

SHINAGAWA TECHNICAL REPORT

イソライト工業株式会社
「Silplate®」

Isolite Insulating Products Co., Ltd.
“Silplate®”

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品川技報

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要 旨

Silplate®は、溶鋼プロセスのバックアップ材として使用可能な画期的な構造断熱材である。一般的な構造断熱材に対するSilplate®の特長は、

- ・高温耐熱性能
- ・低熱伝導性能
- ・優れた機械的強度
- ・寸法安定性

である。

Abstract

Silplate® is a revolutionary structural insulation fiber board for use as back up insulation for the molten metal process. The main performance advantages of Silplate® structural insulating board include

- ・High temperature capability
- ・Low thermal conductivity
- ・Excellent mechanical strength
- ・Dimensional stability

1. はじめに

イソライト工業(株)は1927年の創業以来、耐火断熱れんがやセラミックファイバーに代表される耐火断熱材と省エネルギー製品の製造開発販売に取り組んできた。さらに、全世界に製造販売拠点を有するセラミックファイバーメーカー「Unifrax社」製品の国内販売権を取得し、Unifrax社の特徴ある製品の販売も行っている。本稿では、溶鋼輸送設備のバックアップ用に開発された優れた高強

1. Introduction

Since establishment in 1927, Isolite has been engaging in the manufacture, development and sales of insulating refractory materials and energy-saving products such as insulating firebricks and ceramic fiber. Furthermore, Isolite obtained the sales right of the products made by Unifrax Corporation in Japan. Unifrax has manufacturing and sales bases in the whole world, and they manufacture the characteristic

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度断熱材『Silplate®』を紹介する。

2. 溶鋼輸送設備における断熱性バックアップ材の役割

溶鋼輸送設備（混銑車，取鍋，タンディッシュ等）において断熱性の高いバックアップ材を使用することは，溶鋼温度低下の防止に加えて，鉄皮温度の低下及び内容積の増量という効果がある（Table 1）。このような高断熱性バックアップ材に要求される特性は以下の3点である。

① 高温耐熱性能 ② 低熱伝導性能 ③ 熱間圧縮強度

高温耐熱性能とは，最高使用温度及び高温下での線収縮率が小さく，断熱性を有していることを指標として評価している。

バックアップ材は，ワークライニングが初期厚みの1/3程度まで薄くなっても高温耐熱性，高温下での強度が維持できなければならない。バックアップ材の性能が低い場合，容積安定性が失われ，鉄皮とバックアップ材との間にギャップが発生する。そのため，ワークライニングが鉄皮側に移動することで目地開きが生じ，目地部へ溶湯が侵入しワークライニングの寿命が短くなる。

バックアップ材の中には，低熱伝導性能は非常に優れているが高温耐熱性能及び熱間圧縮強度が低いため，ワークライニングが薄くなると上述した問題が発生するという製品もある。また，高温耐熱性能及び熱間圧縮強度は優れているが，低熱伝導性能が今一つという製品も多々ある。Silplate®は，低熱伝導特性を有しつつ高温耐熱性能及び高温下での圧縮強度を有する優れた製品である。

Table 1 Molten metal transportation

	Target	Effect
1	Prevention from temperature fall of molten metal	Improvement in the yield
		Saving energy
2	Lower temperature at the shell	Prevent deformation of shell
3	Increasing the molten metal volume	Increase the production volume

products. In this article, we introduce a high performance insulation material named Silplate®, which is used for the molten metal transportation.

2. Function of Back-up Material of Equipment for Molten Metal Transportation

Using back-up material with high insulation properties in the molten metal transportation facilities (steel ladle, torpedo car and tundish) is effective not only to maintain the molten steel temperature but also to lower the steel shell temperature and increase the initial volume of the molten metal transportation facilities (Table 1). A back-up material requires the following characteristics.

- ① High temperature capability
- ② Low thermal conductivity
- ③ Compression strength at high temperature

High temperature capability means a high maximum allowable working temperature, low coefficient of linear shrinkage at high temperature and high insulation efficiency.

Even when the thickness of work lining becomes thin to about 1/3 of the initial thickness, high temperature capability and compression strength at high temperature must be maintained for the back-up material. If the back-up material does not have the proper hot crushing resistance or adequate refractoriness it can shrink and deformed a lot, resulting in the generation of a gap between the back-up material and steel shell. With the molten metal pressure on the refractory lining, the work lining tends to move to the steel shell side to where the gap was left by the shrunk insulation. Since molten metal penetrates into the joints, the life of the work lining is decreased.

Some back-up materials occur the above mentioned problems when the thickness of the work lining becomes thin. Because they don't have enough compressive strength at high temperature and high temperature capability, in spite of having excellent low thermal conductivity performance. Also, there are many products

Table 2 General properties of Silplate® series products¹⁾

Grade		1108	1112	1308
Color		White	White	Green
Maximum Use Temperature	°C	1100	1100	1340
Basic Composition	%			
SiO ₂		67~75	64~66	61~62
Al ₂ O ₃		24~33	30~32	35~37
ZrO ₂		0.1~0.8	—	—
Fe ₂ O ₃		<0.1	<0.05	<0.05
Loss on Ignition	%	1.1	2.1	2.5
Bulk Density	kg/m ³	800	900-1000	800
Thermal Conductivity	W/(m・K)			
@351°C		0.15	0.28	0.16
@593°C		0.18	0.35	0.18
@761°C		0.20	0.37	0.21
Cold Crushing Strength	MPa	7.9	11.8	7.9
Hot Crushing Strength (at 500°C)	MPa	18.6	37.2	32.0

3. Silplate®の品質特性

Silplate®シリーズ製品の品質特性について Table 2に示す。シルプレートは標準グレードであるSilplate®1108をはじめ、より強度の高いSilplate®1112や、耐熱の温度が高いSilplate®1308の3グレードに分かれている。

4. Silplate®と他のバックアップ材

一般に市場で販売されているバックアップ材として以下の品種が挙げられる。軽量で施工性の良いカルシウム・シリケート品、熱伝導率が非常に低い特徴を持つマイクロポーラス品、耐圧強度に優れるマグネシア・シリケート品及びセラミックファイバーの各種ボードである。Fig. 1に各製品とSilplate®の性能を高耐熱性能、低熱伝導性能及び熱間圧縮強度の3項目について評価した図を示す。図中の三角形が大きいほど、バックアップ材として適した製品であることを示している。Fig. 1より、セラミックファイバーやカルシウム・シリケート、マイクロポーラスの各種ボードは熱間圧縮強度が低いため三角形の面積は小さく、マグネシア・シリケートにおいては断熱性がSilplate®より劣っている。

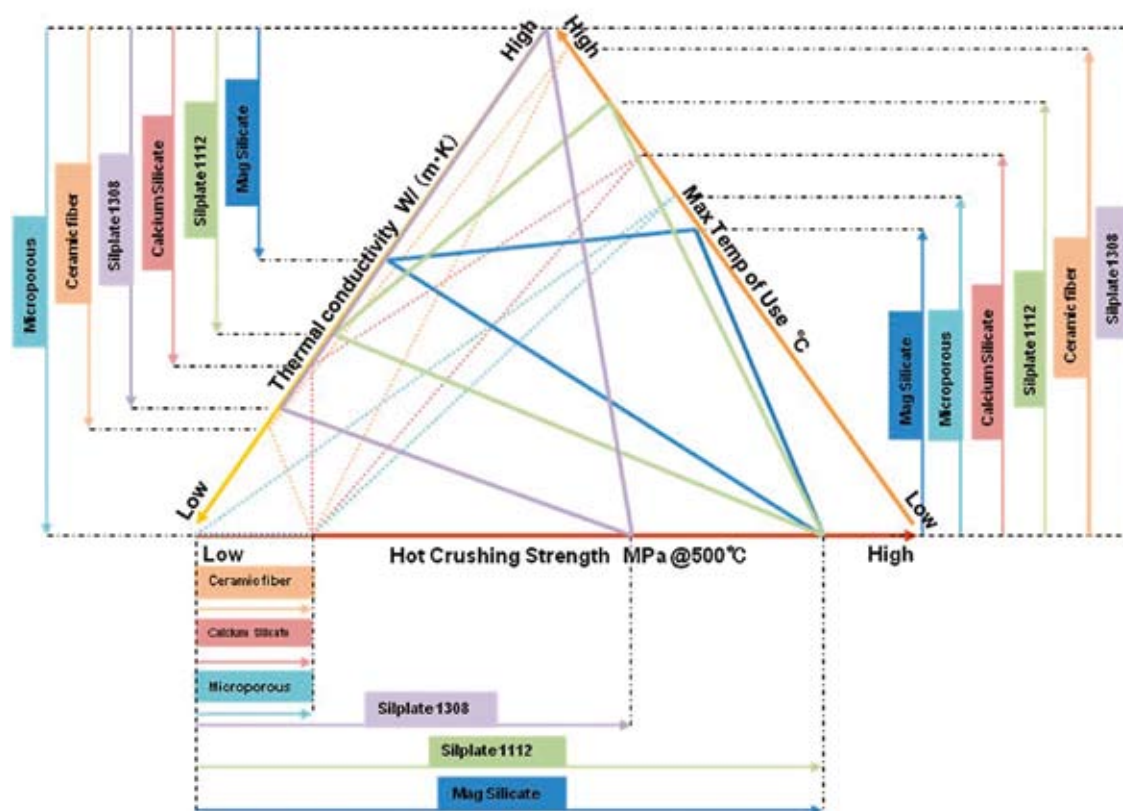
which don't have low thermal conductivity performance although they have high temperature capability and excellent compressive strength at high temperature. Silplate® is an outstanding product which has low thermal conductivity, high temperature capability and compression strength at high temperature.

3. Properties of Silplate® Series Products

Table 2 shows the general properties of Silplate® Series Products. There are three grades of Silplate®, Silplate®1108 is a general grade, Silplate®1112 is high strength grade and Silplate®1308 is for high temperature use.

4. Silplate® and Other Back-up Insulation Material

The back-up insulation materials available in the market are shown below. Calcium silicate has lightweight and provides good installation, Microporous has low thermal conductivity, Magnesia-Silicate has high compressive resistance. Fig. 1 is a graph comparing the characteristics of the respective products and Silplate® regarding high temperature capability, thermal conductivity and compression strength. The bigger area occupied by a triangle, the better the material

Fig. 1 Ideal back up insulation trinomial²⁾.Table 3 Back-up material comparison of Silplate[®] and others¹⁾

	High Temperature Capability	Low Thermal Conductivity	Compression Strength At High Temp	Operational Evaluation
Silplate [®]	◎	○	◎	◎
Magnesia-Silicate	○	△	◎	○
Calcium-Silicate	△	○	△	△
Microporous	△	◎	△	△
Ceramic-Fiber Board	○	○	△	△

◎ : Excellent, ○ : Good, △ : Normal or poor

また、全体のライニングを薄くし溶湯の処理量を増加したいとの要望もある。ところが、断熱ライニングを厚くしワークライニングを薄くすると、断熱ライニングの接面温度が上がるため他の製品では対応できない。Silplate[®]は熱伝導率が低く、耐熱温度及び熱間圧縮強度が高い製品でありこの課題をクリアすることができる。Table 3にSilplate[®]と他のバックアップ材との性能比較につ

は for use as back-up insulation. According to Fig. 1, ceramic fiber board, calcium silicate and microporous cannot be recommended for use in this kind of application due to the low hot crushing strength. Only Silplate[®] and Magnesia-silicate are usable for this application.

Another requirement for back-up material is to maximize the loading capacity for the ladle to increase production. The current insulation

Table 4 Conditions and evaluation ²⁾

A Company Group	
Temperature Problem after VOD Process	
Problem External Temperature over 430°C	16mm of Magnesia-Silicate
External Temperature down to 325°C	25mm of Silplate [®] replacing
Results, A Company Group-19 Ladles (90t) under construction. (in 2007)	

Table 5 Conditions and evaluation ²⁾

S Company Group, Torpedo Car 200 ton	
Back up Insulation	External Temperature °C
6mm of Ceramic Fiber Paper	377
16mm of Magnesia Silicate	348
16mm of Silplate [®] 1112	277

いてまとめた結果を示す。

5. 用途及び実績

Silplate[®]は、取鍋、混鉄車、タンディッシュ、電炉、高炉樋等溶湯搬送装置並びに溶湯容器のバックアップ材として使用されている。代表的なものについて以下に述べる。

5. 1 取鍋のバックアップ材

A社におけるSilplate[®]1308による施工実績及び効果についてTable 4及びFig. 2に示す。

A社の取鍋は、以前バックアップ材として16mmのマグネシア・シリケート材を使用しておりVOD処理後の鉄皮外壁温度は平均430°C以上であったが、25mmのSilplate[®]に変更することにより鉄皮外壁温度が325°Cまで低下した。結果、最終的に19基の取鍋にSilplate[®]が採用された。

5. 2 混鉄車のバックアップ材

混鉄車の断熱において、異なるバックアップ材を用いた際の各バックアップ材による断熱効果をTable 5に、Silplate[®]による施工写真をFig. 3に示す。

6 mmのセラミックファイバーのペーパー、16mmのマグネシア・シリケート材及び16mmのSilplate[®]1112の3種を比較したところ、それぞれ

**Fig. 2 A company group, Ladle ²⁾.**

material available on the market doesn't apply this requirement. If the insulation material is made thick and the work lining thin, the interface temperature goes up and the insulation materials except Silplate[®] doesn't endure. On the other hand, Silplate[®] can be used for this kind of application because of its high temperature capability, compression strength at high temperature and low thermal conductivity. In this case the Silplate[®] will be able to fit properly. Table 3 shows a comparison between Silplate[®] and other back-up materials.

5. Application and Result

Silplate[®] is used as a back-up material for the steel ladle, torpedo car, tundish, electric arc furnace, blast furnace runner trough and dissolution container. Typical examples are described below.

5. 1 Back-up material for steel ladle

The construction track record and effect of Silplate[®]1308 in company A are shown in Table 4 and Fig. 2.

Company A was using 16mm Magnesia-Silicate material for the back-up material in the steel ladle before, and the steel shell temperature after VOD processing was an average of over 430°C. However, the steel shell temperature was decreased to 325°C by changing 25mm Silplate[®]. As a result, Silplate[®] was adopted for 19 sets of

Fig. 3 S company group, Torpedo car²⁾.Fig. 4 S company group, Tundish²⁾.Fig. 5 C company group, Runner trough²⁾.

377℃, 348℃及び277℃となり, Silplate®1112が最も高い断熱効果を示した。

5. 3 タンディッシュのバックアップ材

タンディッシュにおける適用例として, S社における施工状況をFig. 4に示す。こうしたタンディッシュ背面断熱への適用は日本国内の顧客からも採用されており, 従来のマグネシア・シリケート系バックアップ材に比べて鉄皮温度が約25℃低下した, 製品歩留まりが向上したという高評価を得ている。

5. 4 高炉樋のバックアップ材

Fig. 5に高炉樋における施工状況を示す。使用条件に応じて各種Silplate®が使用されており, A社などで2～3年の使用実績がある。

steel ladles.

5. 2 Back-up material of torpedo car

The heat insulation effects of different kinds of back-up materials used in the torpedo car are shown in Table 5. Fig. 3 shows a photograph of Silplate® installation.

When comparing 6mm Ceramic fiber, 16mm Magnesia-Silicate material and 16mm Silplate®1112, the external temperatures of the torpedo cars were 377℃, 348℃ and 277℃ respectively. Silplate®1112 showed the highest adiabatic heat insulating effect.

5. 3 Back-up material of tundish

As an example of application for the tundish, a photograph depicts the construction of tundish at company S is shown in Fig. 4. The application of back-up heat insulation for the tundish has been also adopted by a customer in Japan. Compared with the conventional Magnesia-Silicate system back-up material, the steel shell temperature was decreased about 25℃. As a result, the product yield rate was improved.

5. 4 Back-up material of blast furnace runner trough

Fig. 5 shows the installation of a blast furnace runner trough. A few kinds of Silplate® were used according to the operating conditions and they have been in use for 2～3 years at company A.

6. 海外実績一覧

各種溶鋼輸送設備における実績の詳細を
Table 6～10に示す。

6. Overseas References

Tables 6～10 show the past results of the
equipment for molten metal transportation.

Table 6 Steel ladle²⁾

GROUP COMPANY SITE	MOLTEN METAL	STEEL LADLE		PROCESS	SILPLATE		LINING CAMPAIGN		FEATURE
		QUANTITY	CAPACITY		GRADE	THICKNESS	SILPLATE	WORKING LINING	
A Company Group	Stainless Steel	19	90 Tons	VOD	1308	25 mm	>450 heats	45 heats	Shell case temp. reduction <340℃
G Company Group	Low Carbon Carbon Steel	16	220 Tons	Ladle Furnace RH /Rinsagem	1308	8 mm	250 heats	80 heats	Free board increasing 50mm / Temp. reduction.
A Company Group	Carbon Steel	14	320 Tons	Ladle Furnace RH	1308	8 mm	>700 heats	145 heats	Volume increase-10T Temp. reduction 20℃
G Company Group	Carbon Steel	10	80 Tons	Ladle Furnace	1112	10 mm	>800 heats	150 heats	Temp. reduction <310℃
G Company Group	Carbon Steel	12	65 Tons	Ladle Furnace	1308	10 mm	>700 heats	39 heats	Temp. reduction <340℃
V Company Group	Carbon Steel	12	85 Tons	Ladle Furnace	1308	8 mm (P) 10 mm (F)	>225 heats	75 heats	Temp. reduction <290℃ Weight reduction 340kg
T Company Group	Carbon Steel	18	200 Tons	Ladle Furnace	1112	10/16 mm	>700 heats	180 heats	Temp. reduction <340℃
T Company Group	Carbon Steel	12	85 Tons	Ladle Furnace	1112	10 mm	>800 heats	120 heats	Temp. reduction <325℃

Table 7 Torpedo car²⁾

GROUP COMPANY SITE	MOLTEN METAL	TORPEDO CAR		PROCESS	SILPLATE		LINING CAMPAIGN		FEATURE
		QUANTITY	CAPACITY		GRADE	THICKNESS	SILPLATE	WORKING LINING	
U Company Group	Pig Iron	32	200	De sulphurization	1112	16 mm	440	220	Volume Increase 6% Temp. reduction. 32℃
U Company Group	Pig Iron	28	250	Transportation	1112	16 mm	700	350	Volume Increase 6% Temp. reduction. 30℃
C Company Group	Pig Iron	30	350	De sulphurization	1108	7 mm	860	430	Redução Temperatura carcaça <300℃
G Company Group	Pig Iron	18	350	Transportation	1308	16 mm	—	600	Volume Increase 5% Temp. reduction. 34℃
V Company Group	Pig Iron	8	150/220	Transportation	1112	16 mm	—	180	Volume Increase 5% Temp. reduction. 40℃
T Company Group	Pig Iron	21	200	Transportation	1112	16 mm	800	400	Temp. reduction. to 260℃

Table 8 Tundish²⁾

GROUP COMPANY SITE	MOLTEN METAL	TUNDISH		TEMPERATURE TAPPING	SILPLATE		LINING CAMPAIGN		FEATURE
		QUANTITY	CAPACITY		GRADE	THICKNESS	SILPLATE	WORKING LINING	
G Company Group	Carbon Steel	5/4	25/20 Tons	1570	1108	10 mm	>1100 heats	30 heats	Temp. reduction <310℃
T Company Group	Carbon Steel	12	35 Tons	1580	1112	10 mm	>1100 heats	35 heats	Temp. reduction <320℃

Table 9 Blast furnace runner trough²⁾

GROUP COMPANY SITE	MOLTEN METAL	BLAST FURNACE RUNNER TROUGH		PIG IRON TEMPERATURE	SILPLATE		LINING CAMPAIGN (tons / transp.)		FEATURE
		QUANTITY	CAPACITY		GRADE	THICKNESS	SILPLATE	WORKING LINING	
U Company Group	Pig Iron	2	Metallic	1520°C	1108	12 mm	24 months	35 days	Temp. reduction
G Company Group	Pig Iron	4	Civil	1505°C	1408 1508	25 mm	36 months	28 days	Temp. reduction
A Company Group	Pig Iron	2	Metálico	1510°C	1308	25 mm	24 months	28 days	Temp. reduction

Table 10 Electric arc furnace²⁾

GROUP COMPANY SITE	MOLTEN METAL	Electric Arc Furnace		TILTING TEMPERATURE	SILPLATE		LINING CAMPAIGN		FEATURE
		QUANTITY	TAP TO TAP		GRADE	THICKNESS	SILPLATE	WORKING LINING	
T Company Group	Carbon Steel	115 t	45 min	1660°C/1680°C	1112	10 mm	6/8 months	6/8 months	Temp. reduction < 330°C
A Company Group	Carbon Steel	110 t	50 min	1650°C/1680°C	1112	10 mm	6/8 months	6/8 months	Temp. reduction < 360°C

7. 結言

本稿はUnifrax社製品のSilplate®を紹介した。Silplate®はUnifrax社 Brazilで生産され、近年目覚ましく発展している南米鉄鋼会社の実績が主体となっており、益々生産販売は増加している。また、本稿は技術誌“Industrial Heating June 2012”の“Revolutionary Back up for Morten-Metal Process”並びにUnifrax社の技術資料を翻訳しまとめたものが主体となっている。

7. Conclusion

This paper introduced Silplate® manufactured by Unifrax products. It is mainly based on the past results at a steel company in South America using Unifrax products made in Brazil. Silplate® has been greatly developed in recent years. Silplate® production and sales are increasing now. This paper is mainly translated and summarized from the article “Revolutionary Back up for Molten-Metal Process” published in the technical magazine “Industrial Heating June 2012”, and the technical data of Unifrax.

*Silplate® is a registered trade mark of the U.S. company Unifrax Corporation.

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