Casting Emission Reduction Program

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US Army Task N256

Core Wash Quality Baseline Library Pre-Production Test

Technikon #WBS 12GSA1 DB

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United States Environmental Protection Agency

CISA

AMERICAN FOUNDRY SOCIETY, INC.

UNITED STATES COUNCIL FOR AUTOMOTIVE RESEARCH

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BASELINE LIBRARY TEST
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Reviewed and Approved by: ____William C. Walden____ Date: 23Apr01

The data contained in this report were developed to assess the relative emissions profile of the product or process being evaluated. You may not obtain the same results in your facility. Data was not collected to assess casting quality, cost, or producability.

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A. Summary

This report reviews the results of tests conducted at CERP, working with the American Foundry Society (AFS) 4F Committee, on the effects of various percent solids content in refractory core coatings on casting quality. The traditional control measure for refractory coatings on castings has been the Baume´ test. The latest theory is that Baume´ is not an adequate quality control method and measurement of the percent solids would be an improvement resulting in better correlation with actual casting surface finish. The actual results of these tests were inconclusive in supporting that concept.

It must be noted that the reference and product testing performed is not suitable for use as emission factors or for purposes other than evaluating the relative emission reductions associated with the use of alternative materials, equipment, or processes. The emissions measurements are unique to the specific castings produced, materials used, and testing methodology associated with these tests, and should not be used as the basis for estimating emissions from actual commercial foundry applications.

B. Background

The most common coating control test utilized by conventional sand foundries to control their refractory coatings is the Baume´ test. The 4F Committee has conducted research into the effectiveness of Baume´ as a control test and presented its findings in presentations at both the 102nd and 104th Casting Congresses[i, ii]. Tables 1 and 2 briefly summarize the 4F Committee's Baume´ test results compared to percent solids results for the same data sets.

Table 1 Variability in Baume´ Hydrometer Readings When No Changes are Made to the Coating.

Test Coatings	Hydrometer Range	For A Fixed Dilution	Mean Baume´	±1 σ[B]	% Solids	Mean % Solids	±1 σ
High Solids Coating	89.00 - 101.00	@120 sec. delay & 75 sec after start of test	90.53 [A]	0.082	Grand Mean n = 6	72.56 % [A]	0.045 %
Low Solids Coating	29.00 - 41.00	@120 sec. delay & 75 sec after start of test	32.85 [A]	0.172	Grand Mean n = 11	29.17 % [A]	0.093 %

[A] Tests were restricted to a single manufactured batch, N = 1 for each test coating
[B] σ = standard deviation

Table 2 Variability in % Solids When Coating Dilution is Controlled by Baume´

Test Coating	% Solids "As made"	% Solids When Diluted	% Solids When Diluted	% Solids "As made"	% Solids When Diluted	% Solids When Diluted
Fix Baume' at	100.56 Baume´	90.00 Baume´	85.00 Baume´	66.45 Baume´	30.00 Baume´	25.00 Baume´
High Solids Coating	81.45% ± 0.35 for n = 80	80..22 ± 0.427 [A]	77.96 ± 0.660 [A]			
Low Solids Coating				45.44 ± 0.20 for n = 470	31.07 ± 0.763 [A]	27.30 ± 1.213 [A]

[A] Tests included variation between manufactured batches, N = 2 for each test coating

The 4F Committee had interpreted the above results to indicate that use of the Baume´ test to control coating dilution increases variation in the percent solids of a coating beyond the variability normally inherent in the coating's manufacturing process. It remained to be determined whether the observed increase in percent solids variability has a negative impact on casting quality.

C. Objective

The objective of this study was to determine if percent solids content in a core coating is an accurate quality control parameter. This was to be accomplished by pouring 40 step core castings with various core coatings and compare the finished casting surfaces.

It must be noted that the results from the reference and product testing performed are not suitable for use as emission factors or for other purposes other than evaluating the relative emission reductions associated with the use of alternative materials, equipment, or manufacturing processes. The emissions measurements are unique to the specific castings produced, materials used, and testing methodology associated with these tests. These measurements should not be used as the basis for estimating emissions from actual commercial foundry applications.

D. Procedure

In an attempt to determine the impact of Baume´ induced variability on casting quality, the 4F Committee and the Casting Emission Reduction Program's (CERP) Quality Committee recognized the need to quantify "casting quality". As CERP has established a baseline casting and developed tests that quantify casting surface quality, the Committees proposed applying CERP's baseline casting quality standards to determine the impact of refractory coatings on casting surface finish. The committees realized there are relationships between coating refractory constituents, dry coating deposit (thickness), percent solids and casting surface finish, which are beyond the scope of this investigation. In order to minimize the impact of these differences the Committees proposed using two types of refractory constituents and measuring the dry surface deposit associated with each type of coating at each different percent solids level.

The hypothesis is that casting surface quality is largely controlled by the percent solids present in the refractory coating (it is anticipated that a direct correlation between dry surface deposit and percent solids exists also). By using Baume´ as the singular process control test for coatings, the foundry industry increases the variability of the percent solids in the coating which increases the variability in casting quality. In order to minimize the number of castings necessary to achieve the statistical range of percent solids associated with controlling the coating via the Baume´ test, it was decided that three levels of percent solids would be evaluated for each type of refractory constituent coating (Low Solids Ceramic type and High Solids Zircon type). Based on the results in Table 2 it was proposed that five molds of the 8-on AFS step-block test castings be poured in CERP's Foundry at each of the percent solids ranges presented in Table 3:

Table 3 Range of Percent Solids Based on Table 2 Dilution-to-a-Baume´ Value

Test Coatings		High Baume´				Low Baume´	
Statistical % Solids	- 3 σ	Mean	+ 3 σ		- 3 σ	Mean	+ 3 σ
High Solids	78.92 %	80.20 %	81.48%		75.97 %	77.95 %	79.93 %
Low Solids	28.81 %	31.10 %	33.39 %		26.09 %	27.30 %	28.51 %

Testing Method:

A. Core making, coating and measurements:

1. Coating manufacturers (DeltaHA & Ashland Chemical) each shipped six (6) 5-gallon pails (all coatings from the same production lot) to CERP. These included High Solids Zircon (Ashland) and Low Solids Ceramic (Delta).
2. The AFS 4F Committee procured the equipment necessary to dilute, mix and test the experimental coatings.
3. The experimental coatings were diluted to the prescribed percent solids (not Baume´ values) levels.
4. 40 cold box step-cone cores were made by CERP on Redford core blower.
5. 36 cores were dipped, marked and then dried in OSI oven.
   a. Dimensions were measured with dial calipers before coating application at the 1", 2" and 4" step areas.
   b. Dimensions were re-measured after the coating has been applied and dried.
   c. Coating dry deposit was calculated as ½ of the increase in core dimension.

B. CERP team members prepared 5 green sand molds to set cores in for test.

C. CERP team members poured a total of five (5), 8-on step-block molds in the Production foundry, which contained 40 marked cores.

1. 18 cores were the High Solids (Zircon) coating
2. 18 cores were the Low Solids (Ceramic) coating
3. 4 cores were uncoated as a control group

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E. Results

Analysis of the casting quality was performed at the University of Northern Iowa. Castings were bisected from top to bottom and the surface area reviewed. These casting results are tabulated in Table 4 and the quality comparison (veining surface area) are ranked in order best (1) to worst (40).

Table 4 Veining Comparison with Different Coatings and Baume´ Levels

Casting ID	Total Veining Surface Area	Overall Rank	Coating Baume´	Zircon Coating Rank	Graphite Coating Rank
A1	1.910	17	High		5
A2	1.676	8	High		2
A3	2.289	33	High		14
B1	3.039	40	High		18
B2	1.711	10	High		3
B3	2.109	26	High		11
C1	2.090	25	High		10
C2	2.133	29	High		13
C3	2.055	22	High		8
D1	2.453	36	Low		16
D2	1.934	18	Low		6
D3	2.414	35	Low		15
E1	2.707	39	Low		17
E2	1.863	15	Low		4
E3	2.121	28	Low		12
F1	2.055	22	Low		8
F2	2.051	21	Low		7
F3	1.602	6	Low		1
G1	1.770	11	High	7	
G2	2.070	24	High	13	
G3	1.328	4	High	4	
H1	1.813	14	High	10	
H2	2.254	32	High	17	
H3	2.047	20	High	12	
I1	2.168	30	High	15	
I2	2.168	30	High	15	
I3	1.875	16	High	11	
J1	1.797	13	Low	9	
J2	1.125	2	Low	2	
J3	1.188	3	Low	3	
K1	1.793	12	Low	8	
K2	1.707	9	Low	6	
K3	2.117	27	Low	14	
L1	2.691	38	Low	18	
L2	1.660	7	Low	5	
L3	0.719	1	Low	1	
M1	2.512	37	None		
M2	2.043	19	None		
M3	2.367	34	None		
M4	1.484	5	None		

F. Conclusions

The expected results were not realized in this test series. The data indicates that all core surfaces had some level of veining. The Zircon (high Solids Coatings) was generally better that the Ceramic (low Solids Coatings). The percent solids within each group showed no statistical difference between the high Baume´ and low Baume´ mixes.

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[i] O. Guyer, Meyer, F., Muniza, J., Meyer, F., Stahl, L., and Trinowski, D.; 102nd Casting Congress; Refractory Coating Control Tests (Panel), # 98-132, May 11, 1998
[ii] D. Jablonski, Stahl, L., and Zbiegien, K.; 104th Casting Congress; Baume': Complete Coating Control? (Panel); # 00-151, Apr. 8, 2000