Riser Sleeves – Study
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“To be effective, a riser should continue to feed liquid metal to the casting until the casting has completely solidified. Thus the riser must have a longer solidification time than the casting” [1]

[1] Steel Founders Society of America, Feeding & Risering Guidelines for Steel Castings

Insulating vs Exothermic

**Insulating**

- Cheap
- Range of geometries
- Possibly biocompatible
- No fumes/ignition hazards
- Temperature limit?

![Image of insulating material]

**Exothermic**

- Comparatively expensive
- Range of geometries
- Fumes may be toxic
- Contamination of casting from “pickup”

![Image of exothermic material]

http://www.shankerfoundry.com
Is there a general trend?

- Very few literature reports of fair comparisons between insulating and exothermic
- Conflicting views among different foundries
- Thermophysical properties for modelling are proprietary
Insulating or Exothermic?

Steel Casters State Their Cases

Making these decisions is not easy, and companies have developed their own criteria for using insulating or exothermic riser sleeves based on observations and supplier product information. Traditional logic holds that exothermic sleeves should be used on smaller diameter risers and insulating sleeves on larger risers. However, another line of rationale suggests exothermic sleeves could provide advantages for determining riser size.

Of the 21 respondents, nine (43%) used both insulating and exothermic sleeves (Fig. 1). A total of 78% used exothermic sleeves. Only 22% used insulating hot topping material, while 71% used exothermic hot topping material.

Seventy-one percent of respondents used simulations to determine riser size, while 29% used modular calculation. A few used both.

Skeels, suggesting that exothermic risers would be more effective at the smaller risers. At larger diameters, the surface to volume ratio drops, so the transfer to the use of an insulating sleeve might them approach either based on performance or cost effectiveness.

A number of respondents indicated that they used exothermic sleeves at larger diameters to overcome a cooling shortage, which would otherwise prevent

- **Company C**: Uses insulating 90% of the time unless simulation dictates otherwise
- **Company F**: Insulating sleeves for risers < 6 inch and exothermic > 6 inch
- **Company I**: Exothermic up to 24 inch and insulating brick beyond
- **Company L**: Semi-insulating > 4 inch and exothermic < 4 inch
- **Company M**: Bases the use of exothermic or insulating on pour weight and yield
- **Company N**: Insulating on 2 – 10 inch and exothermic on > 10 inch.
- **Company P**: Exothermic on 3 -10 inch, half exothermic on 11-12 inch and insulating above
- **Company T**: Mainly exothermic but uses insulating when cracks appear from aluminium pickup


Brendan Darby

CTNZ 2015
Experimental Setup

Figure 2 – Original design of chosen casting geometry depicting two sleeves feeding identical rectangular blocks cast from the same feeding column.

Figure 3 – (a) Inside of casting template without and (b) with sleeves in place.
Experimental Setup

Types of Sleeves Tested

<table>
<thead>
<tr>
<th>Sleeve</th>
<th>Fiber Type</th>
<th>Constituents</th>
<th>Max Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCF10</td>
<td>Fibrefrax</td>
<td>Al₂O₃, SiO₂</td>
<td>1400</td>
</tr>
<tr>
<td>ISO20</td>
<td>Isofrax</td>
<td>MgO, SiO₂</td>
<td>1260</td>
</tr>
<tr>
<td>HT10</td>
<td>Fibrefrax¹</td>
<td>Al₂O₃, SiO₂, ZrO₂</td>
<td>&gt; 1400</td>
</tr>
<tr>
<td>RCF20</td>
<td>Fiberfrax</td>
<td>Al₂O₃, SiO₂</td>
<td>1400</td>
</tr>
</tbody>
</table>
Results - Aluminium

Cast Properties

- CC601 Grade
- Pour Temp ~ 670°C
- No hot topping
Results - Aluminium

RCF10 vs EXO10

(a) and (b) show the comparison of temperature over time for RCF10 and EXO10 in Aluminium.
Results - Aluminium

RCF20 vs EXO10

(a)

(b)
Results - Aluminium

Exothermic

PYROTEK
## Results - Aluminium

### Summary

<table>
<thead>
<tr>
<th>Cast</th>
<th>Sleeve</th>
<th>Cast Temp (°C)</th>
<th>$\Delta T$ Pyrotek (s)</th>
<th>$\Delta T$ Exo (s)</th>
<th>% Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>RCF10</td>
<td>668</td>
<td>626</td>
<td>517</td>
<td>21</td>
</tr>
<tr>
<td>3</td>
<td>ISO20</td>
<td>675</td>
<td>810</td>
<td>581</td>
<td>39</td>
</tr>
<tr>
<td>4</td>
<td>HT10</td>
<td>677</td>
<td>699</td>
<td>552</td>
<td>26</td>
</tr>
<tr>
<td>5</td>
<td>RCF20</td>
<td>679</td>
<td>779</td>
<td>548</td>
<td>42</td>
</tr>
</tbody>
</table>

% improvement = $\frac{\Delta t_{PYRO}}{\Delta t_{EXO}}$

$\Delta t = t_{liquidus} - t_{solidus}$
Results - Bronze

Cast Properties

- LG2 Grade
- Pour Temp ~ 1100°C
- No hot topping
Results - Bronze

Cast Properties

- LG2 Grade
- Pour Temp ~ 1100°C
- No hot topping
Results - Bronze

Cast Properties

- LG2 Grade
- Pour Temp ~ 1100\(^\circ\) C
- No hot topping

<table>
<thead>
<tr>
<th>Cast</th>
<th>Sleeve</th>
<th>Cast Temp ((^\circ)C)</th>
<th>(\Delta T) Pyrotek (s)</th>
<th>(\Delta \cdot ) Exo (s)</th>
<th>% Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>RCF10</td>
<td>1190</td>
<td>340</td>
<td>260</td>
<td>30</td>
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<tr>
<td>7</td>
<td>ISO20</td>
<td>1192</td>
<td>431</td>
<td>303</td>
<td>30</td>
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<tr>
<td>8</td>
<td>HT10</td>
<td>1192</td>
<td>334</td>
<td>271</td>
<td>23</td>
</tr>
<tr>
<td>9</td>
<td>RCF20</td>
<td>1192</td>
<td>375</td>
<td>285</td>
<td>32</td>
</tr>
</tbody>
</table>
Results - Iron

Cast Properties

- G100 Grade
- Pour Temp ~ 1400°C
- Hot topping used

- Unable to obtain thermal data
Results - Steel

Cast Properties

- 304 Stainless
- Pour Temp ~ 1550°C
- Hot topping used

- Unable to obtain thermal data
Thermal Conclusions

- Experimental method verified as fair comparison
- Pyrotek ceramic fibre sleeves outperform competitor for Aluminium & Bronze
- No noticeable feeding performance differences with Insulating vs Exothermic
- Steel castings out of performance range of RCF sleeves
- Further thermal data needed for Iron and Ste
Cristobalite Formation in Ceramic Fibre Sleeves
Background

- Concern that RCF based fibers may form Cristobalite during casting
- Cristobalite recently listed as carcinogenic to humans when breathed

Goal: Use X-ray diffraction to measure the cristobalite formation, if any, for sleeves fired under real conditions

X-ray Diffraction (XRD)

http://chemwiki.ucdavis.edu

http://www.microscopy.ethz.ch/images/bragg_welle.jpg

http://cnx.org/resources/f3966ea8053dfde315a4e79d534743e68cf88a4f/graphics5.jpg
X-ray Diffraction (XRD)

Quantitative XRD

- Addition of a known amount of standard powder
- Compare relative peak intensities
- Allows quantitative measure of constituents

2theta XRD pattern of a 48:52 mix of NIST SRM 1879a cristobalite and NIST Corundum powders. The main cristobalite peak at ~25° is clearly visible.
XRD Results – Aluminium

- Green Sleeves – All amorphous, no crystalline peaks detected
- Aluminium – Again amorphous, temperature too low to cause crystallisation of fibres
Quantitative XRD

- Samples spiked with known amount of corundum (Al$_2$O$_3$)
Quantitative XRD

- Samples spiked with known amount of corundum (Al$_2$O$_3$)
Quantitative XRD

- Samples spiked with known amount of corundum (Al₂O₃)
- RCF20 ~ 6% cristobalite
Quantitative XRD

- Samples spiked with known amount of corundum ($\text{Al}_2\text{O}_3$)
- Cristobalite formed @1300°C
- Re-vitrifies @1600°C
## XRD – Summary

<table>
<thead>
<tr>
<th>Sleeve Type</th>
<th>Metal</th>
<th>% Corundum</th>
<th>% Mullite</th>
<th>% Quartz</th>
<th>% Cristobalite</th>
<th>% unidentified/amorphous</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCF20</td>
<td>LG2</td>
<td>35.78</td>
<td>1.07</td>
<td>0</td>
<td>0</td>
<td>63.15</td>
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<tr>
<td>G100</td>
<td></td>
<td>31.68</td>
<td>4.42</td>
<td>0</td>
<td>0</td>
<td>63.91</td>
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<tr>
<td>Steel</td>
<td>304</td>
<td>31.89</td>
<td>24.95</td>
<td>0</td>
<td>6.2</td>
<td>37.27</td>
</tr>
</tbody>
</table>

Table 6 – Summary of the XRD analysis of the crystal structure of RCF20 sleeves used in bronze, iron and steel castings.
• Thermal data indicates Pyrotek insulating sleeves provide superior thermal performance than competitors
• Thermal data still needed to confirm if thicker sleeve competes with exothermic in Iron castings
• Visual casting looks promising with iron
• Tests required on real castings with feeding distances

• No detectable cristobalite content found in any Pyrotek sleeves in Aluminium, Bronze and Iron castings
• Cristobalite in steel castings on the order of 5%