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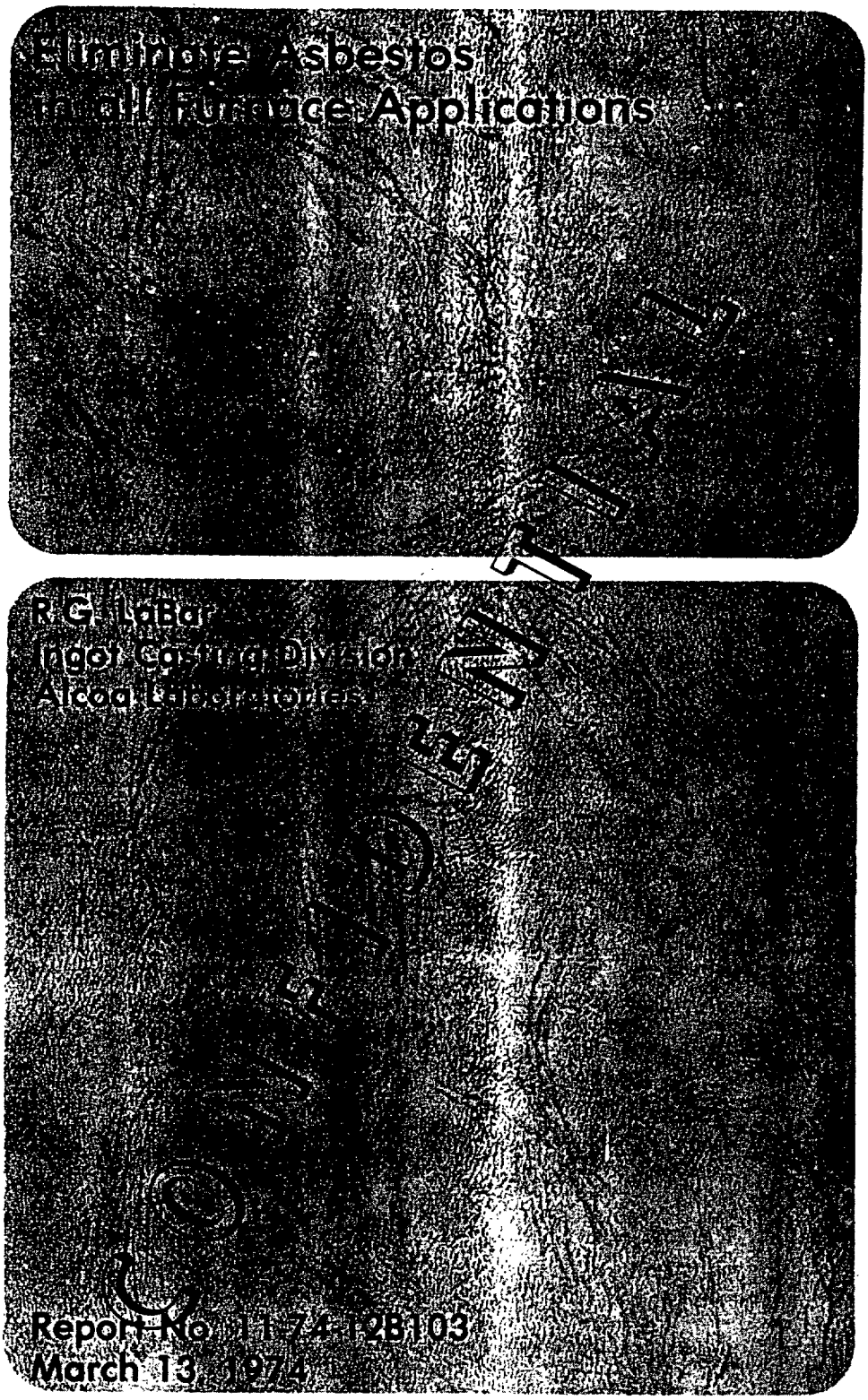

ALCOA

FROM V. L. HAMMERSMITH
INGOT CASTING DIVISION
ALCOA TECHNICAL CENTER - B

TO MR. G. H. LANTZ
ROCKDALE WORKS

1979-02-01

RE: ASBESTOS REPLACEMENTS

On my recent visit, several questions relating to asbestos replacement were noted. The enclosed report, "Eliminate Asbestos in all Furnace Applications," although written in 1974, still can be used as a guideline.

Commercial and developmental refractory evaluations are now conducted by J. E. Hines (8-124-2815) and myself (8-124-2813). If there are any questions about refractory quality, installation, or performance, please feel free to call us.

V. L. HAMMERSMITH

VLH:bls

Attachment - Original Only

cc: ID - ATC, D
E. L. Rooy - Pittsburgh 23
J. E. Hines/R. E. Miller/R. G. LaBar/File: 10.210 - ATC, B

ALCOA

ARD 003118

SF-4563

FROM G. K. TURNBULL
INGOT CASTING DIVISION
ALCOA TECHNICAL CENTER - B

TO MR. J. E. HATCH
INGOT & POWDER PRODUCTS DIVISI(
PITTSBURGH OFFICE - 23

"CONFIDENTIAL"

August 8, 1974

RE: ELIMINATE ASBESTOS IN ALL FURNACE APPLICATIONS
Ingot Casting Division Report No. 11-74-12B103

Asbestos has become thoroughly engrained in ingot casting practices through generations of use. We've learned where and how to use it and have even adapted our practices to take maximum advantage of its characteristics. Yet we must curtail such use and do so over a fairly short transition period.

We could hardly expect to have a shelf item that is the ideal substitute: superior to asbestos in every way. Yet in the series of engineering tradeoffs inherent in such substitution we are fortunate to have a series of alternatives adequate to undertake nearly every aspect of substitution. Some preexisted and have been evaluated by plants and Alcoa Laboratories. Others were recently developed at the Laboratories. Major candidates are compared in the attached report by Dr. R. G. LaBar. Preferred candidates have been singled out into the Appendix section and paired up with detailed installation instructions.

Preferred technique for use of the report is to use Appendicized materials and limit them to the applications and procedures described. If local conditions, refractory availability or other considerations override this approach, some insight into the shortcomings of other candidates are described in the body of the report. It is strongly recommended, however, that use of the not-recommended materials be coordinated through Dr. R. G. LaBar or Mr. D. R. Barch to provide maximum opportunity for their success and to extend the extremely important "In Service Evaluation Results" of Table V.

A separate report will be issued covering parallel developments on asbestos elimination in headers.

Mr. Sartschev plans to expand narrow initial distribution by submitting to you a list of plant recipients.

Keith Turnbull

G. K. TURNBULL

74B830-1

GKT:sh

Attachment

cc: R. E. Spear/TID
T. R. Gauthier/J. H. Dunn - Pgh
K. J. Brondyke/R. T. Teeter - ATC
R. G. LaBar - ATC
Div. File
T. B. Bonney/R. P. Carter - Pgh 7
R. C. Cook - Pgh

One copy routed to SMIC:
A. J. Sartschev - Pgh
E. D. Quade - ATC
E. V. Blackmun - Pgh
M. C. Schoetz - Pgh
R. W. Wrenn - Pgh
E. L. Rooy - Tenn

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ALUMINUM COMPANY OF AMERICA
ALCOA LABORATORIES

ELIMINATE ASBESTOS IN ALL FURNACE APPLICATIONS

R. G. LaBAR

March 13, 1974

"CONFIDENTIAL"

INGOT CASTING DIVISION
REPORT NO. 11-74-12B103

Copy No. 3

Reported by R. G. LaBar
R. G. LaBar
Group Leader

Noted by G. K. Turnbull
G. K. Turnbull
Section Head

ARD 003120

SYNOPSIS

This report summarizes the program to replace asbestos containing products in applications other than HDC and FDC headers. A broad number of candidates (Table I) and test data (Tables II-VI) were narrowed to a specific group of recommended materials. Appendix A contains the recommendations along with updated procedures for installation and use. Whereas the project is closed out, assistance and advice will be provided as required. Further, candidate materials for insulation, trough linings and packing, basin and FDC pot linings, etc. will be evaluated in Project 06W05311, Refractory Evaluation.

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INTRODUCTION

Overwhelming evidence in recent years links human exposure to asbestos dust with several forms of cancer. One result of this is the U. S. Asbestos Standard* which greatly restricts the exposure limit (no. particles/volume air/ unit time) effective July 7, 1972 with a further reduction effective July 1, 1976. The restrictions are so severe, that the dust handling equipment, monitoring equipment and additional personnel required to monitor concentrations will make the use of asbestos containing materials impractical as well as uneconomical.

The major thrust towards solving the problem is the elimination of asbestos containing products in all applications. However, the unique properties of asbestos and many asbestos containing products are not readily matched by any one substitute for all applications. In fact, many different materials had to be qualified and specified for use in various applications; hence, the purpose of the project and this report. Preliminary to this report was a recommendation issued by D. R. Barch and the author in April 1973. The appendix of this report is an update of the original recommendations based on laboratory and in-service results.

CANDIDATE MATERIALS

The number of replacement materials is great, as is the variety of trade names and manufacturer's claims for them. To minimize the confusion, Table I lists the materials according to the following categories:

1. Castables - supplied in bags or drums to be mixed with water and poured, tamped or troweled in place.

2. Moldables - supplied in bags or drums to be used as is (if premixed) or mixed with water and tamped, troweled and/or molded by hand.

3. Board - in most cases to be cut, installed and used as is. However, some products require coatings to improve erosion and corrosion resistance when used in metal contact.

4. Miscellaneous - includes packing materials, gasketing, cements, etc.

5. Preformed Special Shapes - includes drop-in trough liners and other special shapes (FDC pots, etc.).

As a list of major candidates, Table I is neither a list of recommendations, nor an all inclusive compilation of alternatives. Recommendations are detailed later in Appendix A. Materials intentionally excluded from Table I include inadequate candidates plus other materials which were evaluated and for one

*Federal Register, Vol. 37, No. 110, pp. 11320-11322 (6/7/72).

Results of plant trials at Warrick using Thermo 340 (R-340) and a developmental mix designated R-616 (contains equal amounts of fused-silica and plaster with somewhat less calcium aluminate, CA-25) were less than satisfactory. The materials were not sufficiently durable to survive beyond 2 1/2 mos. (Thermo 340) and 5 mos. (R-616) respectively. These results correlate with our observations in the laboratory. We have found that with materials containing considerable amounts of plaster ($CaSO_4$) partial rehydration occurs during cyclical use. This phenomenon produces swelling and dusting which weakens the material. The A-641 product was developed with this in mind so that it only contains 1% plaster which is added to accelerate the hydraulic set of the CA-25 cement so that higher productivity of cast pieces is possible (1% plaster addition halves the time required to develop handling strength).

One unique feature of the R-340 material is that it expands during curing more than it shrinks during firing. We have utilized this property to successfully line pump piping and FDC pot shells. The linings are tight, quite durable and easy to install as the R-340 mix is fine-grained and thus flows easily into small annular spaces.

As mentioned above, we have developed a new product called A-641. This material, in a preformed and fired shape (board or otherwise) can be cut to the required size with standard metal cutting tools and bolted in place. However, because the material is brittle, a back-up cushion of ceramic fiber blanket or ceramic fiber paper is recommended. A companion product now under evaluation is A-646. This is a slight modification incorporating a corrosion inhibiting zinc borosilicate frit which all but eliminates wetting and metal attack (see data in Table IV).

Another new product development is A-647. The concept of this material was derived from J. P. Austin's Mandoseal (See Table III) which contains Portland Cement (unstable in cyclical use). The objective was a moldable mix using expanded vermiculite blended with various other materials to obtain a product which could be wet mixed more easily than mineral wool containing moldables, would have low drying and firing shrinkage and could be used as a substitute for asbestos shorts/Lumnite.

The need for a suitable moldable in many applications is critical. One of the major problems with their use is cracking due to shrinkage. In order to quantify shrinkage versus temperature and product, a series of tests was conducted. Samples of each material were formed into bars 1 in. x 1 in. x 10 in. and then measured after curing, air drying, oven drying to 230 F, firing to 600 F and then to 1350 F. The data are shown in Figure 1 and Table VI.

Of particular interest is the extremely low firing shrinkage of Consolidated's Moldable, Panelex Super (still being evaluated in the laboratory), Variform and A-647. The JM-375 L and asbestos/shorts Lumnite seem to increase their rate of shrinkage

with temperature which is attributed to irreversible phase changes in their fibrous components. The Panelex Super is a new product containing some mica (probably vermiculite) which would tend to counteract shrinkage of the mineral wool constituent As noted in Table VI, the total shrinkage of the Consolidated Moldable is 0.0%. However, as seen in Figure 1, shrinkage occurre during air and oven drying to 230 F. Reports from the field indicate that this product does not shrink at all. This is understandable in view of the fact that in our test, the bars were allowed to air and oven dry lying on one side. Thus the bottom did not dry at the same rate as the top surface, causing the bars to warp (compared to the other materials, this product dries slowly).

Finally, a comment is warranted about moisture content. As reported for JM-375 L, its shrinkage was only 1.4%. However, the mix was prepared using 50% water. When 75% water was used, the shrinkage nearly tripled. This type of sensivity led us to embark on the development of A-647 and simultaneously begin to search for other products such as Plisulate and Panelex Super.

The prices in Table VI are not precisely accurate but were based on recent data to provide a comparative base. The figures for A-647 and A-641 were estimated from available data on raw materials and trial manufacturing (costs to us by outside vendors for preparing experimental materials). The range of prices for fused-silica castables is the difference between the least expensive (Glasrock 840) and the most expensive (Silfrax ARC).

RECOMMENDATIONS

In keeping with our overall effort, previous recommendations have been amended to reflect the results of our work at the Laboratories and to include the results of various and successful plant trials. These recommendations appear in Appendix A.

While the reader may at first be somewhat confused by the diversit of materials, it is recognized that local availability and deliver will at times necessitate the selection and use of alternate products within a specific category.

Recommendations on the use and source of supply for A-641 and A-647 will be forthcoming as more extensive in-service trials are completed and/or when agreement is reached with a vendor(s) for their manufacture.

CONCLUSIONS

1. Molten Metal Marinite and asbestos insulation can be replaced by asbestos free materials in troughs, basins and for back-up insulation.

2. Asbestos shorts/Lumnite and asbestos rope can be replaced by

asbestos free materials for troughs, pot linings and miscellaneous packing.

3. The recommended substitute materials are described herein. They are numerous and, in many cases, suited for a limited number of applications dependent on thermal conductivity, erosion resistance, corrosion resistance, bulk density (as this pertains to inclusions and metal quality), workability and cost.

4. In many instances, asbestos free substitutes for Molten Metal Marinite are less expensive, more refractory but in no instance as uniquely versatile or flexible.

5. More care in handling and use will be required when using other materials where Molten Metal Marinite has been the standard.

TABLE I

MAJOR CANDIDATE MATERIALS BY CATEGORY

Category	Class	Brand	Manufacturer
Castables:			
	1. Fused-silica/calcium aluminate -	Glasrock 840	Glasrock Co., Inc.
		Glasrock 820	" " "
		Insilrock	" " "
		Silfrax ARC	Carborundum Co., Inc.
		Thermosil 120	Thermo Materials, Inc.
		Thermosil TG	" " "
		Vis Sil	Sil Base Co.
	2. Insulating aluminous/calcium aluminate	Kast-O-Lite 30	A. P. Green Co.
	3. Dense aluminous/calcium aluminates	Alcoa C-1	Alcoa, Bauxite, Ark.
		SJP Cast	Wahl Refractories Co.
	4. Eucryptite/calcium aluminate	LO-X (Duramics)	Pryor - Giggey Co.
Moldables:			
	1. Mineral Wool/calcium aluminate	JM-375L	Johns-Manville Co., Inc.
		Panelex Super P-430	Quigley Co., Inc.
	2. Ceramic fiber/calcium aluminate	Variform A and B	Carborundum Co., Inc.
	3. Ceramic fiber/colloidal silica	Consolidated Moldable	Consolidated Ceramics
	4. Vermiculite/talc/ calcium aluminate	A-647	Alcoa Laboratories
	5. Phosphate bonded plastics	Solar 80	J. P. Austin Associates

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Category	Class	Brand	Manufacturer
Board: (See Preformed also)			
	1. Fiberglas/calcium silicate	Thermo 12(Superex Kaylo 10 1600) Superex SG Carey Hi Temp	Johns-Manville Owens Corning Fiberglas Johns-Manville Carey Insulation Co.
	2. Ceramic fiber (vacuum formed)	Thermotect A or B Hot Board M - Board	CE Refractories, Inc. Carborundum Babcock & Wilcox
	3. Mineral wool	Various	Many
	4. Fused silica	Glasrock Foam	Glasrock, Inc.
	5. Fused silica/calcium aluminate	A-641	Alcoa Laboratories and Sil Base Co.
	6. Fused silica/plaster/colloidal silica	Thermo 340	Thermo Materials
Miscellaneous:			
	1. Packing (Ceramic fiber bulk, rope and blanket)	Fiberfrax	Carborundum
		Kaowool	Babcock & Wilcox
		Cerafelt	Johns-Manville
	2. Gasketing	Fiberfrax Paper Fiberseal	Carborundum Fibrous Glass Products
Preformed Trough Liners:			
	1. Ceramic fiber	Thermotect A M - Board Kalmin 5000	CE Refractories, Inc. Babcock & Wilcox Foseco, Inc.

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Category	Class	Brand	Manufacturer
2.	Fused silica	Masrock	Glasrock Co., Inc.
3.	Fused silica/calcium aluminate	A-641	Sil Base Co.
4.	Fused silica/plaster/colloidal silica	Thermo 340	Thermo Materials

RGL/aeh

Note: Materials recommended for plant use are listed in Appendix A.

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TABLE II

LABORATORY TESTS ON CASTABLES

Brand	72 Hour Cup Test/7075 Alloy			
	Temp.	Pickup Si	Pickup Fe	Penetration
Glasrock 840	1500	17.9	.09	Severe
Glasrock 820	"	19.9	.07	"
Duramics LO-X	"	3.8	.03	"
Vi Sil	"	17.9	.07	"
Thermosil 120	"	19.9	.07	"
Thermosil TG	"	11.9	.07	"
Silfrax ARC	"	.12	.00	None
Kast-O-Lite 30	"	2.31	.06	Slight
Alcoa C-1	"	.03	.04	Negligible
GJP Cast	(Same as Alcoa C-1)			

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TABLE III

LABORATORY TESTS ON MOLDABLES

	72 Hour Cup Test/7075 Alloy				"B" Immersion			
		Pickup						
Alloy	Temp.	Si	Fe	Penetration	Temp.	Cracks	Penetration	Thermal Stability
[illegible]	1350°F	.01	.02	None	1400°F	None	None	Excellent
[illegible]					"	Many	"	Poor
[illegible] (Vacuum Melted/ [illegible])	1500°F	.00	.02	None				Poor
[illegible]	[illegible]	.04	.03	None				
[illegible]	[illegible]	.05	.04	Negligible				
[illegible]	[illegible]	.54	.23	Severe				Excellent
Consolidated Moldable	1350°F	14.0	.09	Severe				
IRM Moldable (Carborundum)					1400°F		Severe	N.A.

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TABLE IV

LABORATORY TESTS ON BOARD PRODUCTS

	72 Hour Cup Test/7075 Alloy				"B" Immersion			
		Pickup						
Brand	Temp.	Si	Fe	Penetration	Temp.	Cracks	Penetration	Thermal Stability
Thermo 12	--	--	--	--	1400°F	None	None	Poor
Thermo 10	1350°F	.01	.03	None	--	--	--	Fair
Thermotect A	--	--	--	--	1400°F	--	Severe	--
[illegible]	--	--	--	--	1400°F	--	Severe	--
A-641	1350°F	2.69	.02	Slight	--	--	--	Excellent
[illegible]	1[illegible]	..	.02	None	--	--	--	V. Good
Thermo 340	1500°F	.41	.06	Negligible	--	--	--	Fair

[illegible] is a modification of A-641 with a frit additive.

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TABLE V

IN SERVICE EVALUATION RESULTS

Brand	Erosion Resistance	Cracking Resistance	Metal Adherency	Durability
[illegible] Marinite [illegible] Comparison	Excellent	Excellent	None	Excellent
Glasrock 840	Good	V. Good	Slight	Good
820	"	"	"	"
Duramics LO-X	"	"	"	"
[illegible]	"	"	"	"
Thermosil 120	"	"	"	"
TG	"	"	"	"
Silfrax ARC	"	"	None	"
Kaj-O-Lite 30 w/Lumnite Wash	V. Good	Fair	Negligible	V. Good
Alcoa C-1	Excellent	Fair	Negligible	Excellent
JM-375L	Poor	Fair	Slight	Fair
Variform	Good	Good	None	Good
[illegible]	Poor	Good	Slight	Fair
[illegible]	Excellent	Excellent	None	Excellent
Consolidated M.	Good	Good	Slight	Good
Thermo 12	Poor	Excellent	None	Poor
Thermotect A w/Glasrock Sealer	Good	Excellent	Negligible	Good
A-641	V. Good	Excellent	Slight	V. Good
Thermo 340	Good	Fair	None	Fair

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TABLE VI

PHYSICAL AND THERMAL PROPERTIES

Brand	Fused-Silica Castables	Solar 80	Kast-O-Lite 30	SJP Cast	JM-375L	Variform	A-647	Consolidated Moldable	Thermotect A	A-641	Thermo 340	M. M. Marinite
Bulk Density -												
(lb/cu. ft.)	110-111	175	85	150	40-50	45-55	63*	40	28	90*	95	33-40
[illegible]	1.76	2.80	1.36	2.40	.64-.80	.72-.88	1.01	.64	.45	1.44	1.52	.53-.64
[illegible] -												
[illegible] (psi)	[illegible]	(1800)	300	900	--	130	--	--	--	280*	750	600-700
(kg/cm²)	52.7	133	21	63		9.1				19.7	52.7	46
[illegible] Crush (psi)	5000	(7500)	1000	--	--	--	--	--	--	830*	--	--
[illegible]	[illegible]	527	70							58.4		
[illegible] -												
[illegible] - 1350°F	0.6	0.1	0.1	0.2	1.4*	2.6*	1.5*	0.0*	0.5	0.7*	1.0*	1.85%*
[illegible] -												
[illegible] ft.²/°F/in.	5-6	[illegible]	2.69	(15)	.84	0.8	--	0.5	0.5	3.1*	3.5*	1.0*
[illegible] -												
[illegible]	.45-.65	--	--	--	--	--	--	--	--	(.5)	--	1.3×10^{-6}
(in./in./°C)	.82-1.1[illegible]	--	--	--	--	--	--	--	--	--	--	2.4×10^{-6}
[illegible] -												
[illegible] ft.³	18-[illegible]	31	16	20	3	43	(4)	54	35	(18)	60	22

* ARL Data

( ) Figures in parentheses are estimated.

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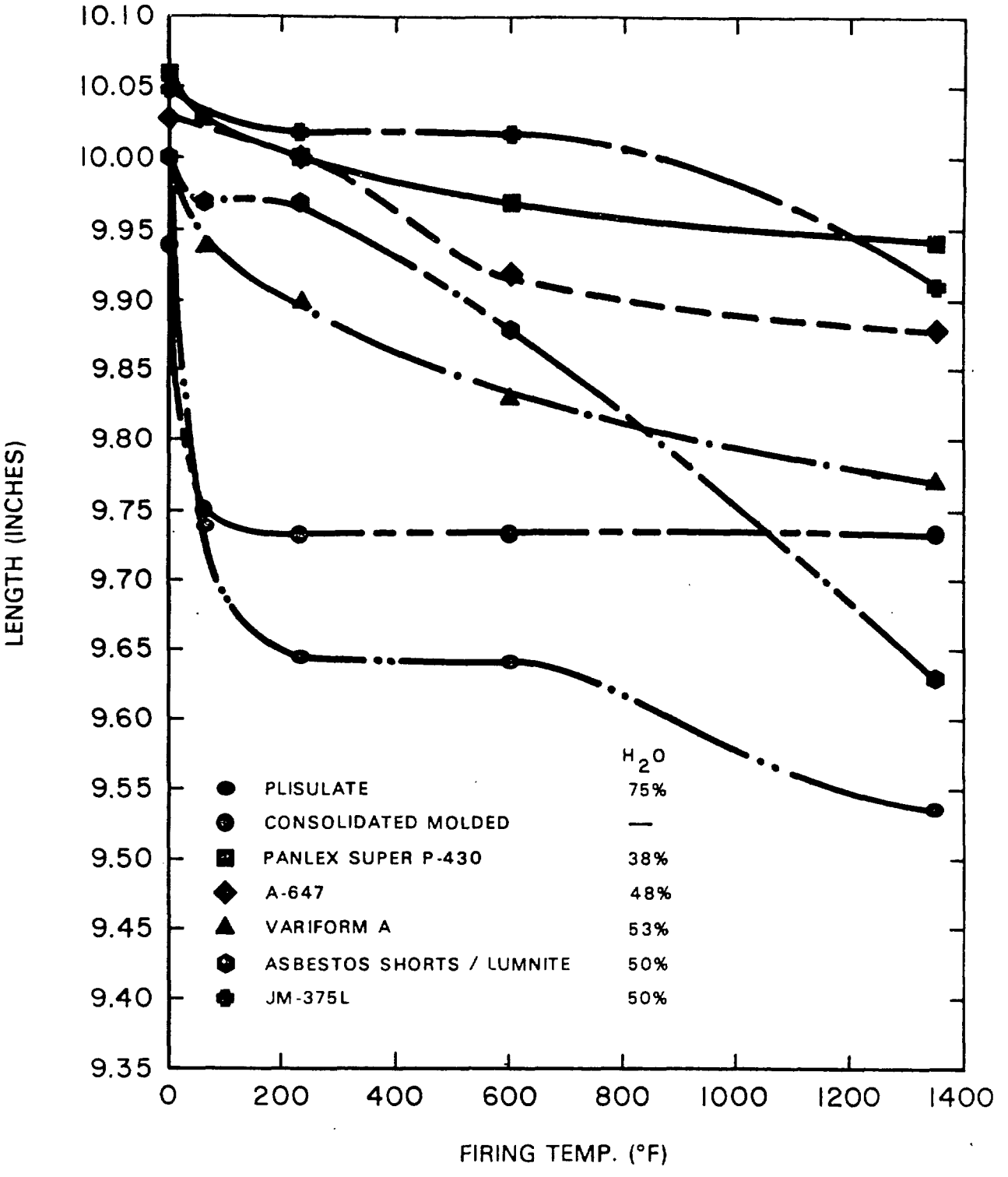

LINEAR FIRING SHRINKAGE INSULATING MOLDABLES

FIGURE 1

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APPENDIX A

Recommendations for Preparation and Installation (Supercedes Memo by D. R. Barch and R. G. LaBar of April 27, 1973).

A. Melter to Holder

Castables: Alcoa C-1, SJP Cast, Kastolite 30, fused-silica castables (See Table I in text).

1. Recommended minimum wall thickness is 2 inches.

2. Follow manufacturer's recommended mixing instructions for a pourable mix using minimum water.

3. Coat forms with oil, grease or polyethylene sheet (Stapled to forms).

4. Tack weld expanded metal mesh lathing to inside of trough 1/2 - 1 inch from steel work.

5. Post-casting procedure:

   a. Cover casting with plastic sheet for 24 hours.
   b. Dry casting in air for 24 hours.
   c. Castables should be heated slowly to 600 F prior to use, preferably overnight.

      Caution: Avoid flame impingement and rapid heatup.

6. The recommended coatings, except for Silfrax ARC which requires none, are Lumnite, Plistix 900 or 900F.

Moldables: Solar 80 Plastic

1. Recommended minimum wall thickness is 1 1/2 inches.

2. Follow manufacturer's recommended procedure for installation paying particular attention to leaving a roughened surface - do not smooth or overwork the surface!

3. One half to one inch of mineral wool or fiber glass board back-up insulation is recommended. It can be glued to the steel lining with sodium silicate.

4. Post-molding procedure:

   a. While some air drying is permissible slow heating of this material is recommended after installation is complete.

      Apply heat uniformly across the entire section.

   b. Heat slowly to 230 F and hold for 1/2 day per inch thickness.

   c. Raise temperature to 600 F and hold for 1/2 day per inch thickness prior to use.

Caution: Avoid flame impingement during initial heatup and use.

5. Coatings are not required.

Brick: Coral P or Chas. Taylor 12054

a. Use R & I Super 3000 mortar.
b. Standard practice for refractory brick installation.

B. Holder to Molten Metal Treatment Process:

Castables: Fused-silicas or Kast-O-Lite 30.

1. Follow recommendations in Section A for castables.

Moldables: JM-375L, Variform B, Consolidated Moldable.

1. Use 50 lb. water to 100 lb. JM-375L for power mixing. Maximum addition should not exceed 75 lb. water to 100 lb. JM-375L!

2. The same restrictions stated in 1 above apply to variform.

3. Thorough mixing will permit the use of minimum water and produce more uniform, workable materials.

4. Consolidated Moldable is ready to use as received.

5. Tack weld expanded metal mesh lathing to inside of trough 1/2 in. from steel work for long trough sections, unless the trough is equipped with an overhanging lip.

6. May be hand molded, tamped and/or troweled in place.

7. Do not overwork the surface!

8. Post-molding procedure:

a. Cover with plastic sheet for 24 hours.

b. Air dry for at least 24 hours, (longer for Consolidated Moldable).

c. Heat each section (between joints) uniformly and slowly to 230 F overnight.

d. Continue heating to at least 600 F prior to use.

Caution: Avoid flame impingement, non-uniform heating, rapid heatup and scraping with sharp edged tools.

9. The recommended coatings are Lumnite, Plistix 900 and 900 F, J-M Cerakote, whiting (apply whiting by rubbing it into the surface after step 8 b. above and brush away all the excess).

Board and Preformed Shapes: Vacuum Formed

Ceramic Fiber (see Table I in text), Glasrock Foam (50 pcf).

1. These materials may be installed using the same procedure as with Molten Metal Marinite or follow manufacturer's instructions (especially in the case of Glasrock Foam).

2. Recommended coatings are Lumnite, Glasrock Sealer (with Glasrock Foam), J-M Cerakote, Plistix 900 and 900 F, whiting (as per instructions under moldables above), or coating supplied with Kalmin (Foseco).

   Caution: Avoid flame impingement and scraping with sharp edged tools.

C. Downstream from Molten Metal Treatment Process

Moldables: Same as B above.

Board: Same as B above except do not use Lumnite or Plistix coatings.

D. Packing and Miscellaneous

Ceramic fiber bulk, blanket and rope may be used in place of asbestos rope for packing, etc.

Thermo 12, Kaylo 10, or Ceramic fiber board products may be used for insulation in place of Thermobestos, Superex, Molten Metal Marinite, etc.

General In Service Care and Cautions

1. Avoid excessive preheating. If preheating is necessary, apply uniform heat, avoiding hot spots and direct flame impingement.

2. Avoid mechanical abuse.

   a. Install protective caps over linings near tap spouts.
   b. Lift skulls by hand, minimize scraping and/or gouging.

3. Extra care is required when installing dams in drop-in liners to avoid breakage. Recommend use of ceramic fiber paper (Fiberfrax, Cerapaper, etc.) gasketing around dams and joints.

4. A program of scheduled inspection and maintenance should be implemented.

It is recognized that individual plant differences exist in trough usage and design, but it has been concluded that these differences can be taken care of if made known and discussed.

The ingot plant metallurgists are requested to inform M. L. Redhair of contacts with various vendors and receipt of sample materials. In addition, brief feedback on plant experiences, either pro or con, with the recommended materials are requested.

New materials and/or revised procedures for installation and use will be added to the list as they develop.