Metallurgical Challenges in Today's Ferrous Foundries

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Metal Quality Challenges in Induction Melting

Controlling Build-Up by Fluoride –free Redux EF40 Flux additions for Coreless Induction Furnaces, Channel /Pressure Pouring furnaces and Ladles

Improving Inoculation in Iron using ASI's Sphere-O-Dox

Magnesium boosting of Treatment Process of Ductile (S.G.) Iron - Nodubloc

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Slag and Insoluble Build-Up in Ferrous Melting FLUXING BENEFITS

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Daily Build-Up Problems facing Today's Ferrous Foundries

Insoluble Build-up depositing on furnace walls of Iron or Steel Coreless Induction Furnaces

Channel Induction Melting furnaces reducing Inductor Power due to Throat or Inductor Build-Up

Channel Induction Holding furnace Uppercase Build-up, Causing Loss of Capacity, Reduce Service Life

Severe Build-up occurring daily in Pressure Pouring Channel Furnaces holding treated ductile or grey iron

Ladle Cleanliness for Iron and Steel

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Sources of Slag and Build-Up in Ferrous Melting

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Fluxing
for Ferrous Melt and Pouring Applications

A Mild Fluoride-free, Chloride-free Flux, Redux EF40$_{(\text{patent7,618,473b1})}$ is used successfully to combat most build-up conditions in ferrous melt and pouring conditions.

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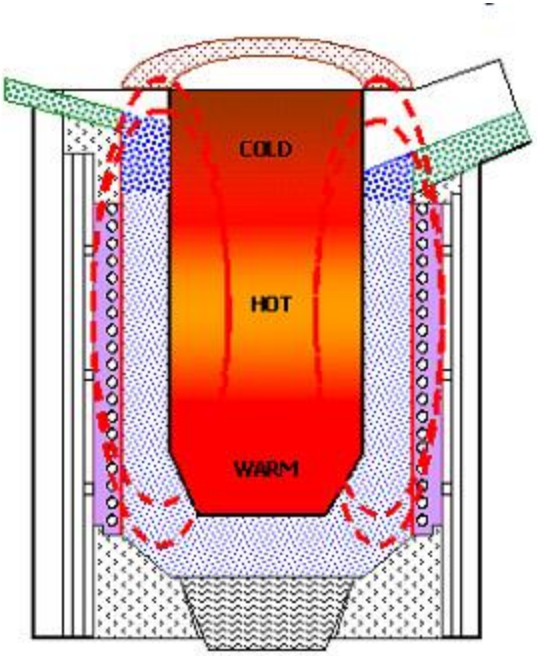
Severe Build-Up in Ferrous Coreless Furnaces



Loss of Effective Melt Power, slower melting rate.

Loss of Capacity, less Production.

Localized superheating of Refractory.

Increased metallic saturation in the Refractory

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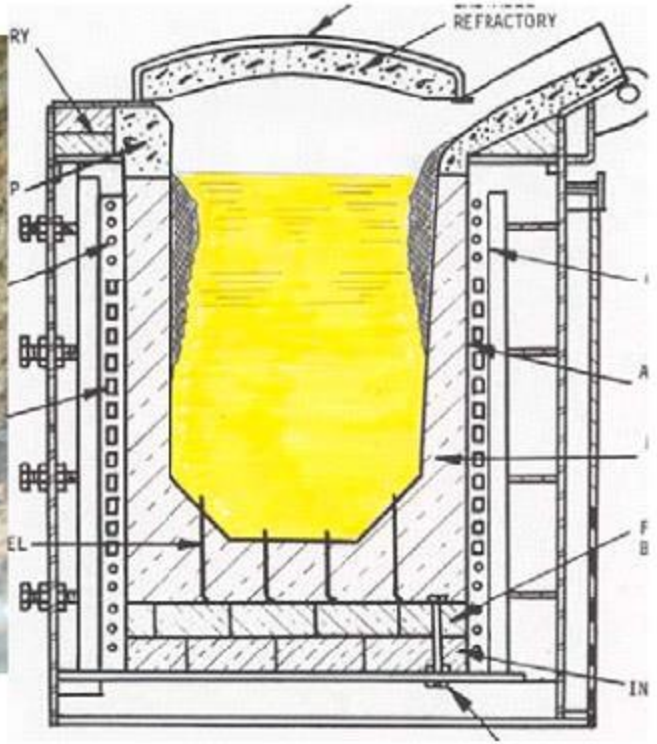
Insoluble Build-up depositing on furnace walls of Coreless Induction Furnaces, effecting capacity and melt efficiency



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Redux EF40L (or LP) flux

REDUX ® EF40L (patent 7,618,473B1)

Fluoride-free Electric Furnace and Ladle Flux

Description: A grayish-white briquetted fluorspar replacement formulated with a proprietary blend of ingredients. When added to molten metal, the ingredients in EF40L react to form various aluminates. These compounds provide most of the fluxing action of EF40L. Redux EF40L briquettes provide performance similar to fluorspar-based fluxes but without the drawbacks of "fluorine emissions". More importantly, there are no "aggressive refractory" interactions that occur with fluorspar containing fluxes. EF40L keeps furnaces and ladles free of slag build-up and extends refractory life.

PHYSICAL PROPERTIES

Bulk Density: 78 lbs./cu. ft. or 2.8 gms/cc
Size: 45 gram roll briquette
Melting Temp: Starts to dissociate at 752°F (400C)

	Element (1)	Typical %
Chemistry:	Sodium Oxide	less than 40%
	CaO	less than 12%
	Al_2O_3	less than 15%
	SiO_2	less than 10%
	MgO	less than 10%
	Inerts	Balance

(1) Atomic Weight Percentage

Illustration of EF 40L Briquettes

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Build-Up in Coreless Induction Furnaces for Ferrous Melting

Continuous treatment -
<u>1-2 lbs of Flux per ton of total metallic charge</u> in the furnace

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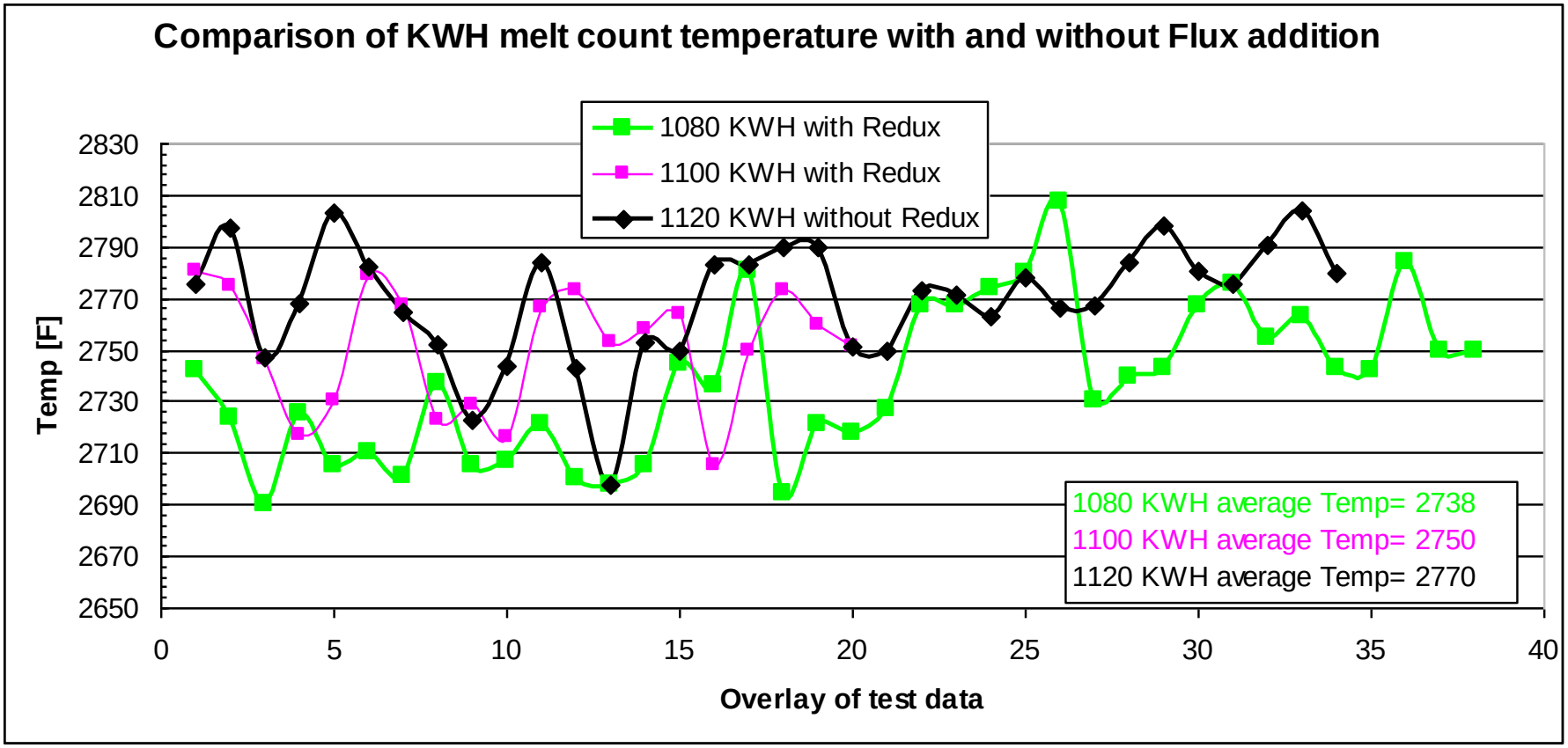
Controlling Severe Build-Up in Coreless Furnaces
Improving Melt Rate



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Controlling Severe Ductile–Base Build-Up in Coreless Induction Furnaces

Foundry D2 operates 7 Ton (6.3m Tn) Coreless furnaces in a 100% batch melting Ductile-base

Three 7 Ton 6000 Kws 180 Hz Coreless furnaces lined With silica dry vibratable refractory / boron oxide

Each charge consisted of ductile "pig iron," carbon steel, Machined turnings and ductile returns. Typical tap temperature 2775-2850F (1523- 1565C). Cost savings to use machined turnings

Build-Up occurred along the front wall area in the active power coil. After a 72 hour period, serious downtime was experienced due to delays in charging, Each melt cycle required an extra 30-45 minutes for each heat daily.

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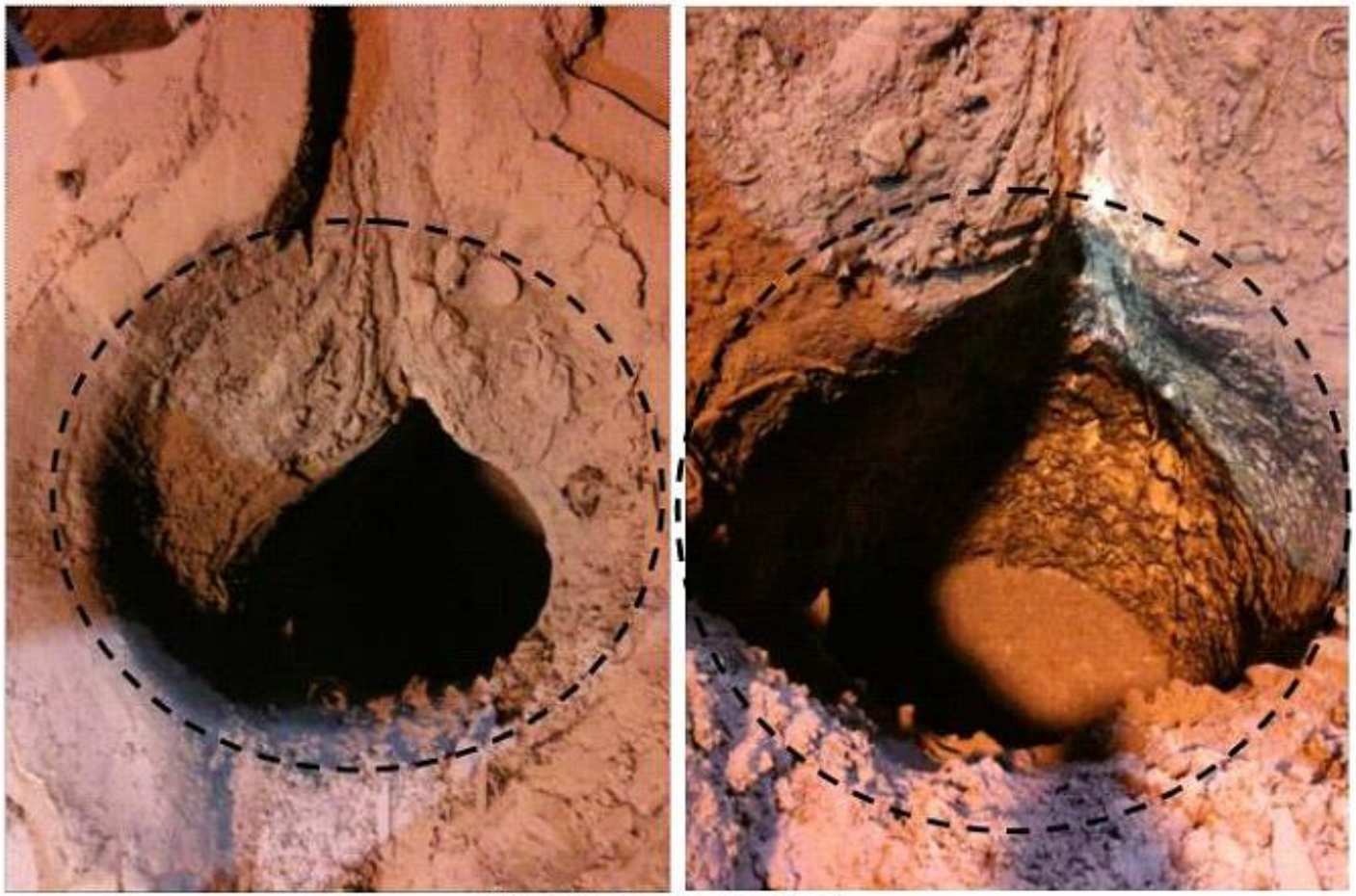
Controlling Severe Ductile–Base Build-Up in Coreless Induction Furnaces



Foundry D2 operates 7 Ton (6.3m Tn) Coreless furnaces

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Controlling Severe Ductile–Base Build-Up in Coreless Induction Furnaces

Foundry D2 operates 7 Ton Coreless furnaces in a 100% batch melting Ductile-base

Adding 10 lbs(4.5 kgs) of Flux per 7 ton heat, build-up eliminated.

Refractory lining was unaffected by the flux. Current Flux addition of 4 lbs (1.8 kgs) per heat per campaign.

Foundry D2 continues to realize the following benefits:

- **Furnace capacity remains consistent at 7 tons while recycling machined turnings in the melt**
- **Normal melt cycle of 40-50 minutes is uninterrupted**
- **Less frequent top cap cleaning $$$**
- **Delays for molten metal from the coreless melters to the holding channel furnace was reduced**
- **Increased lining life to + 6000 tons (5,444 Metric tons) from 4000 tons (3629 Metric tons). $$$**

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Controlling Severe Build-Up in Coreless Induction Furnaces

Foundry G a medium sized captive foundry casting grey iron

Four 3 ton(2.7m Tn) medium frequency Coreless furnaces lined with silica dry vibratable Boron Oxide bonded

Experienced extensive sidewall build-up in a semi-batch melting operation. Temperature between 2500-2650F (1371- 1454C)

The charge make-up is 100% metallic fines, < 20 mesh.

After 48 hours of operation, + 3 inches (76.2 mm) of build-up occurred along the entire sidewall. This led to increased power consumption due to significant downtime to allow for scraping

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Foundry G Build-Up

The Build-Up was approximately 2.5” (63.5 mm) and very dense, fused glass-like material, (Alumino Silicate phase). Other areas showed + 3 inches (76.2 mm)

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Controlling Severe Build-Up in Coreless Induction Furnaces

Foundry G

Solution was to add 2 lbs (1 kg) of Flux per ton of metallic charge added to every backcharge.

Immediate improvements were observed.

Once build-up was removed, continuous 1 lb (0.5 kg) flux per ton of backcharge was part of their melt procedure.

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Controlling Severe Build-Up in Coreless Induction Furnaces

Foundry G observed the following benefits:

Using flux, less tendency for "bridging"
Reduced power consumption during each melt
Hourly maintenance for scraping reduced
Consistent furnace capacities
Improved "electrical coupling" due to improved temperatures

No adverse effects on refractory. Lining Life increased from 2 weeks to 6 weeks. $$$$

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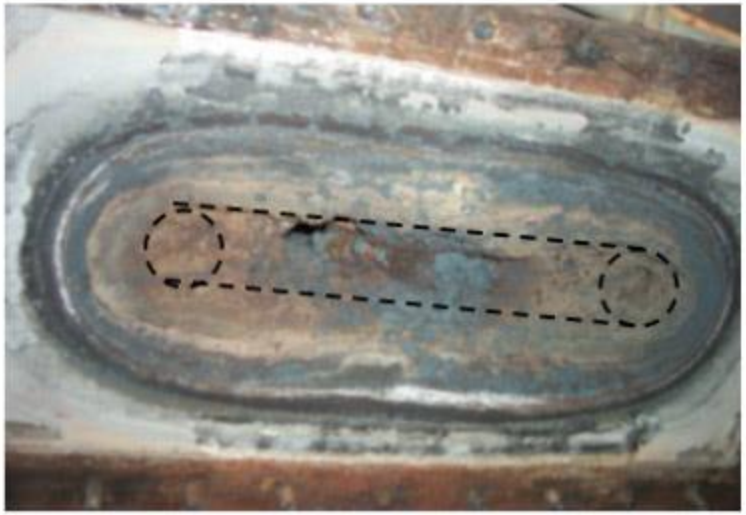
Examples of Ductile Build-up in Induction Melting



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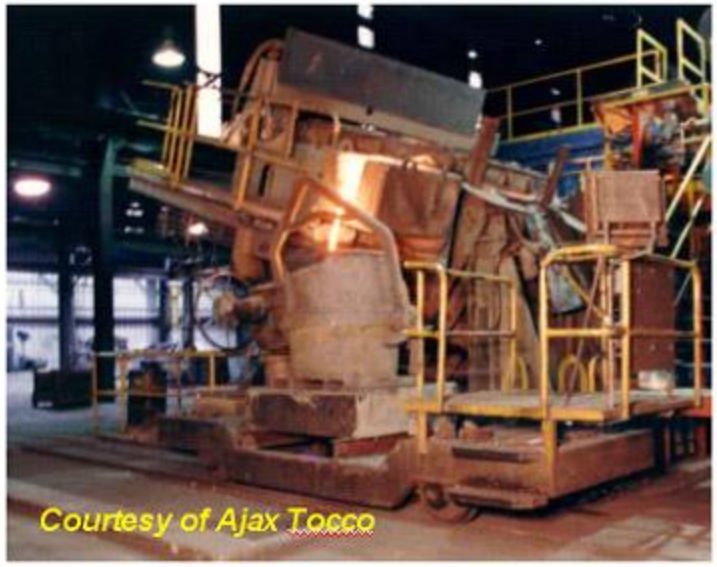
Channel Induction Furnaces
Uppercase and Inductor Build-up



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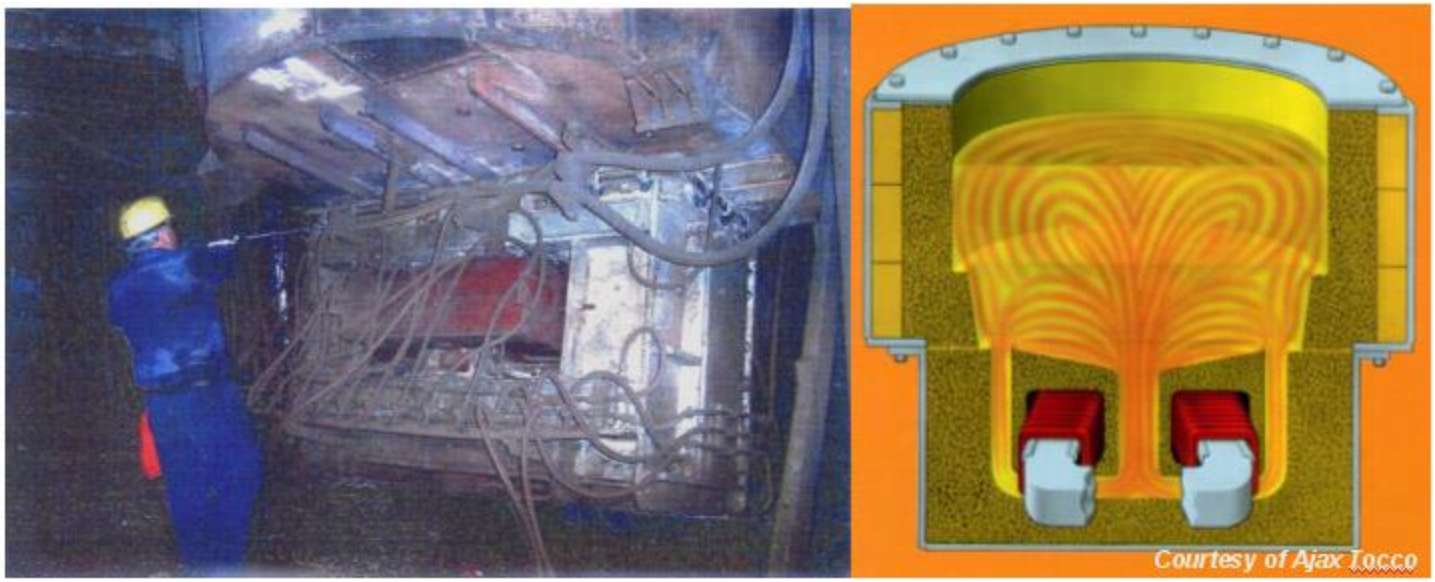
Channel Induction Melting furnaces restricted Inductor Melt Power due to Throat or Inductor Build-Up



Severe Restriction of Metal Flow in Throats or Inductor Channels can caused heavy saturation leading to refractory wear or metal leakage. Inability to superheat the molten iron.

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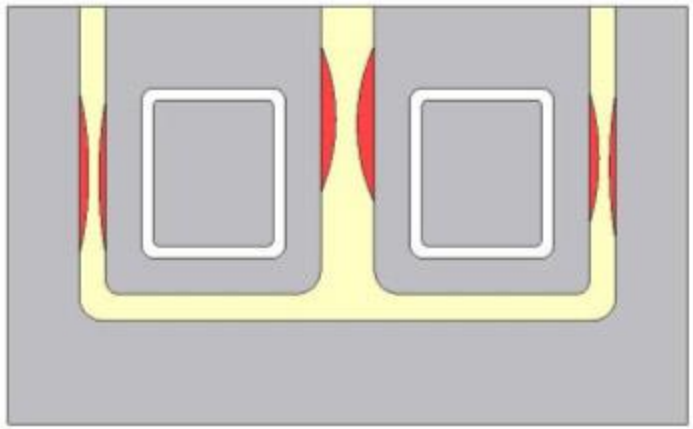
Emergency Flux Treatment of Restricted Channel of 45 ton Vertical Melter



In 48 hrs, foundry experienced severe Build-Up in throat and each of the channels of a Double-loop inductor.

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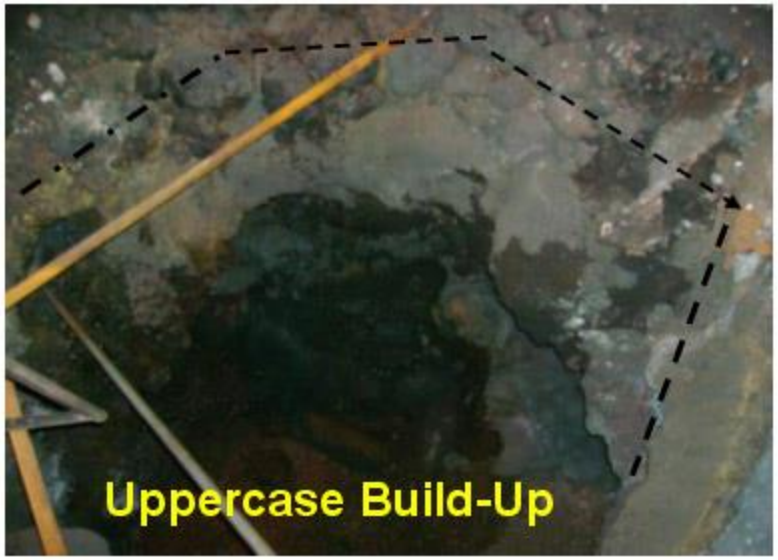
Channel Induction Holding furnace Uppercase Build-up, Causing Loss of Capacity, and Service Life



Furnace history will indicate when to flux. Establish the "threshold" indicator such as a minimum/maximum limit to conductance /reactance depending on equipment.

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Treatment 1: Continuous Additions, Daily Maintenance

Continuous Addition of Flux to Uppercase

1) Continuous Flux Addition rate of 1–2 lbs flux per ton of metal entering the furnace

2) This was continued for every day.

3) Furnace continued to operate until daily Deslagging has been performed.

4) Flux addition resumed each consecutive day and the steps were repeated, Deslagged every day.

The quantity of the Flux will vary depending on the build-up.

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Restoring Original Furnace Capacity in Holding Channel Furnace holding Ductile-base Iron

Two 65 ton Vertical Channel Holders

Capacity was less than 35 tons after 11 months of operation.

Courtesy of ABP Induction

0.05% flux was added continuously to transfer ladles feeding the channel holders for 3 weeks.

The buildup removed AND capacity was restored.

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Restoring Original Furnace Capacity in Holding Channel Furnace holding Ductile-base Iron

3 months later, each furnace was taken off line for its yearly reline and carefully examined. No sign of refractory erosion.

These furnaces now last 24 months instead of 12 months!

Approximate savings of +$100, 000 for each furnace.

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Pressure Pouring Channel Furnaces holding treated Ductile Iron / Severe Build-up occurring daily

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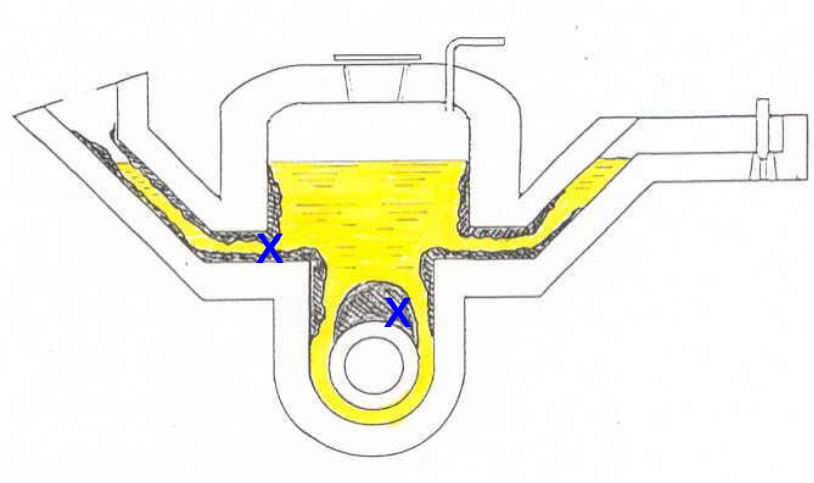
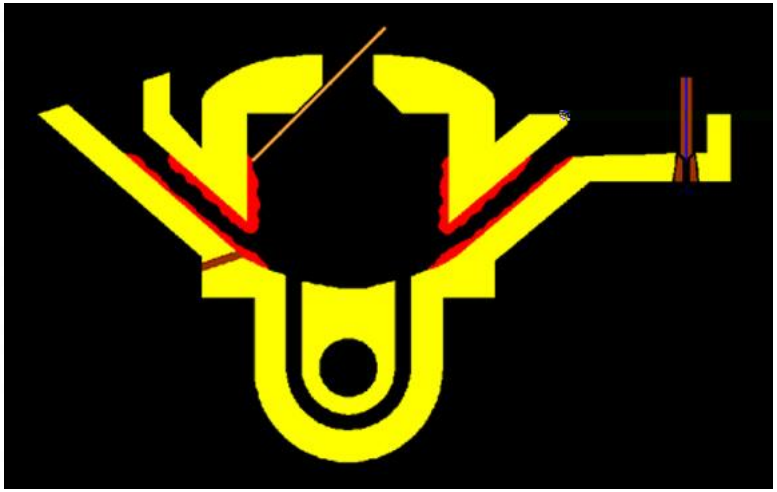
Build-Up in Pressure Pour Furnaces





Insoluble build-up can cause:

- **energy inefficiencies, diminished heat transfer**
- **poor temperature control**
- **superheating in restricted inductor channel**
- **increased metal saturation within the Inductor**
- **reduced rate of filling /pouring of furnace**

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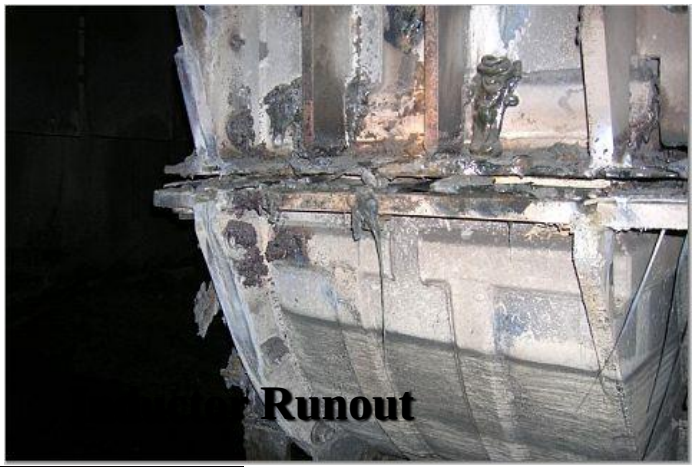
Severe Build-up Consequences occurring daily in Pressure Pouring Channel Furnaces holding treated Ductile Iron



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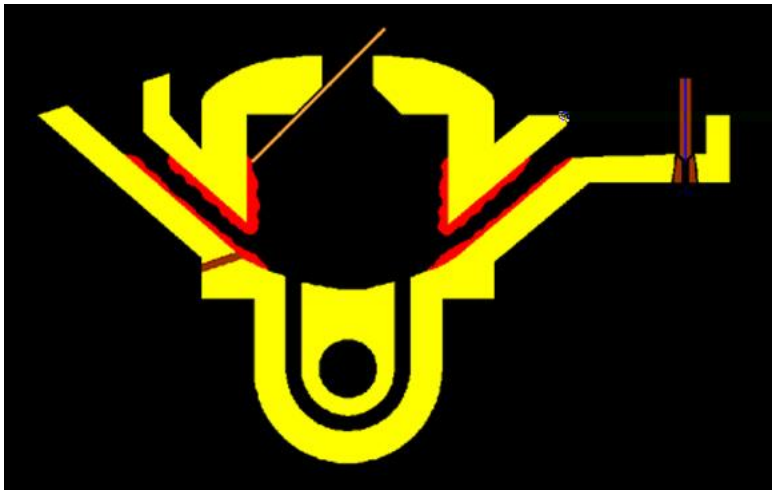
Throat AND Uppercase Build-Up Maintenance
15 ton Pressure Pour Channel Furnace Holding/Pouring Ductile Iron



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Fluxing in Treatment Ladles for Ductile Iron

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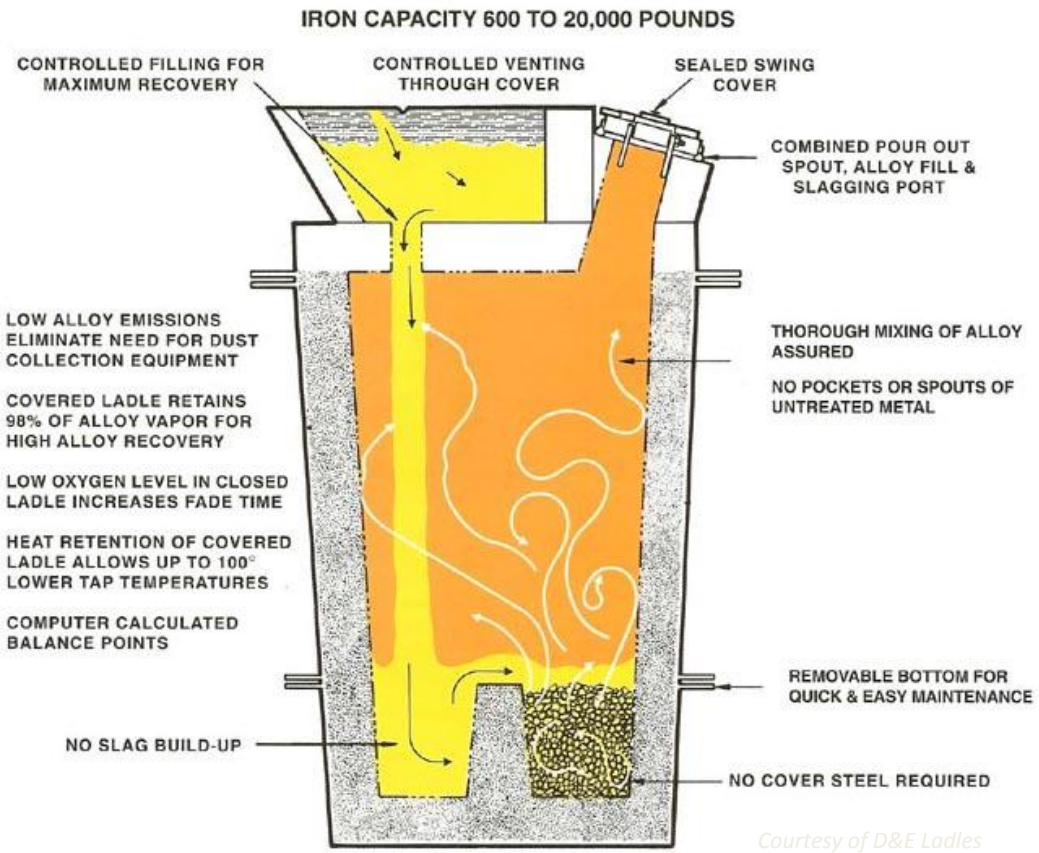
Treatment Ladles for Ductile Iron



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Treatment Ladles for Ductile Iron

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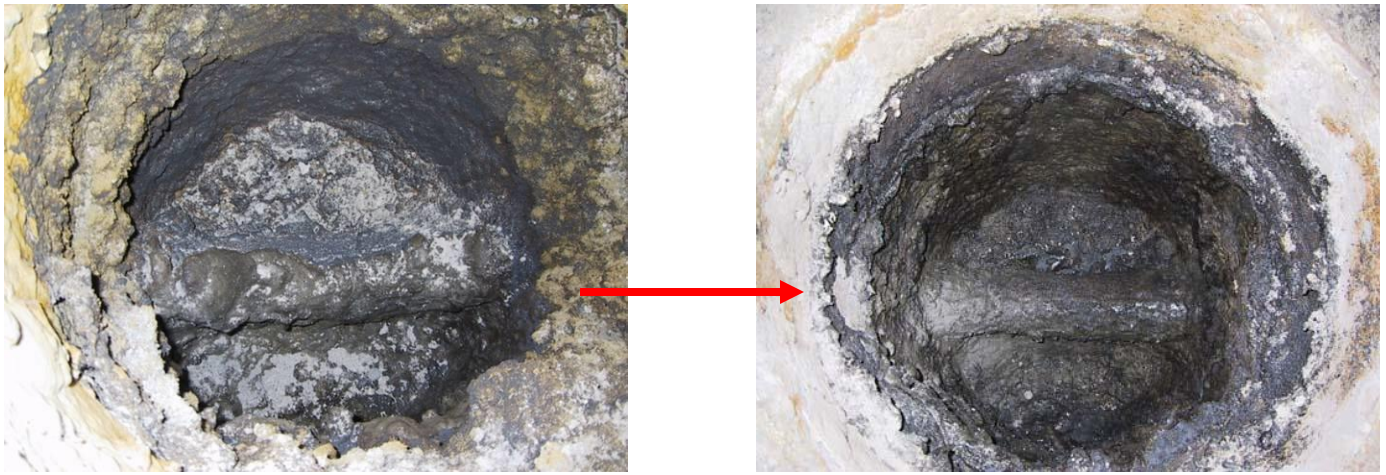
Treatment Ladles for Ductile Iron

Before Treatment **After Treatment**



1000 kg capacity Tundish Ladle

This was achieved with minimal scraping, strictly the addition of Flux to 5 different "wash heats." This treatment allowed for 72 hours of service versus 16 hours of service without fluxing.

Increased savings for prolonged service of ladle. $$$

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Inoculation for Grey and Ductile(S.G.) Iron

Improving Inoculation using ASI's Sphere-o-dox (patent 6,293,988B1)

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SPHERE-O-DOX G **(U.S. Patent 6,293,988B1)** **Inoculant**

Description: **A silvery-gray, granular, high performance inoculant, containing enhanced levels of oxy-sulfide nuclei forming elements that provide high potency nucleation in gray iron.**

PHYSICAL PROPERTIES

Appearance: A silver, gray granular alloy

Bulk Density: 1.25 gms/cc

Dissolution Temperature: Starts to dissolve at 1796F(980C)

Size: 20 x 120 mesh

CHEMICAL COMPOSITION

ELEMENTS	Percentages (%)
Silicon	38 to 39
Oxy-sulfide Formers	32 to 35
(consisting of proprietary ratios of Ca, Al, and other metal sulfide forming elements)	
Iron	Balance

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Sphere-O-Dox incorporates proprietary levels of nucleating components which raise the nucleation level in "freshly" melted irons.

This is done by forming oxy-sulfide nuclei clusters having a crystalline structure very similar to nucleating graphite) encouraging precipitation of flake graphite (gray iron) or graphite nodules (ductile iron).

Elimination of undesirable carbide formation.

Both grades G and S granulated versions, can be used in either gray or ductile irons to reduce carbides, improve structure, increase nodule counts in ductile, and improve physical properties and machinability

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Improving Inoculation using ASI's Sphere-o-dox (patent 6,293,988B1)

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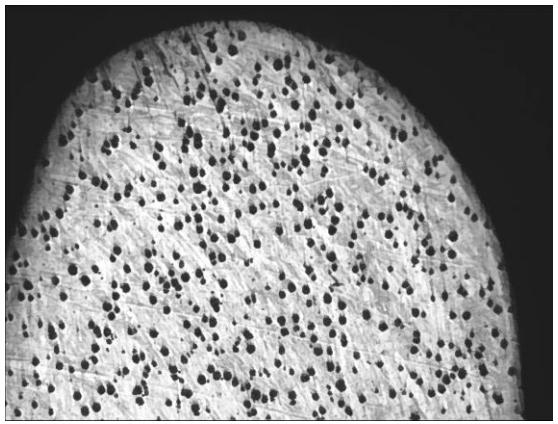
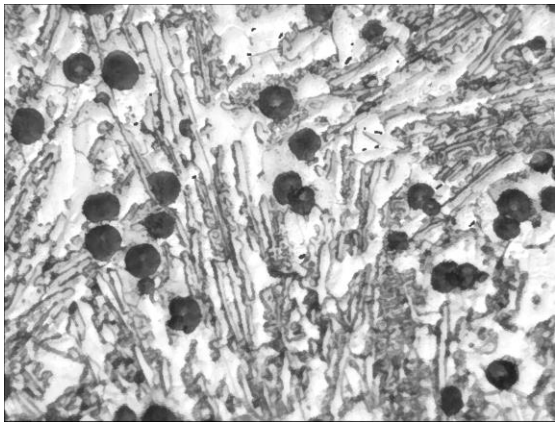
Ductile(S.G.) Iron 60-45-12 Reducing Carbides/ Chill Using Sphere-o-dox S



Unetched at 100 X Mag



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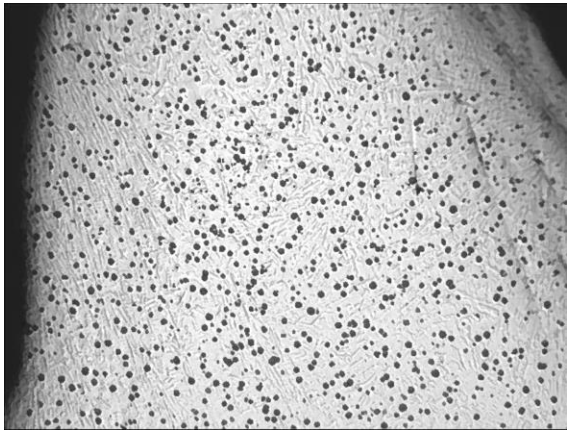
Ladle A – standard 5 lbs of Calsifer, Ca bearing 75% FeSi



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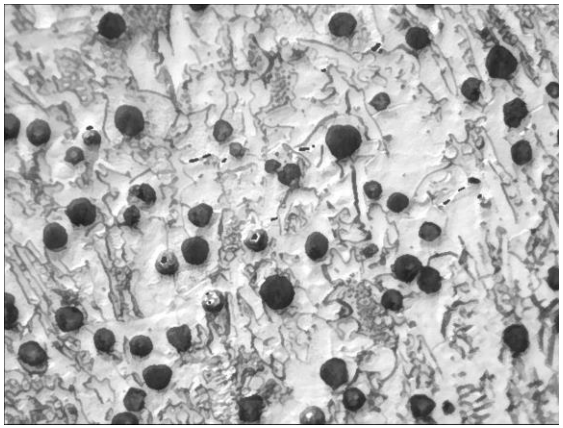

Etched at 500 X Mag

Ladle AA – expt 5 lbs VP216 + 1 lb Sphere-o-dox S

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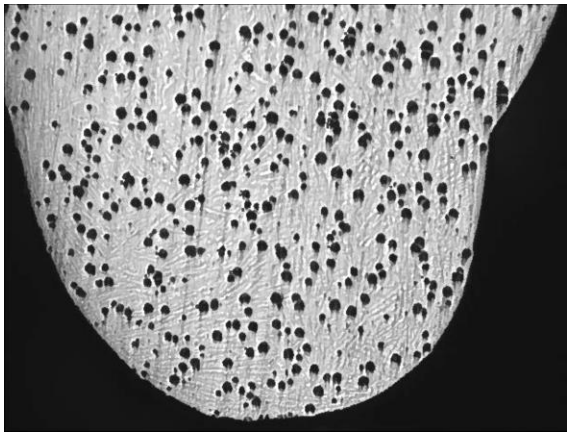
Ductile (S.G.) Iron 60-45-12 Reducing Carbides/ Chill Using Sphere-o-dox S



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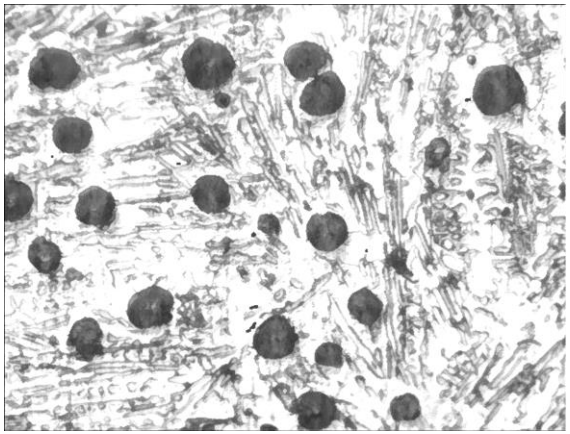

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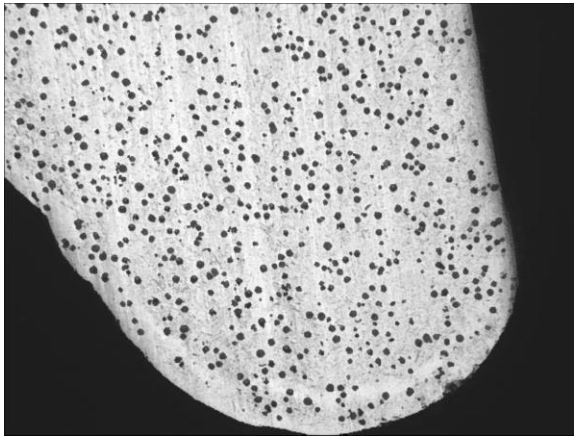
Ladle B – standard 5 lbs of Calsifer, Ca bearing 75% FeSi



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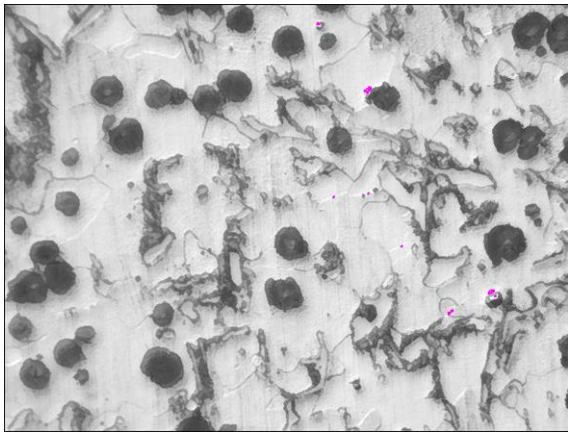

Etched at 500 X Mag

Ladle BB – standard 5 lbs of Calsifer + 1 lb Sphere-o-dox S

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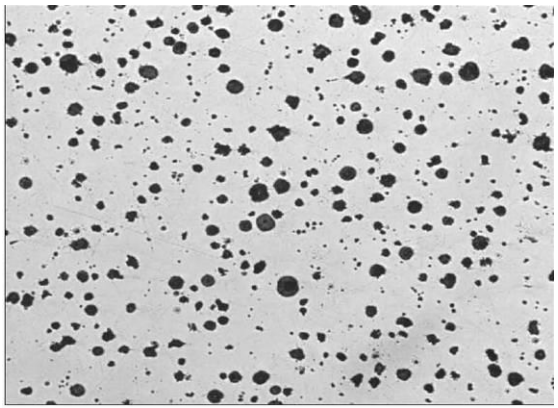
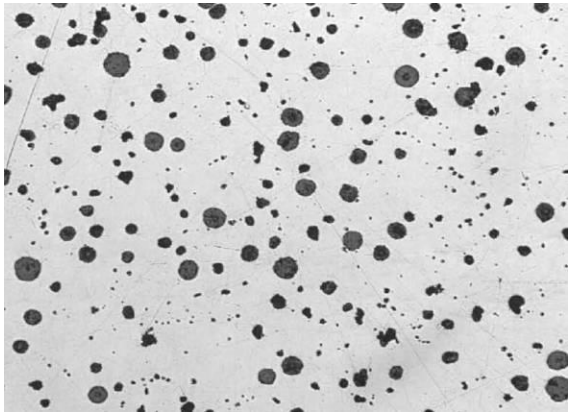
Ductile(S.G.) Iron 80-55-06 Increasing Nodule Count Using Sphere-o-dox S

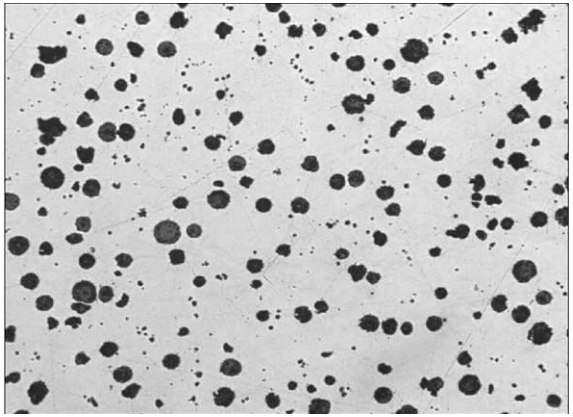
	Sample 1	Sample 2	Sample 3
Total Inoculant Addition	0.46%	0.50%	0.55%
% Sphere-O-Dox S	0.08%	0.04%	0.00%
% Ca Bearing 75%FeSi	0.38%	0.46%	0.55%
Ladle Weight	650 lbs	600 lbs	550 lbs
Mechanical Test Data			
Yield Strength, psi	53,132	57,192	61,803
Tensile Strength, psi	88,770	94,735	98,996
Elongation, %	10.5	9.5	7.5
% Increase Elongation	40%	27%	0.00%
Microstructure Data			
Nodule Count	298	229	190



Sample 1



Sample 2



Sample 3

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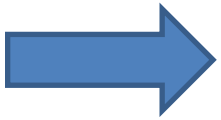
When comparing costs of Competitive inoculants that achieve
similar results as Sphere-o-dox in Ductile Iron,

FOR 1500 lb Ladle

Product X , need 4 lbs @ US$2.25 /lb, or <u>US$10.00 / Ladle</u>

Using Sphere-o-dox as a partial addition to Ca bearing 75%FeSi

Ca bearing 75%FeSi, need 4 lbs + 1lb Sphere-o-dox,
<u>Total Cost US$6.20/ ladle</u>
(based on current 2-28-2011 values)



A savings of US$ 3.80 per ladle. $$$$ This foundry may pour 20 ladles daily.

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Magnesium (Mg) boosting of Treatment Process of Ductile (S.G.) Iron

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NODU-BLOC "Iron Magnesium" Nodularizers

Description: A silver - gray, pressed "synthetic" iron magnesium briquette. Nodu-Bloc is a new, cost effective, magnesium treatment method and an economical replacement or supplement for magnesium ferrosilicon alloys. Nodu-Bloc briquettes are made with a proprietary blend of ingredients that provide outstanding recoveries with only a modest increase in magnesium flare. Nodu-Bloc briquettes are commonly used in conjunction with magnesium ferrosilicon alloys and 75% ferrosilicon post-inoculants.

PHYSICAL PROPERTIES

Appearance: **A silver, gray pillow briquette**
Density: **3.7 to 3.9 gms/cc, bulk packaging density - 120 lbs/cu. ft.**
Dissolution Temperature: Starts to dissolve melt at 1,826 ºF (
Dimensions: Standard Size, 1 1/4 in. long, 1/2 in. thick, 3/4 in wide briquette
Weight: 15.75 grams each approx. (approx. 5/8 ounce) and 60 grams available

CHEMICAL COMPOSITION

ELEMENT	Percentage
Magnesium	15.0 to 15.5%
Calcium	2.50 to 2.75%
Silicon	6.0 to 7.0%
Carbon	0.5 to 2.5%
Iron	Balance

Sizing: Available as 15.75 gram or 60 gram briquettes are available.
Packaging: 551 lbs (250kgs) 55 gal. steel drums, or 2205lbs(1m Ton) in Supersacks

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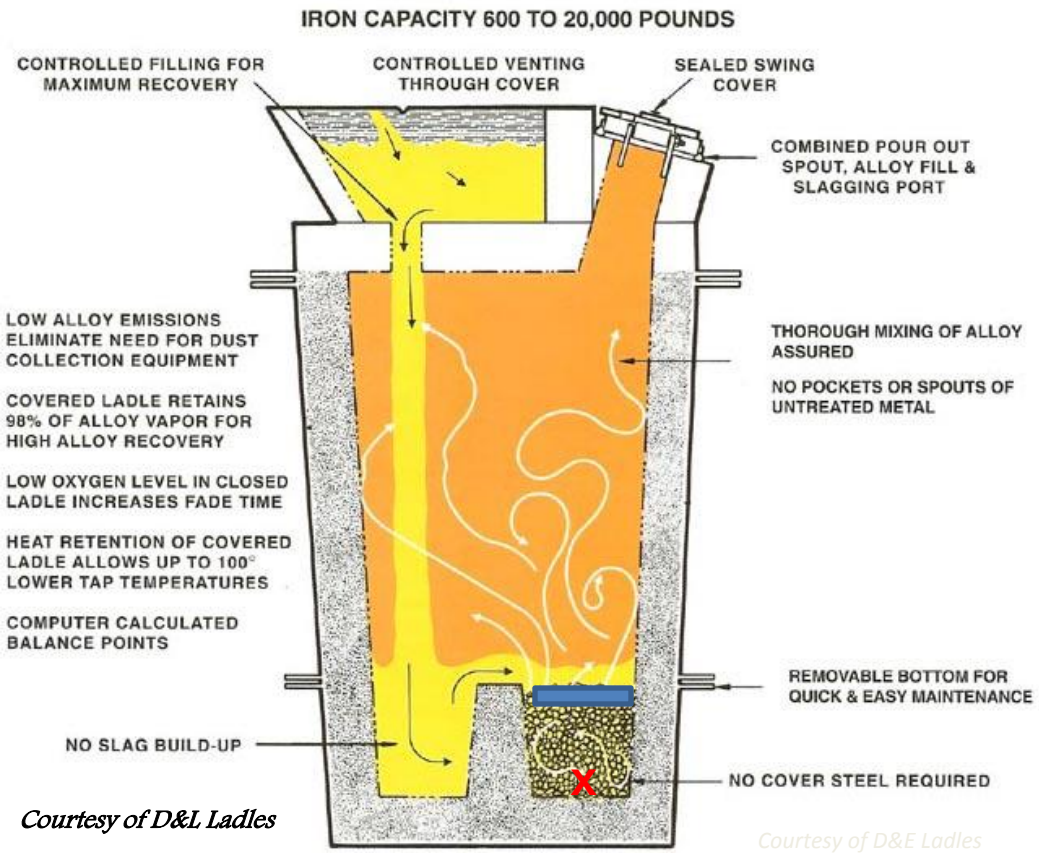
Treatment Ladles for Ductile Iron



X denotes the location of Nodubloc in the bottom of pocket. The blue cover represents 1.2-1.5% Cover steel needed on top of pocket.

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Nodu Bloc (Iron Magnesium) Application in Treatment Ladle

It is desirable for the treatment ladle to have a height to diameter ratio of 2.5 to 1 or greater. The treatment ladle should also have a pocket to contain the alloy(s). It is critical to pour molten iron into the empty ladle at the rate of 100 lbs per second for a 5-10 second period. The use of Cover Steel is optional but highly recommended. The molten iron temperature in the ladle should be a minimum 2650°F(1450°C), preferably 2700ºF.

1) If other Magnesium alloys used as the Nodularizer and the end cast product is NOT ADI;

A direct substitution can be made and the Magnesium content is 15% while there is a possible silicon pick-up. Additions of Nodu Bloc will be dependent on the amount of Magnesium needed by the actual initial molten metal chemistry. It is recommended that good quality **cover steel** to be placed on top of the Nodu Bloc, or use a **"sandwich method" of Mag ferrosilicon first in the treatment pocket followed by the Nodu Bloc briquettes and then more Mag ferrosilicon on top**. Since the density of 15% Nodu-Bloc is 10% less than 5% magnesium ferrosilicon alloys, it is extremely important to maintain ferrostatic pressure on the alloy.

2) If 5-6% Mag ferrosilicon Treatment is applied;

Recommended addition rates for a typical 1.5% addition of 5.5% magnesium ferrosilicon per ton would be 19.5 lbs of magnesium ferrosilicon and 3.85 lbs of Nodu-Bloc(approximately 0.8% of total ladle capacity).

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Case Study of Nodubloc as partial Substitution for 6% Magnesium Ferrosilicon in Mg Treatment - 3000 lb (1361 kgs) tundish ladles.

The standard Magnesium treatment is to use 38 lbs (17.2kgs) of 6% magnesium ferrosilicon treatment along with 20-25 lbs(9 – 11kgs) of cover / carbon steel.

The trial compared Nodu-Bloc 15 gram and 45 gram, magnesium iron briquettes. Nodu-Bloc specific chemistry was 15% Magnesium, 6.35% Silicon, 2.76% Calcium and Iron balance.

Four 3000 lb (1361 kgs) Magnesium treatments were used for this test.

First two ladles observed contained 33 lbs (14.9kgs) of 6 % MgFerrosilicon, 4 lbs (1.8kgs) of Large Briquetted Nodu-Bloc and 45 lbs (20.4kgs) of cover steel. The next two ladles observed contained 33 lbs (14.9kgs) of 6 % MgFerrosilicon, 4 lbs (1.8kgs) of Small Briquetted Nodu-Bloc and 45 lbs (20.4kgs) of cover steel Fill time was about 1 minute for 3000 lb of molten ductile base iron. Complete reaction time for all 4 ladles are listed in the next chart. Normal magnesium levels range from 0.032 – 0.045 %. Minimum lower limit is 0.030%.

Magnesium Boost Ladle Trial
9/10/09

	Large Briq		Small Briq	
	Ladle 1	Ladle 2	Ladle 3	Ladle 4
Base Si	2.43	2.43		
Final Si	2.44	2.45	2.46	2.36
Base S*				
Final S*	0.015	0.014	0.012	0.015
Base Mg	0.05	0.004	0.05	0.004
Final Mg	0.057	0.056	0.049	0.048
Tap Temp	2723	2723	2728	2723
Lb of Iron	3105	2880	3090	3470

3000 lb treatment	3000 lb treatment
4 lbs Nodu-bloc 15 LB	4 lbs Nodu-bloc 15 SB
33lbs MgFeSi 6%	33lbs MgFeSi 6%
45lbs cover steel	45lbs cover steel

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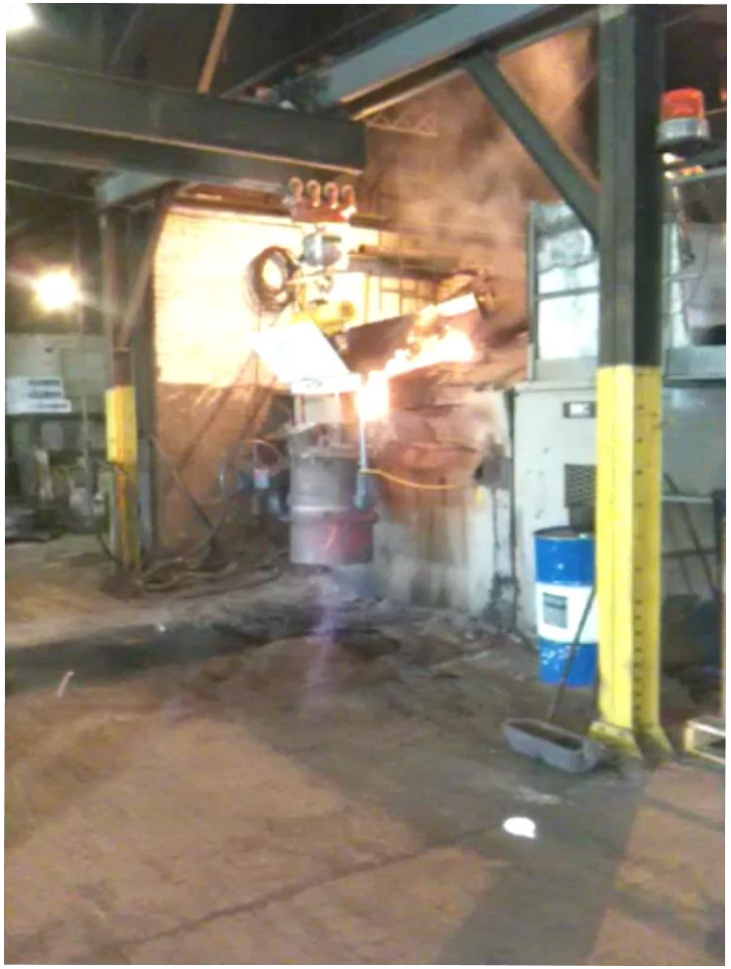
Nodu Bloc (Iron Magnesium) Application in Treatment Ladle



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15% Mg Nodu-Bloc as a partial substitution for 6% Mag Ferrosilicon into 3000 lb tundish treatment ladles.

Magnesium Reaction Time

	Ladle 1	Ladle 2	Ladle 3	Ladle 4
Initial Delay Prior	20 secs	20 secs	30 secs	25 secs
Total Reaction Time	60 secs	60 secs	75 secs	65 secs
Metal weight treated	3105 lbs (1409 kgs)	2880 lbs (1307 kgs)	3090 lbs (1402 kgs)	3470 lbs (1574 kgs)
% Mag Recovery	.057/.083 68%	.056/.089 62.9%	.049/.083 59%	.048/.0744 64.5%

It appeared that using more cover steel proved to be beneficial as we experienced an expected increase in final Magnesium.

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Sulfur Reduction using NODUBLOC from Grey to Ductile

GREY IRON FOUNDRY from cupola, in 4000 lb(1815kgs) transfer ladle from 0.06-0.08% S to below 0.03% S. This will be performed in a typical transfer ladle without a pocket, using a "sandwich" method with clean, dry cover steel (carbon steel, 1020-1040).

Description of Experiment:

Trial #1 – 50 lbs (22.7kgs) of NoduBloc SB and 100 lbs(43.4kgs) of cover steel
Metal Tap temperature of 2650F(1454C) or higher is preferred.

Trial#2 - 50 lbs (22.7kgs) of NoduBloc LB and 200 lbs (87.2kgs) of cover steel
Metal Tap temperature of 2650F(1454C) or higher is preferred.

Trial#3 - 60 lbs (22.7kgs) of NoduBloc LB and 200 lbs (87.2kgs) of cover steel
Metal Tap temperature of 2650F(1454C) or higher is preferred.

Trial#4 - 60 lbs(27.2kgs) of NoduBloc SB and 150 lbs(68 kgs) of cover steel
Metal Tap temperature of 2650F(1454C) or higher is preferred.

After each trial ladle we tested the before and after metal chemistries to verify the effectiveness of the NoduBloc.

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Sulfur Reduction using NODUBLOC from Grey to Ductile

RESULTS:

Trial #1 – **50 lbs** of NoduBloc **SB** and 150 lbs of cover steel. Tap temperature of 2600F.
Cover consisted of 50 lbs of Martin remnants, 100 lbs oversize washers.
Reaction time was 35 seconds, Reaction was violent with white flairing
Sulfur was reduced from 0.068% to 0.035%, Magnesium went from 0.001% to 0.014%

Trial#2 - **50 lbs** of NoduBloc **LB** and 200 lbs of cover steel. Tap temperature of 2600F.
Cover consisted of 50 lbs of oversized washers, 40 lbs bolts and cover steel.
Reaction time was 1 min 25 seconds, Reaction was normal, not violent
Sulfur was reduced from 0.076% to 0.013%, Magnesium went from 0.001% to 0.041%

Trial#3 - **60 lbs** of NoduBloc **SB** and 200 lbs of cover steel. Tap temperature of 2600F.
Cover consisted of 100 lbs of cover steel, 100 lbs oversize washers.
Reaction time was 32 seconds, Reaction was violent with white flairing
Sulfur was reduced from 0.057% to 0.053%, Magnesium went from 0.001% to 0.006%

Trial#4 - **60 lbs** of NoduBloc **LB** and 187 lbs of cover steel. Tap temperature of 2600F.
Cover consisted of 100 lbs of foundry shavings, 47 lbs oversize washers, 40 lbs bolts.
Reaction time was 1 min 48 seconds, Reaction was normal, not violent
Sulfur was reduced from 0.065% to 0.011%,Magnesium went from 0.001% to 0.030%

The NoduBloc would be placed in the bottom of a typical transfer ladle **without a pocket.**

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It appeared that the NoduBloc worked the best with approximately 200 lbs of cover steel. Interesting point was, during the last trial, we used 100 lbs of plant shavings as partial cover. Along with using heavier cover, we were successful.

Using NoduBloc, we were successful in sulfur reduction. We also picked up some magnesium. The foundry's new goal would be to reduce sulfur and pick-up magnesium simultaneously. Their intention is to consider filling the channel holding furnace with grey iron, and desulfurize and add magnesium in one stop.

This sulfur removal process is beneficial to foundries that want To convert from grey iron to ductile base with minimal interruption and wasteful wash heat production. $$$$

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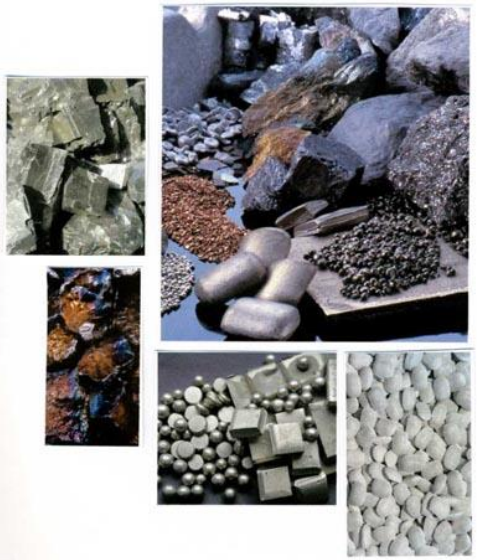

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Thank you

Any Questions?

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