](#)
- [A Review of the North American Foundry Industry](#)
- [Metalcasting Industry Releases 2003 Operational Cost Survey Results](#)
- [AFS Cast Iron Marketing Committee Introduces New Website for Material Property Comparisons](#)
- [Boron Related Hardness Problems](#)
- [Survey on Ductile Iron Practice](#)

DEPARTMENTS

- [News Briefs](#)
- [Advertisers](#)
- [Back Issues](#)
- [DIS Home Page](#)

Nodule Count - Why and How!

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The Nodule Count is usually defined as the number of graphite particles per a specified unit of area. The terminology is usually expressed as the quantity of nodules per square millimeter on a polished surface examined under a microscope at 100 magnifications (100 X). See picture below. To be considered, a nodule should be round or nearly so. When a graphite particle's length is two or more times its diameter, it is usually no longer considered a nodule. What is and what is not a nodule is part of what we call the nodularity rating, which can be from 0 to 100 %. A 100 % rating, which is the ultimate goal, means that all nodules are completely round, no matter how many there are. However nodularity rating is a separate subject and will not be considered in the balance of this article.

Why is nodule count so important? Nodule count can define the quality of the iron. Generally the higher the count, the better, but a certain relationship between the nodule count and the casting section modulus should be maintained. As casting section size increases (meaning slowed solidification), the nodule count generally goes down. Counts below 100 nodules mm² are common in 4 inch and over sections, whereas ¼ inch sections may have over 400 nodules. As the number increases the structure and properties become more uniform, segregation is reduced and carbides generally will be minimized. Higher counts will also generally produce more uniform nodule size. Additionally the fatigue strength for a given matrix structure will improve as will machinability.

The charge materials, alloy additions and metal processing including treatment and of course, inoculation, all affect nodule counts. It has always been my philosophy that the liquid base iron melt, before treatment, should have a low chill value. Whether this value is measured by the wedge test or through measurement of undercooling by thermal analysis, the results should be the same, indicating a well-nucleated base iron. Sulfur levels in the base iron are also very important. A minimum of 0.008% S should be maintained. Lower S levels can result in more carbides being formed as well as keeping nodule counts low. Preconditioning the melt with virgin charge materials and silicon carbide contribute to good base iron nucleation.

While the magnesium treatment reaction with MgFeSi does tend to remove some nucleating particles, it creates others. This iron is then most often, quite well nucleated before the inoculation step. This is not the case with pure magnesium treatments, which require a more severe inoculation addition, because most of the nucleating particles are reduced in the treatment reaction.

Inoculation is the next important step in the process. Increasing inoculation will usually increase the nodule count, but care must be taken to avoid the higher silicon concentration that can come with it. Usually the later the inoculation step is done just prior to pouring, the better, since inoculation fades with time. So in-stream and in-mold inoculation has gained much favor since fading is eliminated and the iron is somewhat cooler at the time of pouring thereby increasing the count.

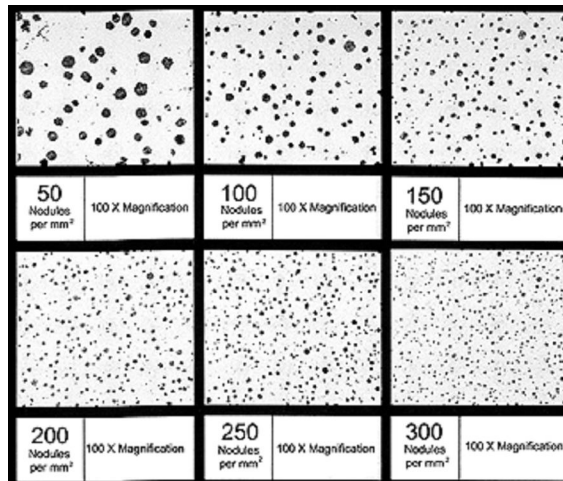
The strength of the inoculant can change the result. In addition to the normal calcium and aluminum found in most FeSi alloys, elements such as Cerium, Lanthanum, Barium, and Bismuth are added to increase nodule counts. They may do this at a smaller addition rate than regular FeSi, as well.

Research work done by the Ductile Iron Society (Research projects 11 & 12) have shown the following regarding the promotion of higher nodule counts:

- Temperature of metal when inoculation was done - lower temperatures were better and fading is reduced.
- Faster solidification (thinner sections and those cast in green sand) increase nodule counts up to section sizes of about ½ inch.
- Calcium level around 1% in FeSi gives good nodule counts.
- Rare earth (RE) content should be at an optimum level.
- Higher nodule counts were obtained with La containing RE (40% La)

than with Ce alone.

- Special inoculants, such as those containing Bi or Ba work well, giving higher counts. (Note that rare earths (Ce) must be used when Bi is employed.)



Nodule count per mm² at 100X. Courtesy of Rio Tinto Iron & Titanium

Nodule counts in various castings and different section sizes should be checked constantly to insure that the process is under control. Many foundries routinely check the nodule counts in all test bars that are tested as a quality measure. As previously mentioned the count should be as high as possible and consistent to avoid carbides and shrinkage and have good fatigue properties.



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