Case Histories of Using Nodu-Bloc as a Cost Saving Replacement/Supplement for Magnesium Ferrosilicon Alloys*

<u>Production Results:</u> To date, several foundries have substituted Nodu-Bloc for MgFeSi as an integral part of their daily production while many others are in the process of evaluating Nodu-Bloc. The production experience of three vastly different ductile iron foundries, each of which had different needs, is discussed in detail in this section.

Foundry A is a medium-sized, high-production foundry in Alabama producing ductile iron parts for the automotive and truck industries using the lost foam process. Daily production capacity is 280 tons. Although Foundry A has a casting yield which ranges from 45 percent to 55 percent, they generate more returns, in the form of gates, risers and pouring basins, than they can remelt. They needed an economical way to increase returns utilization without the accompanying increase in silicon levels. To accomplish these goals, an economical, low-silicon nodulizer needed to be found. Nodu-Bloc 15 met these goals.

Foundry A utilizes three 10-ton induction furnaces for melting. A 2,000 pound capacity open ladle with a height-to-diameter ratio of 2.5-to-1 is used for ductile iron treatments. Extensive tests with Nodu-Bloc iron-magnesium briquettes containing 15 percent magnesium were conducted. It was found that a 25 percent Nodu-Bloc replacement, based on total magnesium, allowed the foundry to use an additional 400 pounds of returns per furnace charge and reduce steel scrap levels by an equivalent 400 lbs.

Nodulizing is accomplished using the sandwich technique. The appropriate amount of MgFeSi is weighed and placed in a charging container. Next, the Nodu-Bloc iron-magnesium briquettes are place over the MgFeSi. The charge container is then dumped into a pocket in a completely empty, heated ladle. Foundry grade 75% ferrosilicon is then added to the pocket as additional cover material, followed by twelve pounds of cover steel. Residual magnesium levels ranged from 0.035 percent to 0.040 percent.

Table 7 shows a comparison of the furnace charge makeup as well as levels of nodulizers employed prior to and after incorporation of Nodu-Bloc. Little-to-no difference in magnesium flare or reactivity was noted by operating personnel when Node-Bloc was used. The favorable height to diameter dimensions of the sandwich ladle most likely accounted for the modest reaction.

Table 7: Production Experience of Foundry A using 15% Nodu-Bloc Iron-magnesium Briquettes

	Original Charge	Nodu-Bloc Modified Charge
Foundry Returns	2,100 lbs	2,500 lbs
Steel scrap	1,500 lbs	1,100 lbs
Carbon	55 lbs	40 lbs
Silicon Carbide	4 lbs	4 lbs
MgFeSi	27 lbs	21 lbs
Nodu-Bloc 15%	0 lbs	2.9 lbs
75% Foundry FeSi	11 lbs	11 lbs
Cover Steel	11 lbs	11 lbs
Final Chemisty		
% Carbon	3.70% - 3.85%	3.70% - 3.85%
% Silicon	2.60% - 2.70%	2.60% - 2.70%
% Sulfur	0.007% - 0.009%	0.007% - 0.009%
% Magnesium	0.030 - 0.040%	0.03 - 0.040%
Nodule Count (mm^2)	275	275
Nodularity	95%	95%
Carbides	None	None

Notes: 1,900 lb. open ladle, sandwich treatment method

The 25 percent magnesium Nodu-Bloc replacement provided identical microstructural results compared to nodulizing with 100 percent MgFeSi. Nodule count, nodularity and matrix structures remained unchanged.

Average nodule count is 275 with an average nodularity rating of 95 percent. Average casting section size is five-eighths of an inch with section sizes ranging between a quarter inch to two inches.

The foundry has realized significant cost savings by utilizing 11.21 percent more returns in the charge make-up. Production costs have been reduced by $7.45 per net ton. The level of daily savings achieved by using a combination of Nodu-Bloc, reduced levels of MgFeSi and increased foundry returns in the furnace charge is $1,489 daily. Annually, these savings approach $375,000. It should be noted that the level of savings is largely dependent on how the foundry values its returns. In this example, the foundry placed a value of $90.00 per ton on its returns. Thus, with these types of savings, Nodu-Bloc iron-magnesium briquettes have now been incorporated into daily production. Trials have been run with Nodu-Discs and have produced encouraging results. Additional trials with the discs are scheduled for in the near future.

Foundry B is a much smaller jobbing foundry in Alabama producing a variety of ductile iron castings. Daily production is about 25 tons. Because of the jobbing nature of their business, optimizing casting yield becomes difficult due to the fluctuating nature of their production schedule. Foundry B melts with two 4,000-pound induction furnaces.

Twenty percent magnesium containing Nodu-Bloc briquettes were evaluated as a replacement for 6% percent MgFeSi for cost-reduction purposes. Foundry B also had a silicon problem and could not utilize all of the returns generated. It was often forced to liquidate excess returns by selling them to the local scrap yard. This practice had an adverse effect on their balance sheet since it involved a significant write-down of assets.

Nodulizing is accomplished in a 750-pound tundish ladle having a height-to-diameter ratio of 2-to-1. MgFeSi is first weighed into a charging container. Then Nodu-Bloc 20% iron-magnesium briquettes are placed over the MgFeSi. The charge container is dumped into the completely empty, heated tundish ladle. Foundry-grade 75% ferrosilicon is then placed over the nodulizers. Finally, 22 pounds of cover steel is added to the ladle.

Table 8 shows the furnace charge makeup as well as levels of nodulizers employed by Foundry B both prior to and after incorporation of Nodu-Bloc. During the foundry trials, no appreciable difference in magnesium flare or reactivity occurred during the nodulizing operation.

Table 8: Production Experience of Foundry B using 20% Nodu-Bloc Iron-magnesium Briquettes

	Original Charge	Nodu-Bloc Modified Charge
Foundry Returns	750 lbs	900 lbs
Steel scrap	750 lbs	600 lbs
Carbon	28 lbs	23 lbs
Silicon Carbide	5 lbs	5 lbs
MgFeSi	12 lbs	6.5 lbs
Nodu-Bloc 20%	0 lbs	2.1 lbs
Proprietary Inoculant	3.25 lbs	
75% Foundry FeSi	----	3.75 lbs
Cover Steel	22 lbs	22 lbs
Final Chemistry		
% Carbon	3.60% - 3.75%	3.60% - 3.75%
% Silicon	2.50% - 2.65%	2.50% - 2.65%
% Sulfur	0.0075%	0.0075%
% Magnesium	0.035 - 0.045%	0.035 - 0.045%
Nodule Count (mm^2)	225	250
Nodularity	95%	98%
Carbides	None	None

Notes: 750 lb. tundish treatment ladle

The 46 percent magnesium Nodu-Bloc replacement provided identical microstructural results compared with nodulizing with 100 percent MgFeSi. This small foundry has realized significant cost savings by utilizing 10 percent more returns in the charge make-up. Ductile iron production costs have been reduced by $10.00 per net ton. The level of daily savings achieved by using a combination of Nodu-Bloc, reduced levels of MgFeSi and increased foundry returns in the furnace charge is $295 daily. On an annual basis, these savings approached $75,000, which pleased foundry management. Needless to say, Nodu-Bloc iron magnesium briquettes have now been incorporated into daily production.

Foundry C is also a small, jobbing foundry in Ohio producing mostly ductile iron castings along with gray iron castings. The foundry uses two one-ton induction furnaces for melting. Foundry C's prime objective was to reduce ductile iron production costs by eliminating costly nodular grade pig iron and replacing it with its own foundry returns. This foundry, not unlike many other small foundries, tends to over treat their ductile iron with MgFeSi and, consequently, is always battling a silicon problem. The reasons for over treatment include MgFeSi is used for desulfurization since base iron sulfurs approach 0.02 percent, non-ideal treatment ladle dimensions, and lengthy ladle filling times due to the tilting mechanism on the induction furnaces.

Nodulizing is accomplished in a 2,000-pound open ladle using the sandwich process. The height to diameter ratio of the ladle is only 1.25-to-1. The treatment is completely empty and pre-heated. Nodu-Bloc 15% briquettes are added to the ladle first, then MgFeSi is placed over the iron-magnesium briquettes, and finally, one 3-pound Nodu-Disc is added as cover. Lastly, 22 pounds of foundry grade 75% ferrosilicon is placed over the nodulizers for "cover".

Table 9 shows the furnace charge makeup as well as levels of nodulizers employed by Foundry C both prior to and after incorporation of Nodu-Bloc.

Table 9: Production Experience of Foundry C using 15% Nodu-Bloc Iron-magnesium Briquettes

	Original Charge	Nodu-Bloc Modified Charge
Foundry Returns	0 lbs	1,000 lbs
Steel scrap	200 lbs	200 lbs
Nodular Pig Iron	1,800 lbs	800 lbs
Carbon	2 lbs	6 lbs
75% FeSi lumps	16 lbs	0 lbs
MgFeSi	49 lbs	21 lbs
Nodu-Bloc 15%	0 lbs	8 lbs
Nodu-Disc 15%	0 lbs	3 lbs
75% Foundry FeSi	20 lbs	20 lbs

Notes: Base iron sulfur level – 0.025%

During the foundry trials, only minor differences in magnesium flare and reactivity occurred during the nodulizing operation. However, some metal splashing has occurred on an infrequent basis, mainly due to the shallow depth of the treatment ladle. Residual magnesium levels continued to be in the range of 0.05 to 0.055 percent.

The 57 percent magnesium Nodu-Bloc replacement provided identical microstructural results compared with nodulizing with 100 percent MgFeSi. This small foundry has realized significant cost savings by completely eliminating over 1,000 pounds of nodular pig iron from its charge make-up. Production costs have been reduced by $33.49 per net ton. The level of daily savings achieved by using a combination of Nodu-Bloc, reduced levels of MgFeSi and increased foundry returns in the furnace charge is $502 daily. On an annualized basis, these savings are in excess of $126,500. As with Foundries A and B, Nodu-Bloc iron-magnesium briquettes and discs have now been incorporated into daily production.

*This paper was extracted and summarized from Nodulizing and Inoculation Approaches for Year 2000 and Beyond - Part 1, Dr. R.L. (Rod) Naro, published in *Ductile Iron News*, Issue #2, 2001, Ductile Iron Society.