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EVALUATION OF COPPER SLAG BLAST MEDIA FOR RAILCAR MAINTENANCE

FINAL REPORT

JUNE 1989

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CONTENTS

		Page
1.0	INTRODUCTION	1
2.0	CONCLUSIONS	1
3.0	RECOMMENDATIONS	2
4.0	SUMMARY	2
5.0	OBJECTIVES	4
6.0	DISCUSSION	4

TABLE

I.	Erosion Rate Calculations - Copper Slag	7

FIGURE

1.	Erosion of A-36 Steel by Copper Slag Blast	8

DISTRIBUTION 9

Reference: Work Request No. I89040 from Clearfield Manufacturing Engineering

Process Engineering Technical Report Categories:

Cleaning
Grit Blasting

1.0 INTRODUCTION

Blackhawk copper slag blast medium has been tested and found to be superior to zirconium silicate for refurbishment of railcars at H-7. Process Engineering was requested to investigate an alternative to zirconium silicate for railcar refurbishment due to the cost and decreasing availability of zirconium silicate. A change to the Blackhawk copper slag would represent a 91-percent cost savings over the currently-used zirconium silicate.

Copper slag is produced from the slag that has accumulated over the years at Kennecott Copper near Salt Lake City. The vendor estimated that, at current production rates, there is a 20 to 30 year supply of the material.

The slag product has been found to remove paint from railcars three to five times faster than zirconium silicate, produces very little dust, and provides a bonding surface for paint adhesion that is comparable to that of zirconium silicate. The copper slag also has the advantage of being environmentally acceptable to the State of Utah for outdoor unconfined blasting. To minimize erosion, a 2-ft or greater standoff distance should be maintained while blasting. Copper slag will embed itself into A-36 steel while blasting.

2.0 CONCLUSIONS

1. The copper slag blast medium removed paint from a railcar three to five times faster than did zirconium silicate.

2. Zirconium silicate costs approximately $ 0.17 per pound in large quantities where Blackhawk copper slag is currently available in large quantities for $ 0.015 per pound.

3. Based on an estimated annual $ZrSiO_4$ consumption for railcar maintenance of 90k pounds at $ 0.17 per pound, the annual savings realized by changing to copper slag at $ 0.015 per pound would be $1,350 or a 91.2 percent savings over zirconium silicate.

4. The above cost savings do not include labor savings from the reduced processing time due to the increased paint-removal rate of copper slag.

5. Testing showed that Blackhawk copper slag (20 - 40 mesh) left a surface with approximately the same average roughness as did 100 to 200 mesh $ZrSiO_4$.

6. The cost savings of a reusable 3,000-lb bag over the 100-lb bags would pay back 150 percent of the cost of the reusable bag on the first purchase. The reusable bag has an estimated life of 10 refills.

7. Blackhawk 20 - 40 mesh copper slag is approved for outdoor unconfined blasting under Section 4.10.3.a(4) of the Utah Air Conservation Regulation.

8. When used as a blast media, copper slag will embed itself into a steel surface.

9. The erosion of A-36 steel caused when blasting with copper slag increases quickly for standoff distances closer than two feet.

10. When blasting with copper slag, the erosion experienced at a 45 degree blast angle is slightly more than that experienced at a 90-degree blast angle.

3.0 RECOMMENDATIONS

It is recommended that:

1. Blackhawk copper slag be used for railcar refurbishment.

2. Copper slag be purchased in 3,000-lb reusable bags with a dispensing port at the bottom corner of the bag.

3. Copper slag should be considered for use on non-critical tooling items.

4. An investigation should be made to determine if copper slag is a suitable replacement for zirconium silicate in general.

5. When blasting with copper slag, standoff distance should be held to two or more feet whenever possible.

4.0 SUMMARY

RSRM Manufacturing Engineering requested that Process Engineering investigate a less expensive blast medium for blasting railcars. A vendor search was conducted and it was found that slag blast media are the least expensive available. In the area, Blackhawk copper slag is the most economical due to local production and the resultant short shipping distances.

Copper slag is a mixture of calcium ferrisilicate and iron orthosilicate and is a byproduct of refining copper from its ore. Copper slag blast medium is produced from the slag that has accumulated over the years at Kennecott Copper on the west side of the Salt Lake Valley. The vendor estimated that, at current production rates, there is a 20 to 30 year supply of the material.

Blackhawk 20 - 40 mesh copper slag is approved for outdoor unconfined blasting under Section 4.10.3.a(4) of the Utah Air Conservation Regulation. The State of Utah requires that media used for outdoor unconfined blasting pass a maximum of one percent through a 70-mesh sieve before blasting. A determination of the acceptability of other types and brands of media must be made before outdoor blasting can be performed.

A local distributor of the slag provided a 100-pound sample, and arrangements were made to test the copper slag medium on a railcar at H-7. Blackhawk copper slag blast medium was tested and found to be superior to zirconium silicate for refurbishment of railcars at Clearfield, H-7. The slag product was found to remove paint from railcars three to five times faster than $ZrSiO_4$, produces very little dust as compared to $ZrSiO_4$, and provides a bonding surface for paint adhesion that is comparable to that of $ZrSiO_4$.

Based on estimates from Clearfield Manufacturing Engineering, approximately 7,500 lb of zirconium silicate per month or 90k lb per year are used to refurbish railcars. Based on an estimated price of $ 0.17 per lb, the annual cost of $ZrSiO_4$ is $15,300. Blackhawk copper slag is available in 3,000-lb bags that can be lifted with a forklift for filling blast tanks at $ 0.015 per lb. If the annual usage of slag were the same as for $ZrSiO_4$, the annual cost would be $1,350, or only 8.8 percent of the cost of $ZrSiO_4$. Since the slag removes paint and rust faster than $ZrSiO_4$, additional savings may be realized from reduced material consumption and labor costs.

After the testing with the slag was completed, the H-7 operators were allowed to use the rest of the slag to finish their work on the railcar. It was observed that while the operator uses $ZrSiO_4$, he must crouch to get the blast nozzle close to the part being blasted for effective removal of paint and rust. But while the operator was using the slag, he was able to stand nearly erect and still get effective paint removal with the increased nozzle-to-surface distance. Therefore, with the slag, the operator could maintain a much more comfortable work position.

5.0 OBJECTIVES

The objectives of this investigation were to:

1. Find an alternate low-cost blast media.

2. Compare the effectiveness of the alternate blast medium in removing paint from a railcar as compared to $ZrSiO_4$.

3. Determine if the surface finish and bonding characteristics of the alternate blast medium are similar to those of $ZrSiO_4$.

4. Determine how erosive copper slag would be if used to refurbish railcars.

6.0 DISCUSSION

Currently, the most popular blast medium in the area for industrial applications is copper slag. Slags of many types are used for blasting, but due to the availability of copper slag locally and the short transportation distances, copper slag is the most economical. Information from vendors states that copper slag is harder than $ZrSiO_4$, and is suitable for blasting outdoors or in a blast house where the medium is recycled. Free silica is a health hazard associated with many types of blast media, but the copper slag is reported to have less than one percent free silica.

The copper slag is available in 100-lb bags, 3,000-lb bags, or in bulk. A comparison of the cost of bags was made to determine the most cost effective way to purchase the media. Bulk purchase of the medium was not considered due to lack of storage facilities.

The 3,000-lb bags are made to be lifted into position with a forklift and the blast medium dispensed through a small reclosable opening in the bottom of the bag. The purchase of reusable bag for $25.00 each would be necessary, but would allow the grit to be procured for $45.00 per 3,000 lb. The reusable 3,000-lb bags can be used about 10 times before they are replaced. If the same 3,000 lb of grit were purchased in paper bags, the cost would be $82.50. The cost savings of the reusable 3,000-lb bag over the 100-lb bags would pay back 150 percent of the cost of the bag on the first purchase.

The Blackhawk medium grade (20 - 40 mesh) has been assigned Stock Number 57-020175. To save time and transportation costs, it should be possible to order the slag from the vendor in Ogden and to have it sent directly to H-7 where it will be used.

A paint-removal test was conducted at H-7 on a railcar typical of those refurbished there. The test was carried out by holding the blast nozzle of the Empire blaster used on railcars 12 inches away from and at 90 degrees to the car bed. The blast nozzle was moved at approximately one foot per second between two marks one foot apart. The $ZrSiO_4$ required three to five passes to remove the paint to a white-metal condition where the copper slag removed the paint on the first pass. The width of the bands of paint removed in each case were approximately the same.

Some areas of railcar were blasted with $ZrSiO_4$ and some with copper slag after which surface measurements were made with a Surtronic 10 surface analyzer. The average roughness of the $ZrSiO_4$-blasted area was 242 microinches with a coefficient of variation of 10.6 percent. The average roughness of the slag-blasted area was 249 microinches with a coefficient of variation of 18.5 percent. It was concluded that the surface finishes were equivalent.

An ASTM-D3359-83 paint-adhesion test was conducted in which the painted surfaces were scored, adhesive tape applied and quickly removed. Surfaces prepared with both types of blast media showed that only a small amount of paint was removed. It was concluded that the bond surfaces for paint adhesion were both adequate and comparable.

Finally, a test was conducted to determine how erosive copper slag would be if it was used on railcars. Twenty A-36 structural steel coupons were divided into four sets of five coupons each. The sets were blasted using differing parameters, as follows:

Set No. 1 - 1-ft standoff, 90 degree blast angle, 15 seconds

Set No. 2 - 2-ft standoff, 90 degree blast angle, 15 seconds

Set No. 3 - 2-ft standoff, 45 degree blast angle, 15 seconds

Set No. 4 - 3-ft standoff, 90 degree blast angle, 15 seconds

The coupons were weighed before and after blasting to the nearest 1/1000 of a gram on the Metler 160 scale in A-4. The erosion was calculated (Table I) and graphed (Figure 1). Results show that erosion increased dramatically for standoff distances less than two feet. It was also discovered that erosion was slightly greater for a 45-degree blast angle than for a 90-degree blast angle. It should be noted that the test coupons had small specks of copper slag embedded in the steel surface after blasting.

The blasting was done with a portable Empire blaster at H-7 (regularly used to refurbish railcars). Great care was taken to empty the blaster of all zirconium silicate before testing began to make sure that only pure copper slag was used for testing.

TABLE I. Erosion Rate Calculations - Copper Slag

Set Description	Coupon	Preblast Wt (grams)	Postblast Wt (grams)	ΔWt-grams	Coupon Area (in^2)	Erosion (mils/15sec)	Avg Erosion (mils/15sec)
1-ft Standoff	26	126.8302	124.0366	2.7926	4.016	5.4	
90 Degree	27	126.8748	123.8089	3.0659	4.002	6.0	
Blast Angle	28	126.9736	124.5577	2.4159	4.022	4.7	4.9
(Set 1)	29	126.8218	124.8163	2.0055	4.020	3.9	
	30	126.6898	124.3327	2.3571	3.994	4.6	
2-ft Standoff	36	126.6657	125.9575	.7082	3.996	1.4	
90 Degree	37	126.9340	126.2485	.6855	4.006	1.3	
Blast Angle	38	126.6451	125.6370	1.0810	3.998	2.0	1.5
(Set 2)	39	126.9112	126.2322	.6790	4.000	1.3	
	40	126.8868	126.1862	.7006	4.024	1.4	
3-ft Standoff	41	126.0281	126.4001	.3720	3.998	.7	
90 Degree	42	126.7884	126.2953	.4931	4.000	1.0	
Blast Angle	43	127.0474	126.4754	.5720	4.010	1.1	.9
(Set 3)	44	126.9295	126.4855	.4440	4.012	.9	
	45	126.8786	126.3430	.5356	4.012	1.0	
2-ft Standoff	46	127.0035	126.0114	.9921	3.998	1.9	
45 Degree	47	126.8415	125.7658	1.0757	4.010	2.1	
Blast Angle	48	127.0320	126.1758	.8562	4.000	1.7	2.1
(Set 4)	49	126.7667	125.9806	.7861	3.994	1.5	
	50	126.8169	125.2371	1.5798	4.002	3.1	

* Density = 0.284 $lb/in.^3$

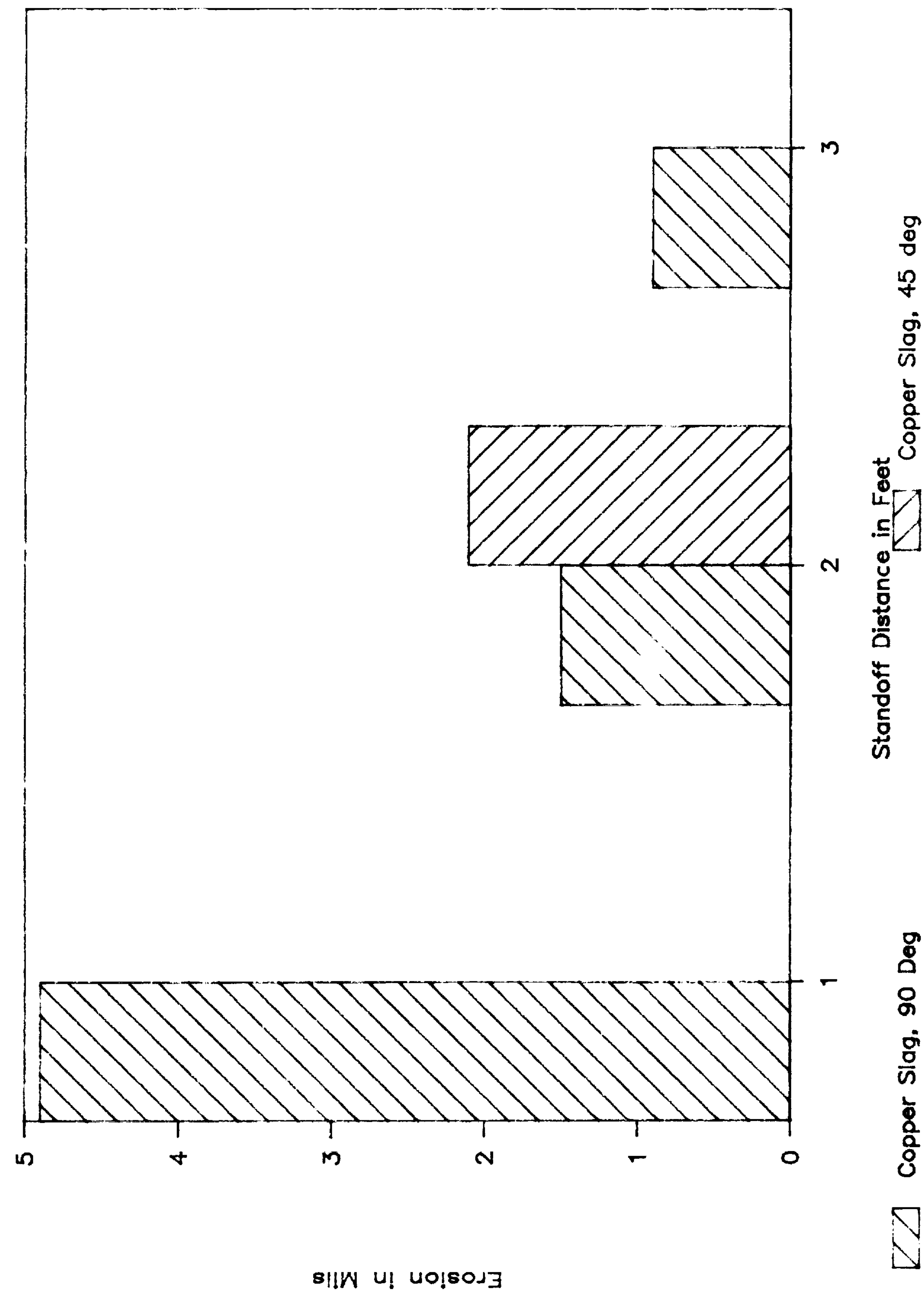

Figure 1. Erosion of A-36 Steel by CU Slag Blast - For 15 Second Blast Time

DISTRIBUTION	M/S
R. S. Adams	851
K. Aragon	427
L. G. Bailey	L10
W. F. Bauer	312
S. J. Bennett	280
B. L. Betenson	411
C. S. Blackhurst	427
J. R. Braithwaite	L34
G. Z. Brinkerhoff	L22
J. L. Busenbark	427
G. A. Caporale	E14
T. F. Christensen	203
R. L. Davis	E00
L. G. Dodd	KSC
M. H. Finlayson	203
S. Goleniewski	L10
G. H. Grunig	U00
M. M. Hash	203
J. P. Jensen	G02
W. B. Johnson	411
T. A. Klick	Louisiana
P. E. Lakomski	E16
R. D. Larsen	851
G. W. LeBaron	L10
R. K. Lund	200
J. P. Martin	506C
A. J. McDonald	G00A
H. H. McIntosh	L40
B. D. Owen	Longhorn
P. C. Petty	L10
T. F. Pinkerman	MSFC
A. B. Porter	411
B. M. Potter	E06
D. L. Rice	203
N. W. Sagers	203
L. E. Seidner	203
G. Thompson	240
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