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THERMAL INSULATION MATERIALS FOR REDUCTION CELL CATHODES

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Low-thermal conductivity block, or slab, insulation is finding increased use in alumina reduction cell cathodes in place of standard brick or alumina insulation between the refractory linings and the furnace shell for improved thermal efficiency.

Performance of a variety of block insulations were evaluated in cup tests and results correlated with respect to shrinkage and resistance to cryolitic bath. The physical properties of block insulations are compared and related to their application in cathodes.

Introduction

Reduction cell cathodes have traditionally been lined with brick or metallurgical grade alumina to provide the thermal insulation necessary to obtain the proper heat balance for low cell energy consumption and long cathode life.

Cathodes with insufficient insulation are usually characterized by shortened life due to 'heaving' of the cathode blocks and collector bars. These cells may require extra voltage in order to operate without difficulties due to excessive anode effects, increased ledge growth, or accumulation of hard muck deposits in the bottom of the cathode cavity.

Reduction cell cathode insulation deteriorates rapidly during the first year of life due to the rapid ingress of cryolitic salts. Thereafter, the process slows but continues with the increasing progress of salts throughout the cathode insulation resulting in:

- The cathode insulation becoming more vitrified or densified in nature due to the reaction of the refractory insulation with the cryolite salts and/or diffusion of cryolitic salts.
- The thermal conductivity of the insulation increases.
- The heat flux out of the cathode increases.
- The temperature at the underside of the cathode carbon blocks decreases.
- Bath salts generate, 'heaving' forces in the cathode blocks which may eventually cause block and cathode failure.

Recent trends toward low anode current densities require improved cathode insulation to provide the proper heat balance to operate cells at the lower power consumption levels.

A typical cathode insulation design for an alumina reduction cell is shown in Figure 1. It consist of prebaked cathode carbon; an upper layer of high-service-temperature, high-thermal-conductivity insulation; and lower layer of lower-service-temperature, low-thermal-conductivity insulation.

Insulation slabs, or blocks, manufactured from vermiculite or perlite granules, diatomaceous silica, and high temperature bonding materials provide a back-up insulation between the brick or alumina linings and the furnace shell. These slabs are characterized by their superior insulation values even at the high maximum service temperatures.

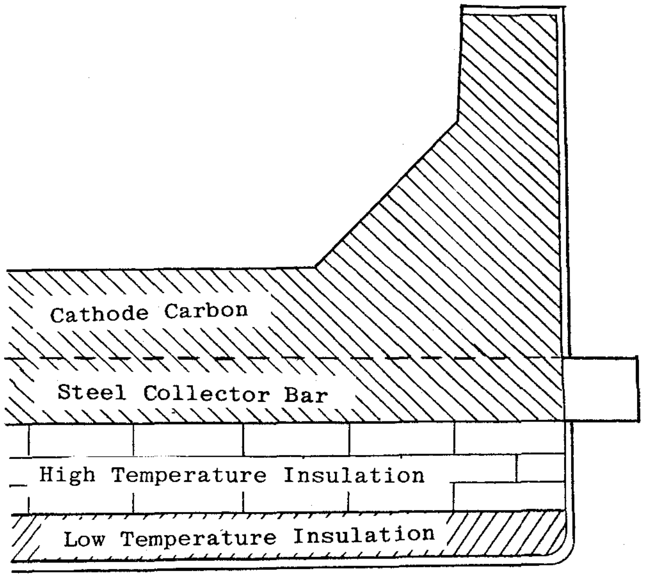

FIGURE 1. REDUCTION CELL CATHODE INSULATION

The necessary thickness of slab insulation, and also combination thickness with the high-temperature insulation, for particular cathode designs will depend upon the total thermal resistance of the cathode and the desired heat flux from the cathode. Another factor to be considered includes the anticipated temperature at the high-temperature insulation and slab interface. The maximum service temperature of the slab must not be exceeded.

Compared to the use of bricks, slab insulation provides the following advantages in the construction of cathode insulation:

1. Lower thermal conductivity materials provide an increased thermal conservation per inch depth of cathode insulation.

2. Faster installation due to the larger block sizes, for example 12 x 48 inches.

3. Increased ease of cutting and shaping materials to fit cathode designs.

4. Fewer seams in the insulation layer reduces the possibility of metal or fluoride infiltration between blocks.

Disadvantages of slab insulation compared to brick in cathode insulation include:

1. Reduced crushing strength.

2. Lower resistance to fluorides.

Considerations in Insulation Selection

A good low-temperature insulation for reduction cell cathodes must:

1. Exhibit a very low thermal conductivity throughout the service range.

2. Resist aluminum penetration and attack.

3. Exhibit a good resistance to attack by molten cryolite.

4. Exhibit stability (non-decomposable) throughout the high temperature service range.

5. Exhibit minimal shrinkage (or expansion) at the maximum service temperature.

6. In some design circumstances, exhibit substantial resistance to crushing.

Additional considerations for selecting back-up insulation include product cost, time and cost of installation, and be environmentally non-hazardous.

Chemistry

Deterioration of the cathode insulation occurs when the insulation is altered by cryolitic bath to form new materials. The deterioration reaction sequence occurs as follows:

1. Vapor and/or liquid phase transport of cryolitic salts through the carbon blocks by either thermal, capillary or hydrostatic forces into contact with the insulation.

2. Reaction of refractory oxides in the insulation by cryolitic bath, for example:

   $3SiO_2 + 2Na_3AlF_6 + 2AlF_3 \rightarrow 3Na_2SiF_6 + 2Al_2O_3$
   $Na_2SiF_6 \rightarrow 2NaF + SiF_4$ (at 650°C)
   $4Na + SiF_4 \rightarrow Si + 4NaF$, or
   $4Al + 3SiF_4 \rightarrow 3Si + 4AlF_3$

   $3MgO + 2Na_3AlF_6 \rightarrow 3MgF_2 + Al_2O_3 + 6NaF$

   These reactions may produce products that have larger volumes than the individual reactants causing volume expansions and densification of the insulation matrix, or on the other hand smaller volumes causing shrinkage or slab loss.

3. The increase in density and changes in chemical structure produce a layer of insulation with a much higher thermal conductivity, permitting a higher heat flux through it. The higher temperatures at the interface of the next layer of insulation increase the transport of cryolitic bath into contact with it.

   The invasion of aluminum metal into the cathode insulation and subsequent reduction of refractory oxides by deposited metal, especially:

$$4Al + 3SiO_2 \rightarrow 3Si + 2Al_2O_3$$

is enhanced by the partial reaction of the insulation surfaces by cryolitic bath creating a surface that is more easily wetted by the metal.(1)

4. The temperature gradient of the insulation layer decreases as the heat flux increases, causing deposits of the higher melting point components of cryolitic bath, especially NaF.

5. The deterioration process is repetitive at each successive layer causing the insulation to become progressively more densified and thermally conductive.

In cells lined with bricks the progress of cryolitic salt penetration is slowed by employing several upper layers of dense 'fire' brick that protects the lower layers of low-thermal conductivity brick.

Alumina insulated cathodes depend upon the natural ability of each successive layer of alumina to absorb large quantities of cryolitic bath, thus becoming more densified, and slowing the progress of cryolitic salts and protecting the lower layers of alumina insulation.

Because of the almost complete deterioration of the upper layers of cathode insulation in both the brick and alumina insulated cathodes, it is the lower layers of insulation that eventually provide the major portion of thermal insulation for reduction cell cathodes.

Compared to the upper insulation layer, the physical requirements to withstand high temperatures and cryolitic-rich environments are substantially reduced for the lower back-up cathode insulation.

Compositions of Insulation

The light-weight, high-temperature insulation slabs with thermal conductivities between 0.08 to 0.18 W/m°C at 600°C are generally manufactured from silica granules or clays with a hydraulic binder and reinforced with mineral fibers. Nine commercial types of insulation investigated included slabs manufactured from vermiculite, diatomaceous silica, calcium silicate, and perlite.

Vermiculite is a hydrated, laminar mineral resembling mica in appearance that contains 5-9% water. When subjected to sudden heat above 2000°F, it expands, or exfoliates, to six or twenty times the volume of the unexpanded mineral. Exfoliation occurs at right angles to the cleavage planes, causing the flakes to expand into concertina shaped granules, shown in Figure 2, that accounts for vermiculite's light-weight, low thermal properties.

Diatomaceous silica is a soft earthy rock composed of microscopic, fossilized skeletons of small aquatic plants called diatoms. The diatoms shown in Figure 3, are made up of hundreds of small thin-walled cells containing air pockets accounting for the light-weight, low thermal properties of diatomaceous silica. In some cases, a proportion of clay is found naturally admixed with the diatoms.

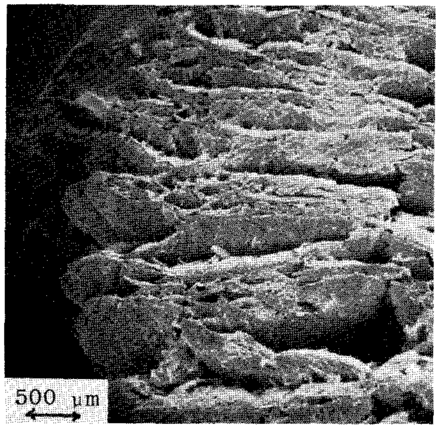

FIGURE 2. EXPANDED VERMICULITE GRANULE

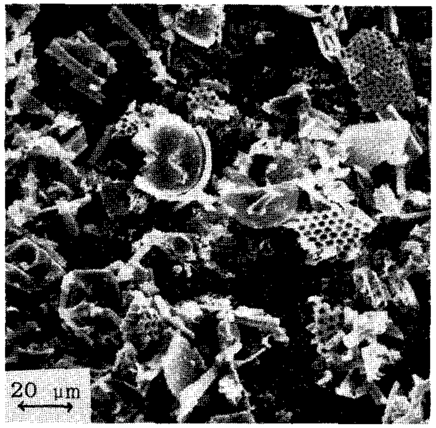

FIGURE 3. DIATOMACEOUS SILICA

Perlite is a naturally occurring siliceous volcanic rock containing 2-5% combined water. When quickly heated to a suitable point in its softening range above 1600°F, the crude rock pops expanding four to twenty times its original volume. When the combined water vaporizes, it creates countless tiny bubbles in the heat softened glassy particles, shown in Figure 4. The tiny glass sealed bubbles account for the light-weight exceptional thermal properties of the expanded perlite.

Calcium silicate hydroxide hydrate, when heated to appropriate high temperatures, forms laminar plated granules which are light- weight and have low thermal properties.

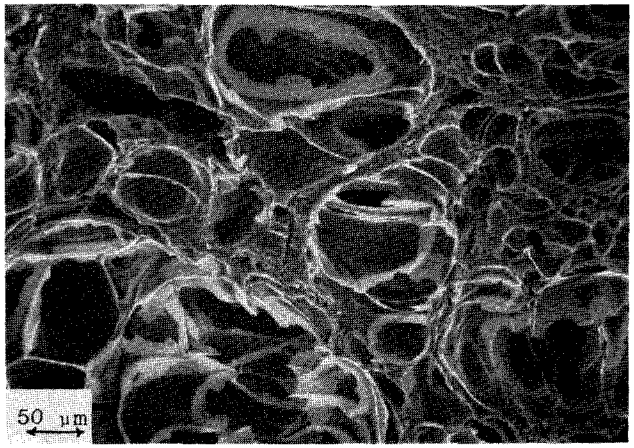

FIGURE 4. EXPANDED PERLITE GRANULE

A typical chemical analysis of diatomaceous silica, and unexpanded and expanded vermiculite and perlite are presented in Table I. Diatomaceous silica consists almost exclusively of silica 87%. Vermiculite consists of silica 39%; alumina 15%; magnesia 23%; and lesser quantities of ferric oxide 9%; and potash 8%. Perlite consists primarily of silica 73% and alumina 13%.

Compared with expanded vermiculite granules, the chemical analysis of the three vermiculite slabs shown in Table II demonstrate about 10% increase in silica; decrease in alumina and magnesia; and increase in either the CaO, Na_2O, or K_2O content depending upon the refractory binder used in manufacturing the vermiculite slabs.

Scanning electron micrographs of the surfaces of the three vermiculite slabs A, B and C are shown in Figures 5 - 7. The concertina shaped vermiculite granules with their open laminar cell structure are evident in the micrograph of each vermiculite slab despite the use of refractory binders

Two of the three diatomaceous silica insulation slabs, samples D and E, shown in Table III exhibit a 9% decrease in silica content and a general increase in CaO, MgO, and Al_2O_3 content compared to diatomaceous silica due to the additions of refractory binders. Sample F exhibits a 36% decrease in silica and a corresponding increase in CaO_2 and Al_2O_3 content. The lower silica content for Sample F results from the utilization of diatomaceous silica admixed with clays from natural deposits.

Diatom skeletons are evident in the micrographs of the three diatomaceous silica slabs D, E, and F shown in Figures 8 - 10.

The two insulation slabs manufactured from calcium silicate are composed of 41-50% SiO_2, 38-42% CaO, and 11-13% H_2O, as shown in Table IV.

Micrographs of the two calcium silicate slabs G and H shown in Figures 11 and 12 demonstrate a porous cell structure in the two slabs.

The chemical analysis of a perlite insulation slab shown in Table V exhibits a 44% decrease in silica and a corresponding increase in CaO content compared with expanded perlite granules due to the addition of calcium silicate bonding agent.

The open cell structure in perlite granules and binder of a perlite slab are shown in the micrograph in Figure 13.

Effect of Slab Insulations on Cryolite Recovery

The solubility of slab insulations in cryolite plant digestion liquor was determined to find out what effect, if any, these slabs had on the cryolite recovery plant process and the cryolite product. The normal practice is to crush and digest carbon lining and alumina insulation from reduction cell cathodes to recover the fluoride values to manufacture cryolite.

Insulation slab samples were digested in 0.57 N NaOH solutions. The 0.57 N concentration is equivalent to the average caustic value that appears in a cryolite recovery plant digestion tanks. The samples were digested for 200 minutes, the approximate retention time for the

TABLE I.

TYPICAL CHEMICAL ANALYSIS OF INSULATION MATERIALS

	DIATOMACEOUS SILICIA	VERMICULITE		PERLITE	
		UNEXPANDED	EXPANDED	UNEXPANDED	EXPANDED
SIO_2	86.9	39	38.6	67-75	72.7
AL_2O_3	2.3	15	14.9	10-20	13.2
FE_2O_3	1.3	9	9.3	-	0.7
MGO	-	21	22.7	-	0.3
K_2O	3.6	5-7	7.8	1	4.8
CAO	0.4	1	1.2	1	0.4
NA_2O	–	-	-	2-5	4.0
H_2O	4.9	5-9	5.3	2-5	2.5

TABLE II.

CHEMICAL ANALYSIS OF VERMICULITE INSULATION SLABS

	SAMPLE		
	A	B	C
Al_2O_3	9.2	10	11.8
SiO_2	54.4	51	45.8
Fe_2O_3	5.4	5	5.2
MgO	13.2	19	22.8
CaO	11.5	1	2.0
K_2O	3.7	11	2.5
Na_2O	0.9	1	9.0
H_2O	1.8	-	-

TABLE III.

CHEMICAL ANALYSIS OF DIATOMACEOUS SILICA INSULATION SLABS

	SAMPLE		
	D	E	F
Al_2O_3	3.0	4.3	11.0
SiO_2	79.0	74.8	56.0
Fe_2O_3	1.3	2.0	-
MgO	3.8	0.8	5.0
CaO	6.8	6.0	12.0
K_2O	-	-	-
Na_2O	-	2.7	1.0
H_2O	5.1	9.1	4.0

TABLE IV.

CHEMICAL ANALYSIS OF CALCIUM SILICATE INSULATION SLABS

	SAMPLE	
	G	H
Al_2O_3	1.2	1.2
SiO_2	41.0	49.6
Fe_2O_3	0.5	0.3
MgO	-	0.2
CaO	42.0	37.6
K_2O	-	-
Na_2O	-	-
H_2O	13.0	10.9

TABLE V.

CHEMICAL ANALYSIS OF PERLITE INSULATION SLAB

	SAMPLE
	I
Al_2O_3	8.9
SiO_2	40.6
Fe_2O_3	1.6
MgO	0.5
CaO	25.2
K_2O	2.4
Na_2O	4.0
H_2O	4.0

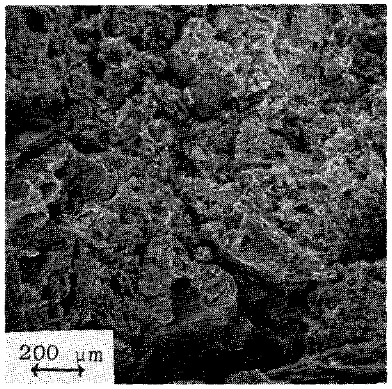

FIGURE 5. SAMPLE A

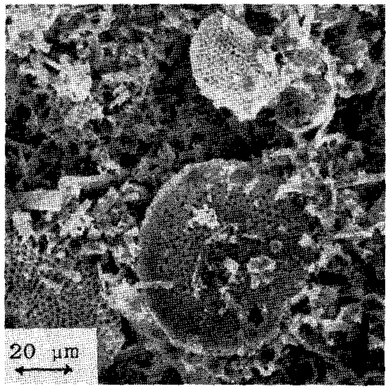

FIGURE 8. SAMPLE D

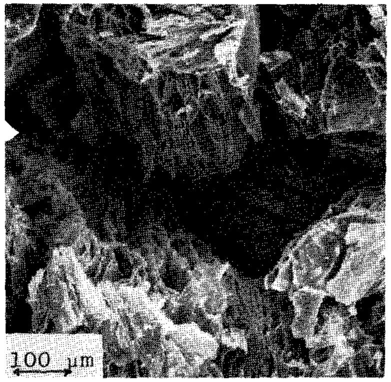

FIGURE 6. SAMPLE B

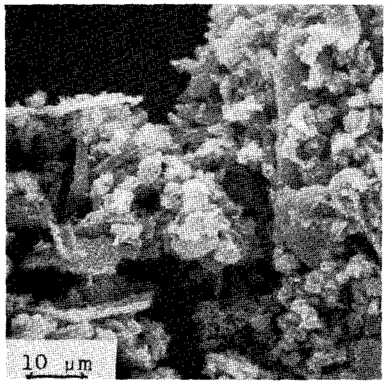

FIGURE 9. SAMPLE E

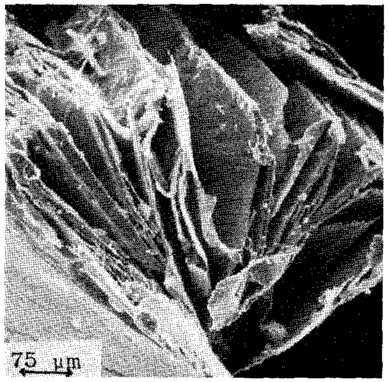

FIGURE 7. SAMPLE C

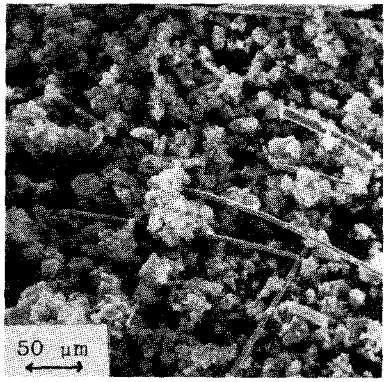

FIGURE 10. SAMPLE F

digestion process in the cryolite recovery plant. The results of the tests shown in Table VI indicate the percent solubility of each measured element of the total sample weight.

The only elements found to be soluble in cryolite digestion liquor in significant quantities were silicon and potassium. The silicon will go into solution and reprecipitate as sodium aluminum silicate, causing a loss of sodium and aluminum from the cryolite recovery process. However, the potassium could build up in the cryolite recovery plant digestion liquor and co-precipitate with the cryolite product.

It appears because of the potassium silicate binder, (11% K_2O) used in vermiculite slab B that much more potassium is soluble in cryolite recovery liquor than the other insulation slabs. Based on slab usage and cathode relining rates, if all the potentially soluble potassium were to precipitate with cryolite; the potassium level in the cryolite product could increase from a present level of 0.040% to 0.064%

By comparison, if all the soluble potassium from sample A could build up and co-precipitate with cryolite, it would cause an increase of 0.002%, an insignificant amount compared to present potassium levels.

An increase in potassium content in the cryolite would result in higher KF levels in the electrolyte of alumina reduction cells which has been shown to have a detrimental effect on cathode carbon linings.

Cryolite Resistance Tests

Test Procedure

To measure the resistance of insulation slabs to cryolite, two identical test pieces were used of appproximate size, 6 x 6 inches with 2 inches thickness. On one sample a 1.75 inch hole is drilled. Dust is removed from the hole and the slab sample is placed on top of the other corresponding slab sample. Fifteen grams of Greenland cryolite powder is poured into the hole. The samples are placed in a furnace and held at the test temperature for the selected time periods. The results of cryolite attack were determined by visual and photographic examination and measurements.

Whole sample blocks as well as the cryolite resistance test blocks, were used to measure shrinkage and weight loss at the test temperatures. A comparison of block dimensions before and after the test gave the results.

Test Results

In cup tests the three vermiculite slab samples A, B and C exhibited almost no reaction with cryolite in tests below 900°C. Reaction with cryolite at 930°C for 24-hour test periods produced 25mm deep cone-shaped, dark-brown reaction zones shown in Figure 14. Unreacted vermiculite granules and corundum were detected in the reaction zones, Figure 20. The cone shaped reaction zone and unreacted vermiculite indicate limited reaction with cryolite. A yellow discoloration extended 5-10mm deeper into the samples.

The two diatomaceous silica slab samples D and E demonstrated a poor resistance to cryolite. The two samples were found to react rapidly, (in less than 4 hours) to form a glass phase with substantial slab loss as shown in Figure 15. For example, after reaction with cryolite sample E

TABLE VI.

SOLUBILITY OF INSULATION SLABS IN CAUSTIC SOLUTION

SAMPLE	CHEMICAL ANALYSIS OF SOLUBLE MATERIAL, W/O									
	SI	K	CA	AL	FE	MG	TI	CR	MN	P
A	0.64	0.02	0.001	0.015	*	*	*	*	*	*
B	6.36	2.16	0.001	0.002	*	*	*	*	*	*
C	11.20	0.06	0.001	0.036	*	*	*	*	*	*
D	12.00	0.27	0.003	0.034	*	*	*	*	*	*
E	10.20	0.17	0.003	0.034	0.001	*	*	*	*	*
F	11.25	0.33	0.002	0.022	*	*	*	*	*	*
I	2.25	0.26	0.107	0.063	0.001	*	*	*	*	0.015

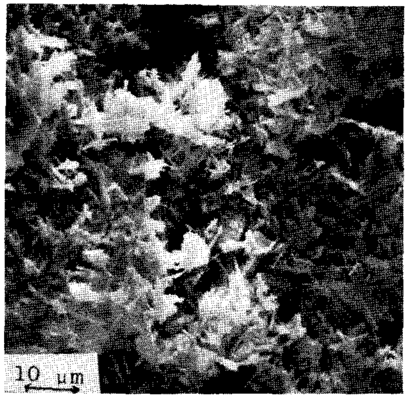

FIGURE 11. SAMPLE G

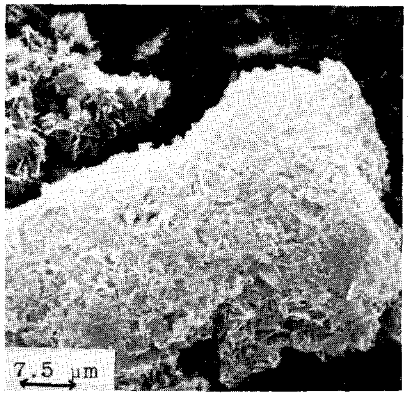

FIGURE 12. SAMPLE H

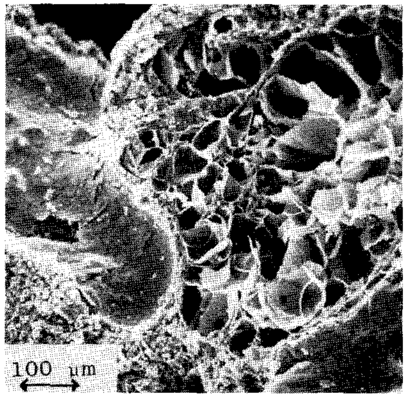

FIGURE 13. SAMPLE I

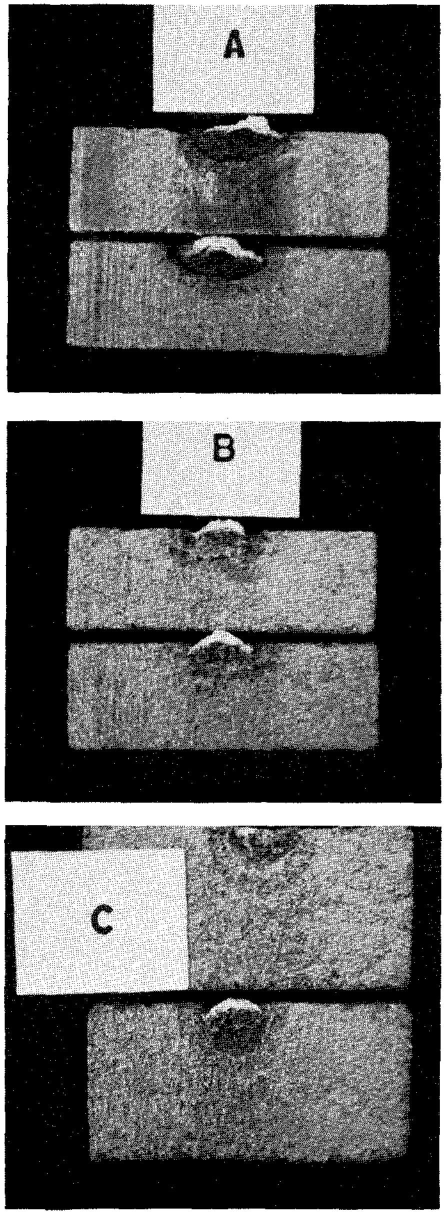

FIGURE 14. CRYOLITE RESISTANCE TEST-VERMICULITE SLABS

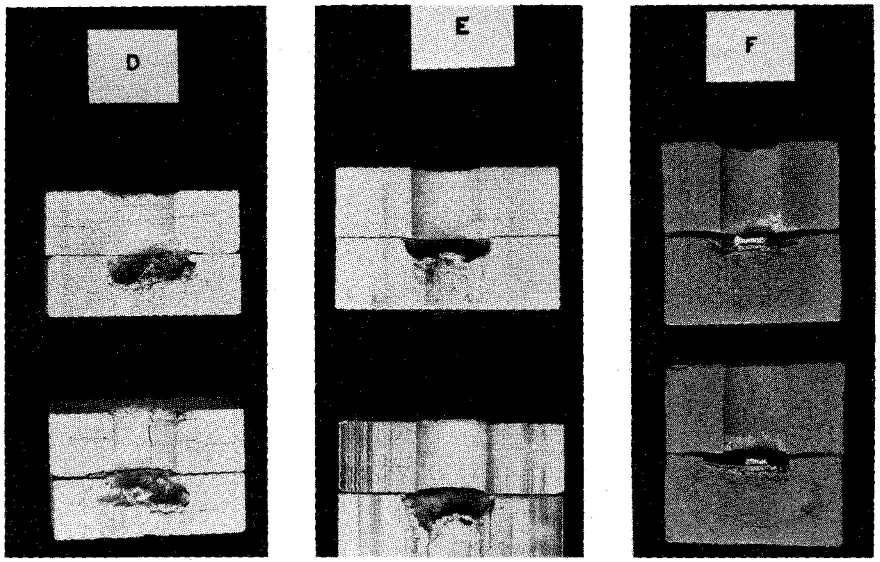

FIGURE 15. CRYOLITE RESISTANCE TEST-DIATOMACEOUS SILICA SLAB

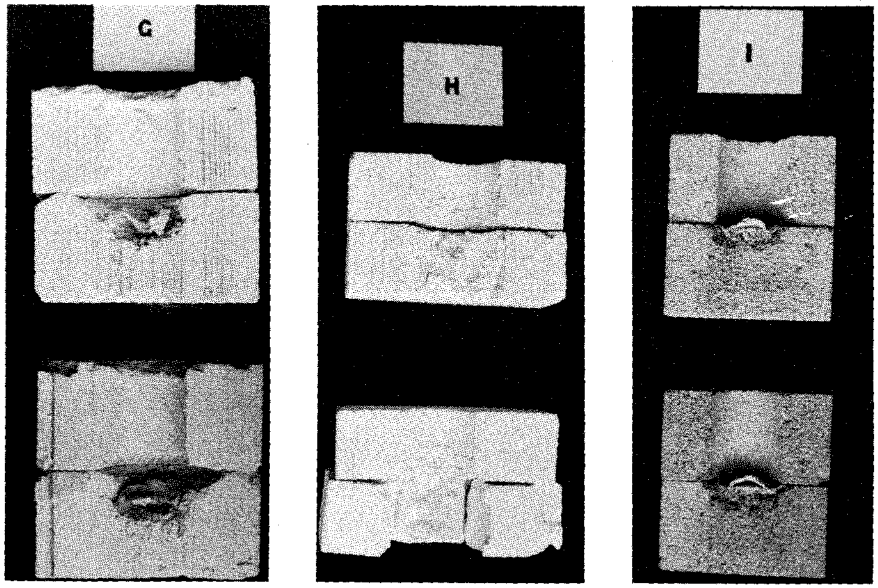

FIGURE 16. CRYOLITE RESISTANCE TEST-CALCIUM SILICATE AND PERLITE SLABS

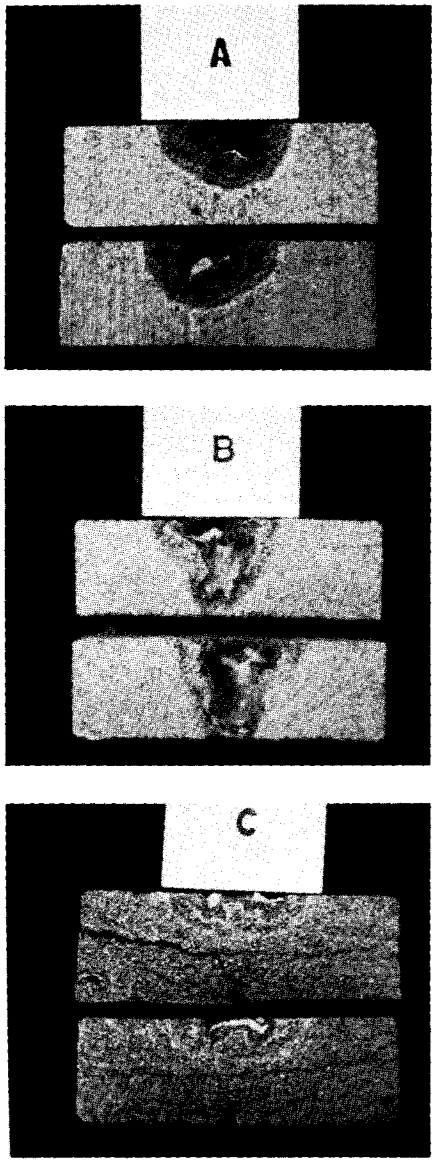

FIGURE 17. HIGH RATIO CRYOLITE RESISTANCE TEST-VERMICULITE SLABS

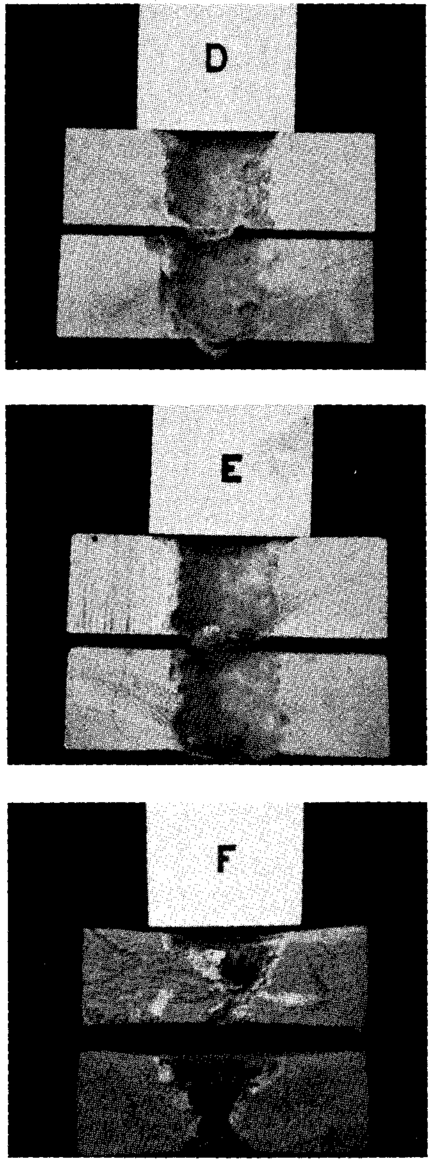

FIGURE 18. HIGH RATIO CRYOLITE RESISTANCE TEST-DIATOMACEOUS SILICA SLABS

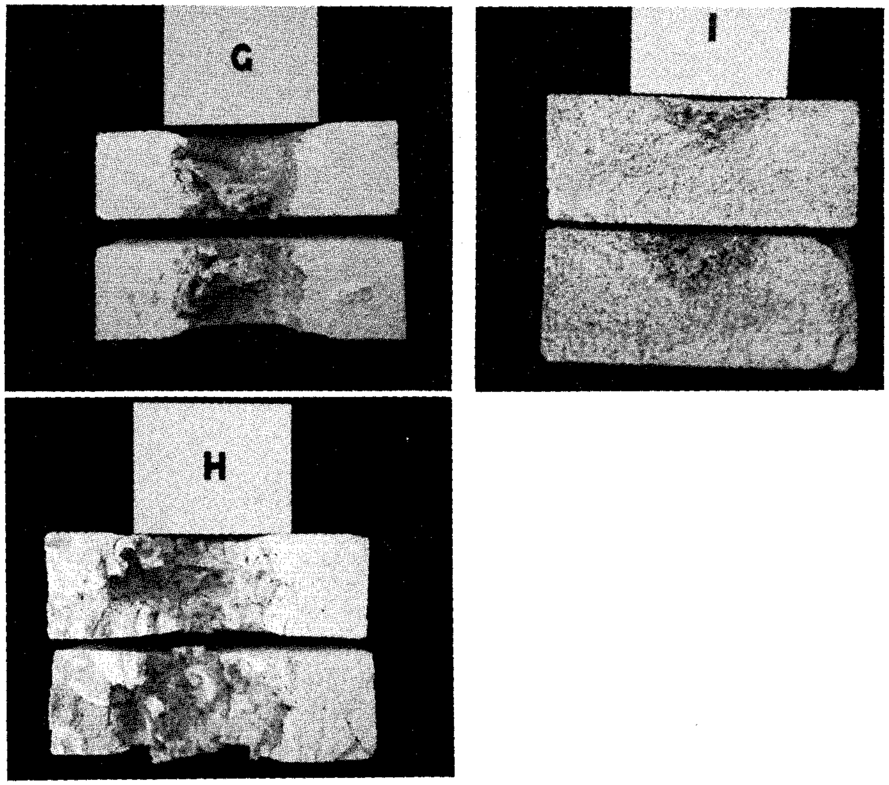

FIGURE 19. HIGH RATIO CRYOLITE RESISTANCE TEST-CALCIUM SILICATE AND PERLITE SLABS

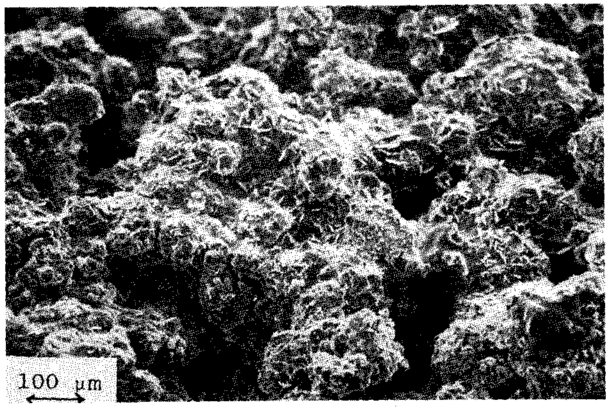

FIGURE 20. VERMICULITE-CRYOLITE REACTED SURFACES

had a 50 mm hole completely through the bottom.

Diatomaceous silica slab sample F, however, sustained less chemical attack. Cryolite penetrated only 10- 15 mm deep with a small loss of slab in the formation of a glass phase. A light brown coloration existed about 2 mm deeper in the sample.

A certain amount of deformation and cracking was observed in sample F and can be explained by the fact that the test temperature was 180°C above the recommended 750°C service temperature.

Calcium silicate slab samples G and H, shown in Figure 16, demonstrated identical zone reactions with cryolite as did samples D and E. They both had extensive slab loss and the formation of a smaller-volume silicate glass phase. Cryolite penetrated completed through the bottom of sample H leaving a 50 mm wide hole.

Perlite slab sample I exhibited similiar reaction zone properties as those found in the vermiculite slabs; a 10 mm deep cone shape reaction zone with unreacted perlite aggregrate or granules shown in Figure 16. A purple discoloration extended 10 mm deeper into the sample.

Perlite has been reported to have been used for reduction cell insulation due to the heat insulation and resistance to fluorides.(2)

Figure 21 shows micrographs of the vermiculite-cryolite reaction zone. The presence of the vermiculite structure in the reaction zone is evident even though the surfaces are covered with cryolitic salts. The glass phase formed in the reaction of diatomaceous silica and cryolite is shown in Figure 22.

Results of slab shrinkage and weight loss, obtained from measurements of slab dimension and weight before and after heating tests, are presented in Table VII-IX. Most slabs experienced about 2-3% linear shrinkage, and between 4-7% volume shrinkage at temperatures between 800-900°C.

Sample F experienced a 8-17% linear shrinkage and 14-36% volume shrinkage at the test temperature. The test temperatures were 50 to 150°C above the 750°C maximum recommended temperature.

Temperatures at the interface between the high temprature insulation and the low thermal conductivity backup insulation change with cell life. Temperatures in the range of 700-800°C have been measured for some cells at the interface.

Vermiculite sample B exhibited more cryolite penetration, and reaction, with high ratio cryolite than the other two vermiculite samples as shown in Figure 17. Sample C showed evidence of cracking due to being heated above the 900°C recommended service temperature.

Diatomaceous silica and calcium silicate slab samples D, E, G, and H exhibited complete destruction of slab material in the cryolite reaction zone when heated with 'high' ratio cryolite (1.60) at 930°C for 24-hour test periods. A hole 60 mm wide completely through all samples resulted from the reaction with high-ratio cryolite and formation of a smaller volume, lower melting point glass silicate phase as shown in Figures 18-19.

TABLE VIII

SHRINKAGE TEST - DIATOMACEOUS SILICA SLABS

SAMPLE	TEST CONDITIONS	SHRINKAGE, % LINEAR	SHRINKAGE, % VOLUME	WEIGHT LOSS, %
D	800°C-24 HRS.	1.45	3.45	7.03
D	900°C-4 HRS.	3.13	5.57	-
D	900°C-24 HRS.	1.51	3.63	7.05
D	930°C-24 HRS.	3.72	5.18	-
E	800°C-24 HRS.	2.70	7.18	8.65
E	900°C-24 HRS.	3.64	8.66	-
E	900°C-24 HRS.	3.12	7.81	8.70
E	930°C-24 HRS.	3.16	8.02	-
E	950°C-6 HRS.	1.61	9.39	-
F	800°C-6 HRS.	16.6	32.1	-
F	800°C-24 HRS.	16.7	26.2	-
F	800°C-24 HRS.	8.14	17.48	9.22
F	900°C-4 HRS.	-	35.6	-
F	900°C-24 HRS.	9.94	20.13	9.75
F	900°C-24 HRS.	8.41	14.34	9.91
F	930°C-24 HRS.	11.12	18.23	-

MAXIMUM RECOMMENDED SERVICE TEMPERATURES:

D = 1,093°C
E = 1,193°C
F = 750°C

TABLE VII

SHRINKAGE TEST - VERMICULITE SLABS

SAMPLE	TEST CONDITIONS	SHRINKAGE, % LINEAR	SHRINKAGE, % VOLUME	WEIGHT LOSS, %
A	800°C-24 HRS.	1.64	3.51	12.15
A	900°C-5 HRS.	2.81	4.33	-
A	900°C-24 HRS.	3.31	5.79	13.04
A	900°C-24 HRS.	2.35	4.13	-
A	930°C-24 HRS.	2.35	4.13	-
B	800°C-24 HRS.	0.67	0.77	5.72
B	900°C-5 HRS.	2.81	4.33	-
B	900°C-24 HRS.	2.16	2.93	6.59
B	930°C-24 HRS.	0.43	0.54	-
C	800°C-24 HRS.	0.22	0.13	12.69
C	900°C-8 HRS.	0.84	2.74	14.49
C	900°C-8 HRS.	2.77	6.48	10.96
C	900°C-24 HRS.	2.95	5.61	14.68
C	930°C-24 HRS.	1.70	2.81	-

MAXIMUM RECOMMENDED SERVICE TEMPERATURE:

A = 1,037°C
B = 1,100°C
C = 900°C

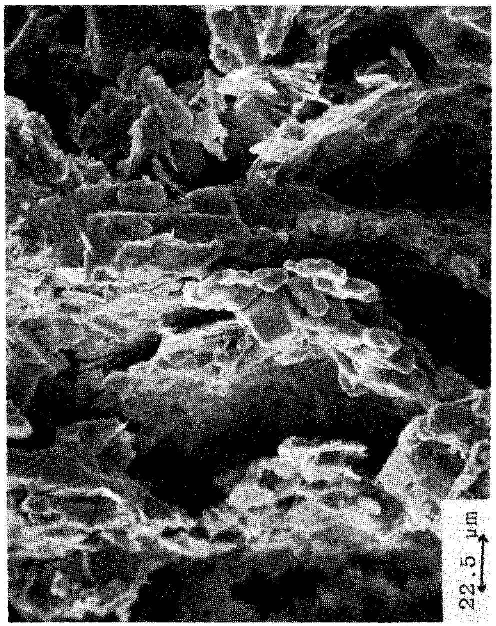

FIGURE 21. VERMICULITE-CRYOLITE REACTED SURFACES

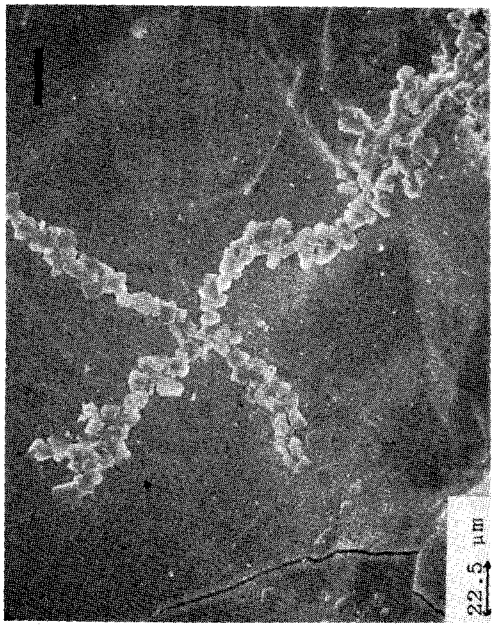

FIGURE 22. DIATOMACEOUS SILICA-CRYOLITE GLASS PHASE

TABLE IX

SHRINKAGE TEST - CALCIUM SILICATE AND PERLITE SLABS

SAMPLE	TEST CONDITIONS	SHRINKAGE, % LINEAR	SHRINKAGE, % VOLUME	WEIGHT LOSS, %
G	800°C-6 HRS.	3.2	6.3	-
G	800°C-24 HRS.	2.04	2.79	14.81
G	900°C-24 HRS.	3.72	5.18	-
G	900°C-24 HRS.	3.66	5.31	15.35
G	930°C-24 HRS.	3.72	5.18	-
H	800°C-24 HRS.	3.22	5.59	11.52
H	900°C-24 HRS.	3.71	6.45	13.51
H	930°C-24 HRS.	3.5	7.81	-
I	800°C-6 HRS.	-	4.6	-
I	800°C-24 HRS.	4.05	6.20	15.89
I	900°C-24 HRS.	2.98	5.30	18.35
I	930°C-24 HRS.	4.88	7.57	-
I	940°C-5 HRS.	3.0	5.0	-

MAXIMUM RECOMMENDED SERVICE TEMPERATURES:

G = 1,000°C
H = 871°C
I = NOT AVAILABLE

From *Light Metals 1982*, J.E. Andersen, Editor

The increased reaction between cryolite containing excess NaF suggest that compared to the tests with Greenland cryolite that the excess sodium accelerate the reaction with the silicate containing insulation. This finding is reinforced by previous investigations conducted with bricks and cryolite(3).

Conclusion

The low-thermal conductivity properties of a series of insulation slabs developed for application between the high thermal insulation and the furnace shell of alumina reduction cell cathodes are attributed to the unique cell-like structures of the silicate granules or particles employed.

The choice of insulation slab depends upon the maximum service temperature of the cathode cell design, i.e., shrinkage, cryolite resistance, and the method of cryolite recovery.

In cup tests vermiculite slab samples were found to exhibit excellent resistance to cryolite attack. Almost no penetration could be detected by cryolite in vermiculite samples at test temperatures under 900°C. The formation of cone shaped reaction zones with unreacted vermiculite granules indicated limited reaction with cryolite at 930°C for 24 hour test periods.

With one exception, diatomaceous silica and calcium silicate slabs demonstrated poor resistance to cryolite attack. They were found to react rapidly with cryolite at temperatures below 900°C to form a smaller volume glassy phase with extensive slab loss. One diatomaceous slab sample which contained proportions of naturally admixed clays exhibited good resistance to cryolite attack with limited penetration and loss of slab. However, because of its lower maximum service temperature the sample showed substantial shrinkage and some deformation and cracking at the higher test temperatures.

The perlite slab sample also exhibited an excellent resistance to cryolite attack similar to that of the vermiculite slab samples.

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