A Look Inside Greenville Metals part of the
The PCC Revert Group

Norm Wilson Technical Manager Greenville Metal Inc.
Heritage Recycling Metals Conference June 18 - 20, 2019
• Established in 1968
• Located in Transfer, PA
• Acquired by PCC in 1998
Alloys Processed and Manufactured

- Nickel-Based Alloys – IN718, 625, 600, 800 etc.
- Co Based Alloys - Alnicos, F-75, etc.
- Refinery Ni/Co Consolidation Melts
- Cu based alloys - Monel and Cupro-Ni
- High Alloy Castings – HN, HK, HU, NA22H etc.
- Stainless Steel – all grades
- FAP - Foundry Additive Products - Ni-Mg and Ni-Ca
- Tool Steels and Mn Steels – M2, M4, T15, etc.
- Powder Metal Alloys : MnS, Fe$_2$P, Fe$_3$P
10 Ton EAF Melting 10 MVA Twin Shell EAF FCE
Electric Arc Furnace

principle oxidizing reactions
5FeO millscale + 2P + 3CaO = 5Fe + Ca₃(PO₄)₂ slag - dephos
2C + O₂ = 2CO off gas
4Al + 3O₂ = 2Al₂O₃ slag
Si + O₂ = SiO₂ slag
Ti + O₂ = TiO₂ slag
4B + 3O₂ = 2B₂O₃ slag

principle reducing reactions
C + metal oxide = metal + CO gas (metal oxide = Nb₂O₅, Cr₂O₃, FeO, MoO₃, MnO₂)
Al + metal oxide = metal + Al₂O₃ slag (metal oxide = Nb₂O₅, Cr₂O₃, FeO, MoO₃, MnO₂)
Si + metal oxide = metal + SiO₂ slag (metal oxide = Nb₂O₅, Cr₂O₃, FeO, MoO₃, MnO₂)
3S + 2Al + 3CaO = 3CaS slag + Al₂O₃ slag – desulfurize
Materials Processed
Materials Processed

Spills and Skulls
Materials Processed

Grindings, Turnings and Swarf
Materials Processed

Oxides in the form of Dust or Pellets
Wet Grindings and Sludges
EAF Capabilities

- Melting of metallics at high temperatures
- Freeing of entrapped metallics
- Reduction of slags with oxides of metals
- Oxide additions to alloys
- Removal of oxidizable components
- Establishment of composition from non-uniform raw feedstock - settlements
- Removal of sulfur
- The manufacture of atomized shot or pigs
EAF Nickel Alloy Melting Criticalities

- Charge Density
- Reactive Metal Components – Al, Ti, C, Si, Zr
- Carbon Content in the Initial Melt-In (more next page)
- Metallic Content - conductivity
- Processing Forms – Expected and Actual Recoveries
  - Grindings – grinding media and oil-moisture content
  - Turnings – heavy and light with/without oil content
  - Solids – sizes, ceramics and refractories
  - Dust – metallic or not?
EAF Carbon Benefits in Nickel Alloys

- lowers liquidous of most all alloys
- provides an economical reductant
- promotes slag-metall interactions
- reduces nitrogen transfer to AOD
- recovers metal oxides of interest
\[ K = \left( \frac{[\text{Nb}_{2}O_{5}]^{2} \cdot [\text{CO}]^{5}}{[\text{Nb}_{2}O_{5}]^{3} \cdot [\text{CO}]^{5}} \right) \]

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<th>Cp</th>
<th>( \Delta H )</th>
<th>( \Delta S )</th>
<th>( \Delta G )</th>
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**Unfavorable**

**Favorable**

**Legend**

- **PCC Revert Group**
- **Part of SPECIAL METALS CORPORATION**
- **CALEDONIAN ALLOYS LIMITED**
- **GREENVILLE METALS, INC.**
- **SOS**
\[ K = \frac{[La]^2[CO_2]^7}{[LaCO_3]^3} \]
10 Ton AOD Refining
AOD Capabilities

- Decarburization
- Desulfurization
- Controlled oxidation rates to prevent chromium losses
- Reduction of metal oxides as in Nb$_2$O$_5$ and MoO$_3$
- Removal of oxidizable components as in Al, Ti, Si, Zr and B
- Good mixing for complete reactions and uniform bath composition
- Removal of N$_2$ through CO evolution and heat
- The manufacture of lip poured pigs or BP ingots
Casting as Pigs
Pouring Metallic Shot or Casting Bottom Pour Ingots
Induction Melting
Grindings Drier

Drying of Wet Materials at ~1,300 F or ~700 C
THERMITE Exothermic Reductions
Fe2P - Fe3P – MnS
Grinding and Sizing
Powder and Shot Blending
FAP – Foundry Additive Products

NiMg & NiCa Main Products

- Incommag #3LC (4.0-5.0%Mg)
- Incommag #5 (16.0-17.0%Mg + Fe)
- Incocal #10 (4.5 – 6.5%Ca)
- Incommag#1 (14.0 – 16.0%Mg + C)
Greenville FAP Products - GM #3LC

GM #3LC is a nickel base alloy containing 4.0 to 5.0 percent magnesium and about 0.025 percent carbon. A highly efficient magnesium transfer is achieved with this alloy, resulting in magnesium recoveries of 80 to 90 percent and generation of minimal MgO fumes to acceptable emission levels.

The product has an approximate density of 7.7g/cc compared to 6.9 g/cc for liquid cast iron. GM #3LC can thus be dropped into the melt ladles or furnaces. The relatively quiet reaction that follows depends on proper balance of the alloy composition.

The capability of adding GM #3LC directly into the melt makes it possible to treat at the most advantageous point in the process cycle. Small trim additions can also be made to furnaces or ladles to bring subcritical magnesium residuals into range and restore full spheroidization.

The usual relationship of improved magnesium treatment efficiency with decreasing temperature also applies to this alloy. Good performance in extensive laboratory and field testing has been obtained throughout the 2550°F to 2750°F (1400°C to 1510°C) range for all grades of ductile iron. GM #3LC is also used as a deoxidizer and desulfurizer, and to control the morphology of sulfide inclusions in ferrous and nickel-base wrought alloys.

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<tr>
<td>Packaging</td>
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</table>

| Typical Chemical Analysis (percent) |
| Nickel | Balance | Silicon | 0.1 |
| Magnesium | 4.6 | Sulfur | 0.001 |
| Carbon | 0.025 | Copper | 0.001 |
| Iron | 0.05 | Lead | 0.001 |
GM #10 is a nickel-calcium alloy with 4.5 to 6.5 percent calcium produced in the form of pieces weighing about 3 lb (1.4 kg). GM #10 facilitates the addition of calcium to molten baths during the production of low alloy steels, stainless and heat resisting alloys, and nickel-base alloys. Calcium can be introduced safely and efficiently by means of this foundry additive product in both cast and wrought alloys.

GM #10 has a density of 7.3 to 7.6 g/cc, which is greater than that of liquid cast iron. (The theoretical density is 7.6 g/cc). This allows for a clean, consistent calcium addition to molten iron and steel under controlled conditions. Calcium is not only a scavenger for deleterious elements but, when present as a residual, it can improve ambient and high temperature properties of both ferrous-and nickel-base alloys. GM #10 permits a safe, final addition of calcium to achieve improvement in mechanical and physical properties without sacrificing cleanliness of the product.

The advantages to be gained by adding calcium to a wide variety of cast and wrought alloys include: 1) efficient deoxidation and desulfurization to consistent low levels; 2) sulfide shape control; 3) improved hot workability in high alloy steels; 4) improved ingot surface quality for reduced billet grinding; 5) improved mechanical properties and machinability for low alloy steels; and 6) increased consistency in resistance wire alloys.

### Specifications

**Form**
- Silver-gray pieces approximately 3 lb (1.4 kg) each.

**Packaging**
- 761 lb (345.25 kg) steel drums; 4 drums per pallet; strapped.
- Net weight 3044 lb (1381 kg).

### Typical Chemical Analysis (percent)

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<th>Element</th>
<th>Value</th>
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<tr>
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<td>Copper</td>
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Questions?