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J-M History
FILE COPY

3000F

2400F

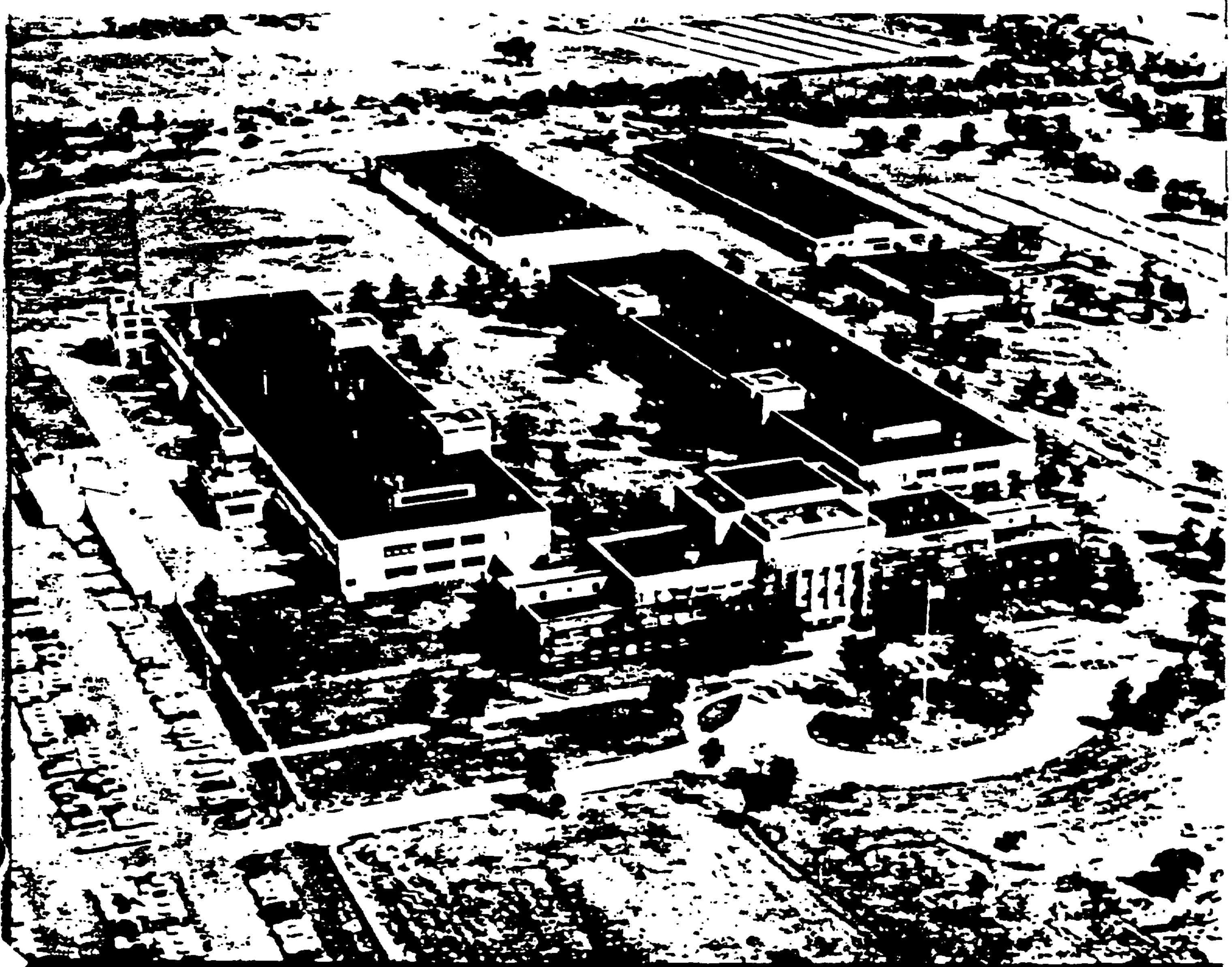
2000F

JOHNS-MANVILLE

and refractory products

Johns-Manville's Modern Research Center and Manufacturing Plants Combine to Produce Insulating Fire Brick and Refractories of Highest Quality and Top Value

JOHNS-MANVILLE
JM
PRODUCTS



oduce

JOHNS-MANVILLE

RODUCTS

IN THE REFRACTORIES LABORATORY

Optical pyrometer and other temperature-measuring instruments are used by ceramic engineers in test furnaces capable of maintaining up to 3000F. In illustration below, an insulating fire brick designed to withstand very high heat is being tested under simulated service conditions.

JOHNS-MANVILLE RESEARCH CENTER

The Johns-Manville Research Center (left), near Manville, New Jersey, is one of the country's largest and most fully equipped groups of buildings of its kind, with a large staff of scientists, engineers and technicians.

A special refractories laboratory with the most advanced testing equipment is located at the J-M Research Center. There, ceramic engineers regularly test the performance of all J-M refractories under conditions closely simulating those of high temperature service in the field. Chemical as well as physical tests are made, and individual raw materials are subjected to scientific analysis. Evaluations are also made to determine the optimum balance of refractory properties.

There, too, comparisons of different formulations and blends are continually checked for development of new refractories. Tests are also made to determine new uses for established J-M refractories in order to meet present production requirements. Special testing furnaces are available for this research, as well as the most advanced apparatus for temperature measurements, microscopic studies and X-ray.

The ceramic engineers also carry out research assignments related to specific customer problems. This broad research program plays a major part in Johns-Manville's ability to offer exactly the right insulating fire brick and refractory—the most economical and efficient castable, gunning mix, lightweight aggregate, mortar or patching material—for a given service.

TWO MODERN PLANTS TO SERVE YOU

Johns-Manville's modern refractories plant at Zelienople, Pa. (above), is one of the two plants that manufacture J-M insulating fire brick. This plant, and the one at Lompoc, California, are geographically situated to supply industry with the most complete line of insulating fire brick to meet the diversified requirements of modern furnace construction.

At Zelienople's control laboratory, trained ceramists continually conduct physical and chemical tests to insure product uniformity and high quality. This control is of paramount importance in these days of higher operating temperatures and mounting operating expenses. It is important whether you use insulating fire brick, castable, gunning mix, bonding mortar, patching material or lightweight fill.

At Lompoc, California (below), in an area once submerged beneath the sea, Johns-Manville owns and works the largest and most uniform deposit of diatomite—the fossilized remains of microscopic marine plants (diatoms) which died millions of years ago. From it, the Lompoc plant manufactures three types of Sil-O-Cel insulating brick used for back-up insulation behind refractory fire brick linings or behind insulating fire brick linings.

TABLE OF CONTENTS

Insulating Fire Brick and Sil-O-Cel Insulating Brick

JOHNS-MANVILLE INSULATING FIRE BRICK PROVIDE UNSURPASSED HEAT-CONTROL EFFECTIVENESS TO 3000F

Johns-Manville provides industry with the most complete line of insulating fire brick and lightweight refractory aggregates, fills, and castables for temperatures through 3000F.

J-M INSULATING FIRE BRICK—Produced from high quality refractory clays. All six types contain a carefully graded organic filler which is burned out during manufacture, resulting in a uniform, controlled pore structure. Each insulating fire brick or shape is accurately ground to size.

With six types of top-quality fire brick, Johns-Manville offers operators and builders of high temperature equipment the opportunity to use the one insulating fire brick that is *right* for a given service.

Each J-M insulating fire brick has the correct balance of thermal, chemical and physical properties for its recommended use. In addition, J-M insulating fire brick has high purity (low reducible oxides), making them adaptable for use in prepared atmosphere furnaces and special ceramic kilns that use salt glazing processes. All six types have light weight, low conductivity and high structural strength for the efficient and economical control of heat.

J-M insulating fire brick are used as refractory lining or as back-up insulation behind other refractory protection. Their light weight and high insulating value make possible thinner furnace walls, improved efficiency and lower operating costs. Furnaces can be brought up to operating temperatures with unusual speed, thus resulting in increased production.

COMPLETE LINE OF INSULATING FIRE BRICK

The six types of J-M insulating fire brick with their respective temperature limits are described below. The weights are approximate.

JM-3000 (to 3000F)—A high temperature insulating brick made for back-up or exposed use. This brick is especially adaptable for use in forge furnaces, ceramic

kilns, chemical process furnaces and other types of high-temperature equipment operating above JM-28's temperature range. JM-3000 has exceptional service advantages in many operations at lower temperatures where regular or special fire brick is ordinarily used (3.8 lb. per brick).

JM-28 (to 2800F)—With its comparatively light weight of 3.4 lb. per brick and high spalling resistance, this brick can be used as insulating fire brick or back-up insulation in enameling furnaces, forge furnaces, soaking-pit covers, ceramic kilns and other locations where it will not be subjected to temperatures above 2800F.

JM-26 (to 2600F)—Combines high spalling resistance and light weight (2.8 lb. per brick). It is suitable for use as an insulating fire brick or back-up insulation in calciners, ceramic kilns, heat-treating furnaces and similar equipment where the temperature on the JM-26 brick does not exceed 2600F.

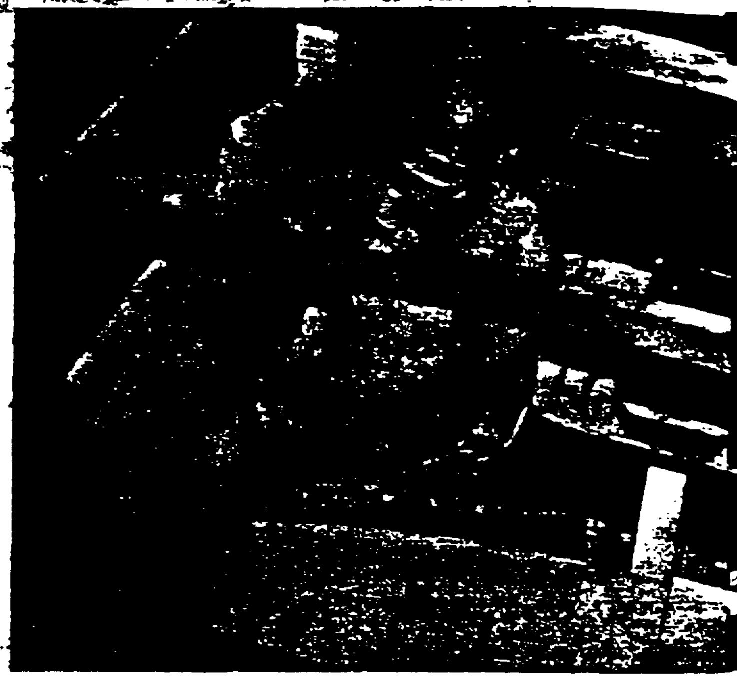
JM-23 (to 2300F)—A lightweight high purity brick (1.7 lb. per brick) with low iron content which provides high resistance to the deleterious effects of prepared atmospheres. It is designed for direct exposure or back-up insulating in such equipment as oil heaters, ceramic kiln domes, drawing furnaces, electric furnaces and hardening furnaces.

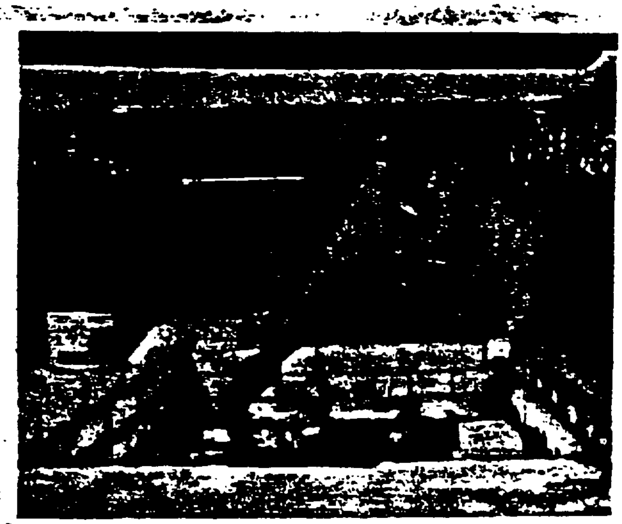
JM-20 (to 2000F)—This is a high purity brick (1.6 lb. per brick) with the perfect balance of chemical and physical properties for effective heat control in prepared atmospheres. It is made from carefully selected materials with an extremely low iron oxide content. The brick has high cold-crushing and hot-load bearing strength. It is used in annealing ovens and various other types of equipment such as carbonizing furnaces, lehrs, normalizing furnaces, oil stills and heaters, and for stack linings.

JM-1620 (to 1600F exposed, to 2000F back-up)—This insulating fire brick (1.5 lb. per brick) is recommended for use as a direct refractory lining for temperatures not over 1600F, and for service behind fire brick or other insulating fire brick where the temperature on the JM-1620 brick will not exceed 2000F. It is used in such equipment as core ovens, hot blast mains, producer gas mains, regenerators, recuperators, stress-relieving furnaces and similar equipment.

INSULATING FIRE BRICK

Specification Data





Standard Sizes

TYPE	SIZE
JM-3000	Accurately sized in all standard 9-in. shapes of the 2½ and 3 in. series, as well as special shapes.
JM-28	
JM-26	
JM-23	
JM-20	
JM-1620	

Physical Properties*

	JM-3000	JM-28	JM-26	JM-23	JM-20	JM-1620
Temperature Limit	3000F**	2800F**	2600F**	2300F**	2000F**	2000F*** 1600F**
Approximate Density, pcf	65	58	51	31	29	27
Transverse Strength, psi	200	175	140	140	105	95
Cold Crushing Strength, psi	400	300	210	210	155	145
Linear Shrinkage, percent	†0.8 at 3000F	1.4 at 2750F	1.0 at 2600F	0.1 at 2300F	0.0 at 2000F	0.0 at 2000F
Reversible Thermal Expansion, percent	0.65-0.75 at 2000F	0.65-0.75 at 2000F	0.65-0.75 at 2000F	0.5-0.6 at 2000F	0.5-0.6 at 2000F	0.5-0.6 at 2000F

*The figures given in this table are average values obtained in accordance with accepted test methods.
**Back-up or exposed ***Back-up only.
†24-hr Simulative Service Panel Test; all others 24-hr soaking period.

Typical Chemical Analysis

Material Composition	JM-1620	JM-20 and JM-23	JM-26	JM-28	JM-3000
SiO_2	43.0	44.2	57.4	39.0	29.4
TiO_2	1.3	1.29	1.7	1.25	1.0
Fe_2O_3	0.5	0.46	.8	.5	.71
Al_2O_3	36.9	38.0	39.7	59.0	65.6
CaO	17.6	15.2	0.2	–	0.3
MgO	.06	.06	.1	–	0.5
Na_2O	.03	.02	.1	.19	0.1
K_2O	.21	.27	.1	.06	0.1
P_2O_5	.13	0.16	–	–	–
Al Metal	–	–	–	–	3.6

Thermal Conductivity: BTU IN. PER SQ FT PER F PER HR

MEAN TEMPERATURE, F

	500	1000	1500	2000
JM-3000	3.22	3.30	3.37	3.46
JM-28	2.55	2.80	3.06	3.32
JM-26	2.22	2.44	2.68	2.93
JM-23	1.01	1.18	1.34	1.50
JM-20	0.95	1.11	1.28	–
JM-1620	0.88	1.05	1.23	–

Compliance with Government Specs

JM-20 complies with MIL-B-16305A, Class A
JM-28 complies with MIL-B-16305A, Class B

Streamlined methods cut production time and speed delivery of J-M Insulating Fire Brick in standard and many sizes of special shapes

In Johns-Manville's modern refractory plant at Zelienople, Pa., high quality insulating fire brick is made *better* and *faster* by an improved method different from the conventional process. With the J-M method, standard brick and a wide range of special shapes are cut out of fired slabs.

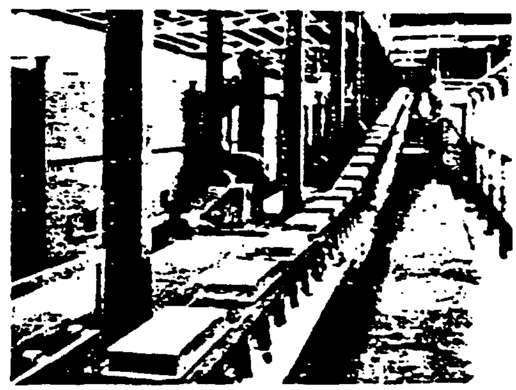
The slabs are molded, fired rapidly through tunnel kilns, then cut into the desired shape. Handling of the slabs throughout the process is easier, a more stable load is possible on the kiln cars, with uniform temperatures and better spacing to permit burn-out.

Many shapes which normally have to be molded and processed as special items can now be produced directly from slabs. They are also superior to shapes made by joining individual brick.

This streamlined operation provides the flexibility and basis for giving quick shipment of high quality standard and special insulating fire brick shapes to J-M customers.

SLINGER METHOD (JM-26, JM-28 and JM-3000)

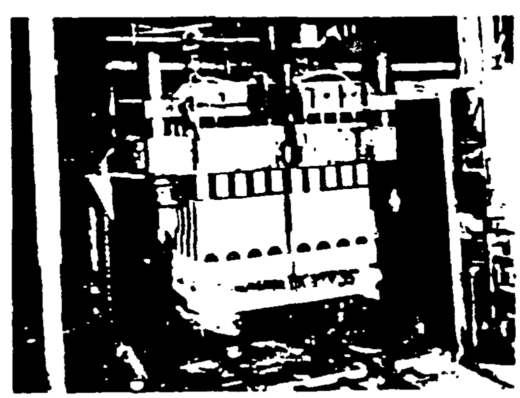
(1) Slinger machine throws selected mix from pug mill and forms continuous stiff column on pallets moving along molding conveyor.



(2) Sharp blades first trim top and sides of column, then cut it into slabs so that each slab is on a pallet.

CASTING METHOD (JM-1620, JM-20 and JM-23)

(1) Blends of high purity refractory materials, setting agent and burn-out are thoroughly mixed with water in paddle-type mixer, then poured into a mold.



(2) When mix hardens, the mold is moved to the stripping machine where slabs are removed from mold and put on kiln car.

■ The two types of fired slabs receive the same finishing procedure after they are removed from the tunnel kiln. They are ground and cut into standard and special brick shapes by a sizing machine which slits the slabs to the proper width and length. The brick are then packed into cartons and stored until they are shipped by rail or truck.

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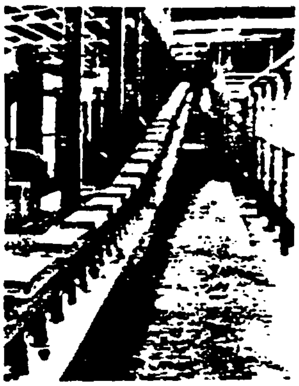

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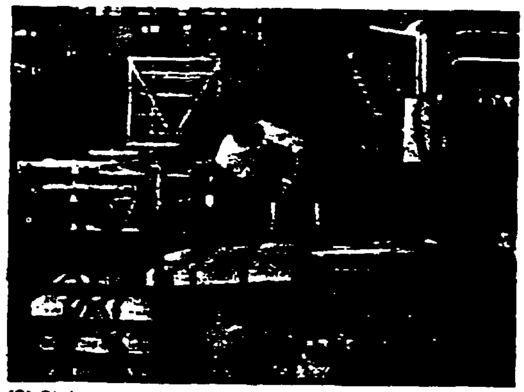
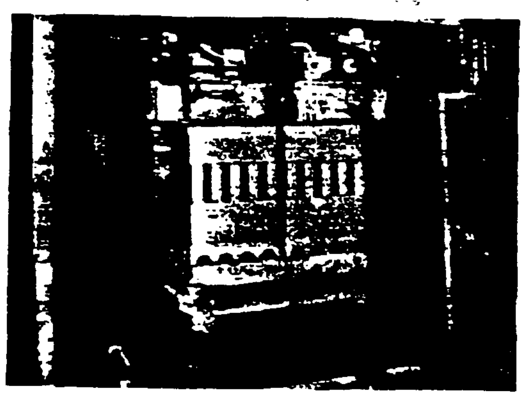


(3) Slabs are automatically transferred from the main conveyor onto dryer cars which are then stored until slabs are dry.



(3) The same procedure is repeated two more times until the kiln car is loaded with three courses of slabs.

Insula

Typical uses for J-M

IN THE FERROUS METALS INDUSTRY

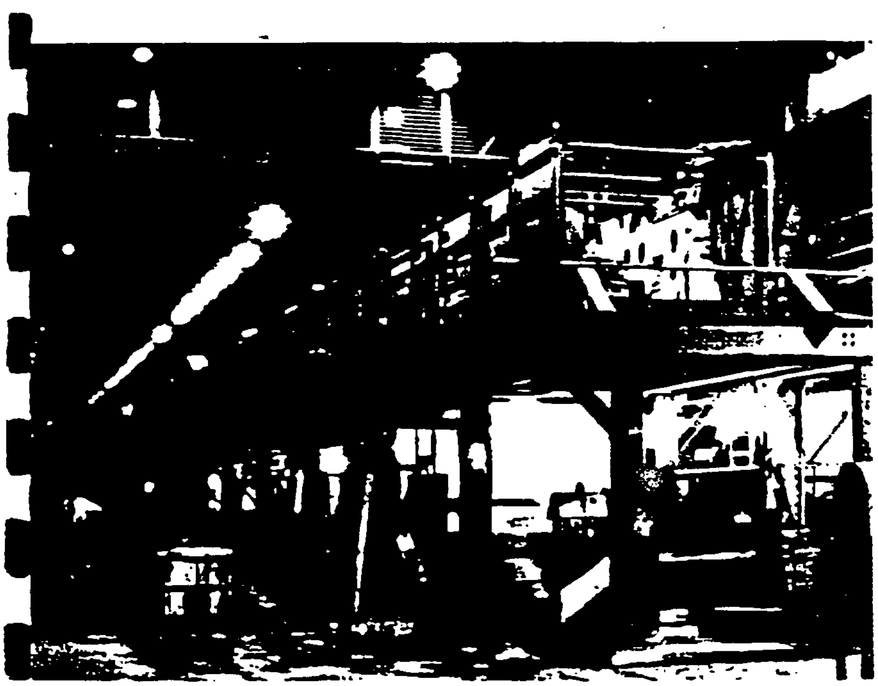
Annealing furnaces
Barrel furnaces
Billet-heating furnaces
Blast furnace stoves
Butt weld furnaces
Calorizing furnaces
Carburizing furnaces
Car tops
Case-hardening furnaces
Controlled-atmosphere furnaces
Crucible furnaces
Electric furnaces
Flues (high temperature)
Forge furnaces
Hardening furnaces
Laboratory furnaces
Malleableizing furnaces

IN THE NON-FERROUS METALS INDUSTRY

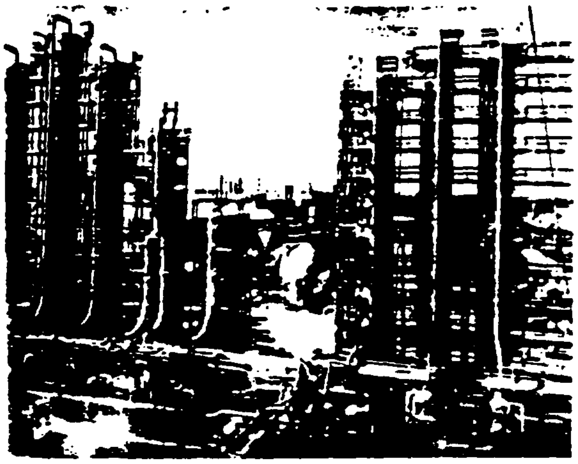
Die-casting machines
Electrolytic cells (magnesium)
Galvanizing and tinning furnaces
Heat-treating furnaces
Annealing furnaces
Reduction pots (aluminum)
Crucible furnaces (lead)
Brazing furnaces

Insulating Fire Brick

- Normalizing furnaces
- Open-hearth furnaces
- Plate-heating furnaces
- Pusher furnaces
- Radiant tube annealing covers
- Recuperators
- Rolldown furnaces
- Rotary hearth furnaces
- Sintering furnaces
- Slab-heating furnaces
- Soaking pits
- Soaking pit covers
- Spheroidizing furnaces
- Stress-relieving furnaces
- Tempering furnaces
- Walking beam furnaces



IN THE PETROLEUM AND CHEMICAL INDUSTRIES



PETROLEUM INDUSTRY

Hot air and gas mains
Breechings
Catalytic reformers
Ducts
Flues
Oil heaters or furnaces (walls, arch, floor)
Reactor chambers
Regenerators
Stacks
Stills
Vessel linings

CHEMICAL INDUSTRY

Ammonia reformers
Calcining furnaces
Carbon baking oven covers
Driers
High-temperature pressure vessels
Hot gas mains
Rotary calciners and dryers
Special process furnaces
Stacks and breechings
Sulphur furnaces

IN THE CERAMIC AND GLASS INDUSTRIES

CERAMIC INDUSTRY

Chamber kilns
Tunnel kilns
Shuttle kilns
Rotary kilns
Car seal backs
Periodic kilns
Movable hood kilns
Procelain enamel furnaces
Flues and stacks
Controlled atmosphere kilns
Calcining furnaces

GLASS INDUSTRY

Bending furnaces
Flattening ovens
Gas mains
Glass tanks, regenerators, flues and uptakes
Lehrs
Ports

l uses for J-M

Insulating Fire Brick

IN POWER PLANTS AND MARINE

Boiler walls, floors, tops
Breechings
Ducts
Flues
Stacks
Fireboxes

ıkes

MISCELLANEOUS APPLICATIONS

Core-drying ovens
Japanning ovens
Enameling furnaces
Bake ovens
Burners
Coke ovens
Cross-over flues
Domestic oil burners
Furnaces
Gas producers and mains
Heaters
Incinerators
Kilns
Ovens
Retort benches
Stacks
Stoves
Gas generators
Duct linings

Providing Good Insulating Value and High S:

Sil-O-Cel insulating brick is made in Johns-Manville's Lompoc, California plant, using selective blends of diatomaceous silica. This material contains millions of microscopic cells that offer maximum resistance to the flow of heat. Consequently, these high load-bearing brick are ideal for use behind fire brick at temperatures through 2500F.

Three types of Sil-O-Cel insulating brick are available to meet the varying temperature requirements encountered in back-up insulation service: Si-O-Cel Super, Sil-O-Cel C-22 and Sil-O-Cel 16L. All are used in boilers, stills, heat-treating furnaces, kilns, lehrs, flues, retorts, stacks and other types of high-temperature equipment. (Sil-O-Cel 16L insulating brick may also be used for exposed as well as back-up service.)

Used as back-up insulation, Sil-O-Cel insulating brick make it possible to reduce the necessary thickness of the exposed refractory as much as one-third. This results in a considerable saving in furnace wall construction for all types of high-temperature equipment.

Sil-O-Cel insulating brick are pressed, then dried and fired in tunnel kilns. They are pressed to size, not sized after firing, as is the case with J-M insulating fire brick.

THREE TYPES OF BRICK

The three types of Sil-O-Cel insulating brick are:

Sil-O-Cel 16L—Made from diatomaceous silica, molded and calcined. They serve for temperatures to 1600F, back-up or exposed. This type of Sil-O-Cel brick is one of the most efficient insulating brick obtainable and is used in preference to other types of Sil-O-Cel brick except where severe temperatures are encountered.

These brick have a cold crushing strength of approximately 350 psi, so they are amply strong for structural purposes. Owing to the extremely low reversible thermal expansion, less than 0.1 at 1600F, Sil-O-Cel 16L brick are particularly advantageous in building long-lasting refractory masonry. Because of this valuable property, 16L brick can also be bonded for direct exposure.

Sil-O-Cel 16L brick are finished so that accurate, smooth surfaces are assured. This enables the brick to be laid up with thin joints and permits bonding with the fire brick where required.

Sil-O-Cel C-22 — A
brick, pressed and
sulation behind fir
brick where the te
not exceed 2000F.

In preventing
are three to four
retarding heat flow
characteristics, they
gree, all those qualit
purpose insulating b

These brick have
700 psi, which is equ
They are therefore e
tions where high load

Sil-O-Cel Super — A
designed for except
ice where subjected
refractory.

These brick have
proximately 300 ps
tons per sq. ft.

In many cases, it
thickness of first-qu
Super brick are used
where Sil-O-Cel 16L
fire brick, Sil-O-Cel S
back of 9", or in some
tory, thus making a

Value and High Strength . . .

Johns-Manville
Sil-O-Cel
Insulating Brick

Sil-O-Cel C-22 — An efficient, diatomaceous silica brick, pressed and calcined for use as a back-up insulation behind fire brick or behind insulating fire brick where the temperature on the insulation will not exceed 2000F.

In preventing transmitted heat loss, C-22 brick are three to four times as effective as fire brick in retarding heat flow through furnace walls. In other characteristics, they combine, to a remarkable degree, all those qualities desirable in an ideal, general-purpose insulating brick.

These brick have a cold crushing strength of about 700 psi, which is equivalent to over 50 tons per sq. ft. They are therefore especially recommended for locations where high load-bearing properties are essential.

Sil-O-Cel Super — A calcined type of Sil-O-Cel brick designed for exceptionally severe insulating service where subjected to temperatures behind the refractory.

These brick have a cold crushing strength of approximately 300 psi, which is equivalent to over 21 tons per sq. ft.

In many cases, it is possible to cut down on the thickness of first-quality fire brick when Sil-O-Cel Super brick are used. For instance, in equipment where Sil-O-Cel 16L would be used behind 13½" of fire brick, Sil-O-Cel Super brick could safely be used back of 9", or in some cases as low as 4½" of refractory, thus making a considerable saving.

Physical Properties*

	Super	C-22	16L
Temperature Limit	2500F**	2000F**	1600F***
Approximate Density	40 pcf	38 pcf	34 pcf
Transverse Strength	90 psi	115 psi	60 psi
Cold Crushing Strength	300 psi	700 psi	350 psi
Linear Shrinkage	2.0% at 2500F	0.8% at 2000F	0.7% at 1600F
Reversible Thermal Expansion	1.3% at 2000F	0.7% at 2000F	less than 0.1% at 1600F

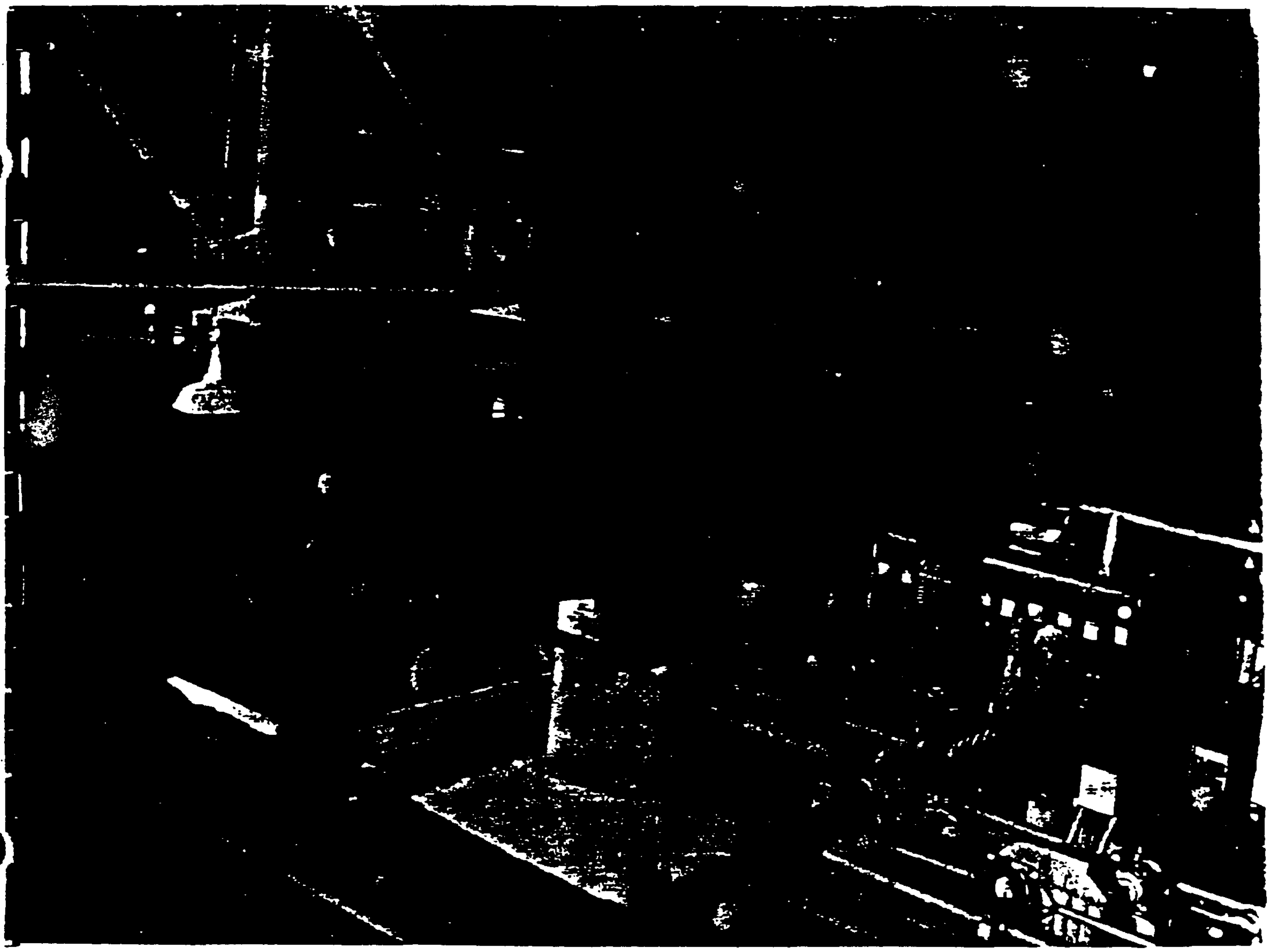
*The figures given in this table are average values obtained in accordance with accepted test methods.
**Back-up only. ***Back-up or exposed.

Thermal Conductivity: BTU IN. PER SQ FT PER F PER HR

	MEAN TEMPERATURE, F			
	500	1000	1500	2000
Super	1.70	1.95	2.19	2.45
C-22	1.67	1.88	2.08	–
16L	0.92	1.07	1.22	–

Typical Chemical Analysis

Material Composition	SIL-O-CEL 16L and C-22	SIL-O-CEL Super
SiO_2	90.2	90.0
TiO_2	0.2	–
Fe_2O_3	1.6	1.05
Al_2O_3	4.9	4.3
CaO	0.8	3.4
MgO	0.6	.75
Na_2O	0.6	–
K_2O	0.7	–
P_2O_5	0.4	–



Compliance with Government Specs

Sil-O-Cel Super complies with MIL-B-16182B

Standard Sizes

TYPE	SIZE
Sil-O-Cel Super Sil-O-Cel C-22 Sil-O-Cel 16L	Furnished in all standard 9-in. shapes of the 2½ and 3 in. series, as well as special shapes.

Heat Losses, Heat Storage and J-M Insulating Fire Brick and

HOT FACE TEM

Wall Thickness	Construction	1000 HL	1000 JT	1000 ST	1000 HS	1200 HL	1200 JT	1200 ST	1200 HS	1400 HL	1400 JT	1400 ST	1400 HS	1600 HL	1600 JT	1600 ST	1600 HS	1800 HL	1800 JT
4½"	4½" JM 1620	169	—	158	1175	214	—	176	1440	263	—	196	1740	314	—	216	2050	—	—
	4½" JM 20	173	—	163	1250	220	—	183	1550	269	—	202	1900	322	—	222	2200	379	—
	4½" JM 23	191	—	171	1450	241	—	191	1850	293	—	212	2200	345	—	232	2550	407	—
	4½" JM 26	383	—	243	2500	479	—	274	3100	581	—	303	3700	688	—	329	4400	800	—
	4½" JM 28	432	—	280	2850	541	—	292	3450	657	—	322	4170	779	—	349	5100	906	—
	4½" JM 3000	515	—	285	3300	639	—	318	4100	768	—	347	5000	900	—	372	5750	1036	—
	4½" FIRECLAY BRICK	974	—	387	6300	1272	—	430	8300	1596	—	468	9400	1933	—	510	10800	2259	—
6"	4½" JM 1620 + 1½" SX	122	418	141	1630	156	500	156	2070	191	585	171	2550	227	675	186	2980	—	—
	4½" JM 20 + 1½" SX	126	423	142	1790	159	508	157	2250	194	595	172	2740	231	686	187	3240	[illegible]	779
	4½" JM 23 + 1½" SX	134	444	145	2070	168	531	161	2550	204	620	176	3150	242	712	192	3800	282	805
	4½" JM 26 + 1½" SX	202	615	175	3880	252	735	196	4700	304	855	216	5770	359	975	235	6730	416	1096
	4½" JM 28 + 1½" SX	214	645	180	4260	267	771	202	5540	323	897	222	6600	381	1022	243	7860	441	1148
	4½" JM 3000 + 1½" SX	230	684	187	4880	285	812	208	6250	341	938	229	7620	400	1063	249	8900	461	1186
9"	9" JM 1620	87.7	—	126	2220	110	—	134	2740	135	—	144	3310	162	—	156	3990	—	—
	9" JM 20	89.8	—	125	2400	114	—	136	2940	139	—	148	3650	167	—	160	4300	195	—
	9" JM 23	99.7	—	130	2800	125	—	142	3500	152	—	154	4100	181	—	166	4940	211	—
	9" JM 26	207	—	177	4700	257	—	198	5700	310	—	218	6800	365	—	237	8100	422	—
	9" JM 28	235	—	189	5300	293	—	211	6600	352	—	233	8000	415	—	254	9600	480	—
	9" JM 3000	285	—	208	6100	350	—	232	7800	416	—	255	9000	484	—	276	10600	553	—
	9" FIRECLAY BRICK	551	—	286	11400	703	—	333	14600	868	—	366	17600	1047	—	395	21000	1238	—
12"	9" JM 1620 + 3" SX	63.3	400	114	3320	79.5	478	122	4080	97.3	561	131	4950	116	646	140	5900	—	—
	9" JM 20 + 3" SX	64.6	403	113	3480	81.6	485	121	4345	99.7	569	130	5335	119	656	139	6310	139	746
	9" JM 23 + 3" SX	69.0	425	115	4010	86.6	508	123	5090	105	594	132	6250	125	682	141	7340	145	772
	9" JM 26 + 3" SX	106	596	133	7250	132	713	144	9350	158	830	156	11000	186	948	169	13200	216	1067
	9" JM 28 + 3" SX	112	627	136	8480	140	750	148	10600	169	873	161	13100	198	997	174	15400	229	1121
	9" JM 3000 + 3" SX	121	667	140	9720	150	792	153	12200	179	916	165	14700	209	1039	178	17600	240	1161
17"	13½" JM 1620 + 3½" SX	45.5	346	105	4280	56.8	409	111	5540	69.8	478	117	6790	83.7	552	123	8060	—	—
	13½" JM 20 + 3½" SX	46.5	350	104	4900	58.8	418	110	6030	71.8	489	116	7310	85.6	564	123	8890	100	641
	13½" JM 23 + 3½" SX	50.0	369	106	5530	62.8	440	112	7100	76.2	513	118	8690	90.3	589	125	10200	105	666
	13½" JM 26 + 3½" SX	80.5	536	121	10000	100	640	130	12800	120	745	139	15600	142	851	149	18500	164	958
	13½" JM 28 + 3½" SX	86.4	568	123	11800	107	678	133	15300	129	789	143	18700	152	901	154	21800	176	1013
	13½" JM 3000 + 3½" SX	94.4	610	127	13700	116	723	137	17400	139	836	148	21100	162	947	158	24610	185	1058

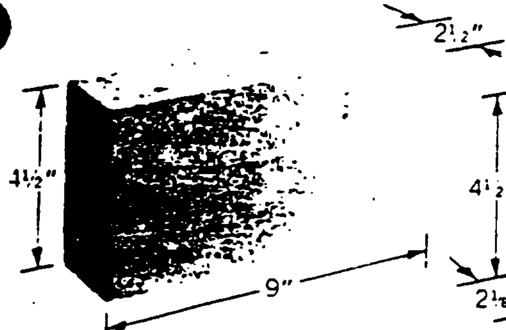
HL – Heat Loss at Steady State Condition, BTU/SQ FT/HR.
JT – Junction Temperature between Brick and Backup Insulation, F.
* Ambient – 80 F, Still Air.
ST – Outside Surface Temperature, F.
HS – Heat Storage, BTU/SQ FT.

Outside Surface Temperatures of Walls
Superex Compared to Fireclay Brick

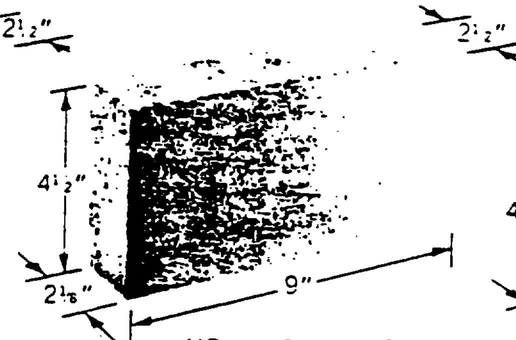
PERATURE*—F

1800		2000				2200				2400				2600				2800			
ST	HS	HL	JT	ST	HS	HL	JT	ST	HS	HL	JT	ST	HS	HL	JT	ST	HS	HL	JT	ST	HS
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
242	2550	438	—	261	2900	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
252	2950	469	—	271	3350	533	—	290	3800	—	—	—	—	—	—	—	—	—	—	—	—
353	5000	917	—	374	5700	1040	—	394	6400	1168	—	411	7000	1300	—	427	7600	—	—	—	—
373	5850	1040	—	394	6600	1179	—	413	7400	1324	—	430	8200	1474	—	447	8800	1627	—	465	9600
394	6600	1175	—	414	7400	1317	—	431	8400	1462	—	448	9200	1607	—	465	10000	1754	—	482	11000
570	12700	2670	—	586	14100	3070	—	619	15500	3510	—	642	17200	3990	—	658	18700	4450	—	703	20500
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
203	3790	312	873	219	4330	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
207	4350	324	899	223	5000	368	994	238	5550	—	—	—	—	—	—	—	—	—	—	—	—
254	7710	476	1216	273	8770	538	1336	291	9650	604	1455	308	10700	673	1574	325	11800	—	—	—	—
263	9030	505	1273	282	10300	572	1398	300	11400	642	1522	318	12700	716	1645	335	13800	793	1766	350	14900
268	10300	523	1308	287	11600	588	1428	304	12700	656	1546	321	14200	726	1662	336	15300	798	1775	351	16400
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
172	4900	226	—	185	5600	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
179	5700	242	—	192	6400	275	—	205	7200	—	—	—	—	—	—	—	—	—	—	—	—
257	9400	482	—	275	10600	543	—	292	12000	607	—	309	13600	673	—	325	14600	—	—	—	—
274	11000	547	—	293	12600	617	—	312	14000	689	—	329	15600	764	—	345	16800	841	—	360	18400
295	12400	623	—	314	14000	694	—	330	16000	767	—	346	17600	840	—	361	19200	915	—	374	21000
421	23400	1440	—	445	26000	1653	—	469	29000	1871	—	497	33000	2090	—	533	35000	2305	—	584	39000
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
148	7400	160	838	157	8290	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
151	8410	166	864	160	9920	189	957	170	10800	—	—	—	—	—	—	—	—	—	—	—	—
181	15300	246	1186	193	17200	278	1305	206	19300	311	1424	218	21300	345	1543	231	23400	—	—	—	—
187	17700	262	1245	199	20100	296	1369	212	22200	331	1493	225	24300	368	1616	238	26500	406	1738	251	29700
191	20200	272	1282	203	23100	304	1401	216	25200	338	1518	228	27400	373	1634	240	30500	409	1749	252	32600
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
130	10100	116	720	137	11700	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
132	11600	121	746	139	13200	137	826	147	15100	—	—	—	—	—	—	—	—	—	—	—	—
159	21600	187	1065	169	24400	210	1173	179	27500	235	1281	189	30100	261	1389	199	32900	—	—	—	—
164	25000	200	1126	174	28100	226	1239	185	31200	252	1352	196	35000	280	1465	206	38100	308	1578	217	41200
168	28600	209	1167	178	32600	234	1276	188	35800	259	1383	198	39500	285	1489	208	43500	312	1593	218	46600

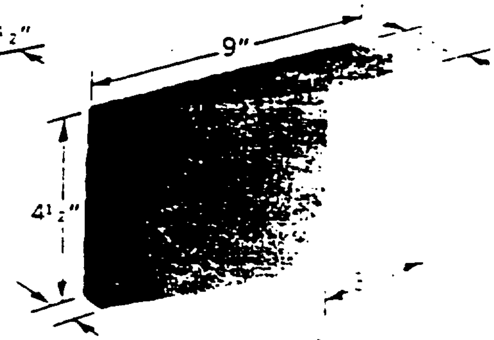
■ Standard Shapes of J-M Insulating



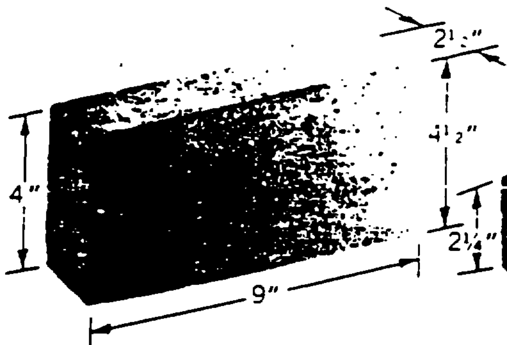
9-INCH STRAIGHT



NO. 1 ARCH



NO. 1 NECK



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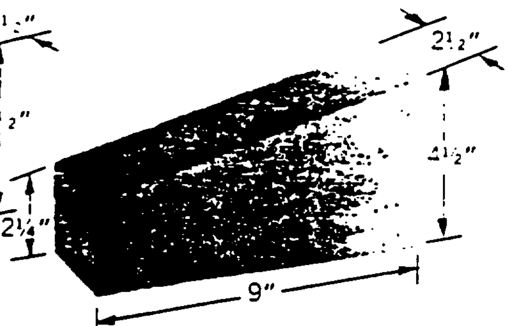

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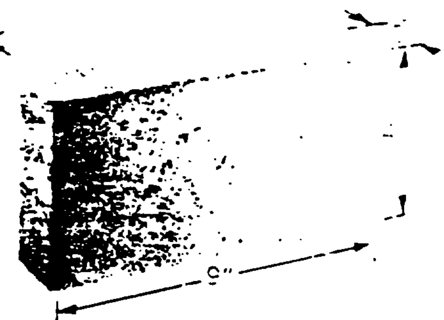
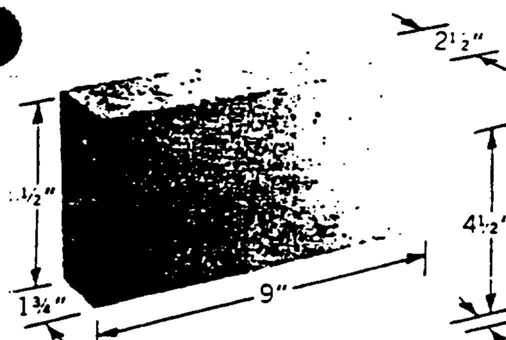

2-INCH BRICK



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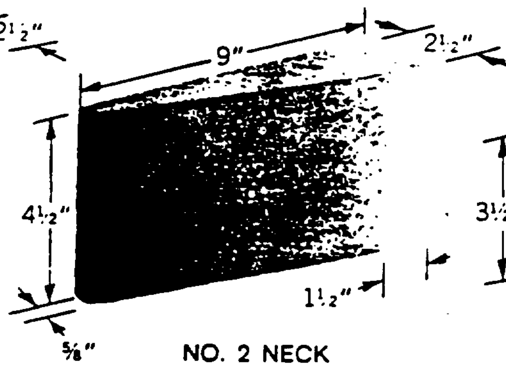

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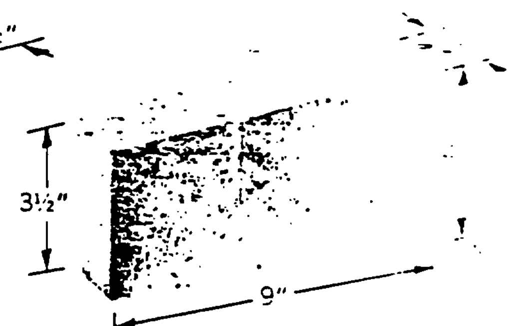

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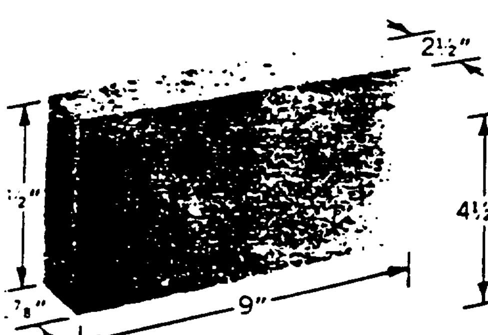
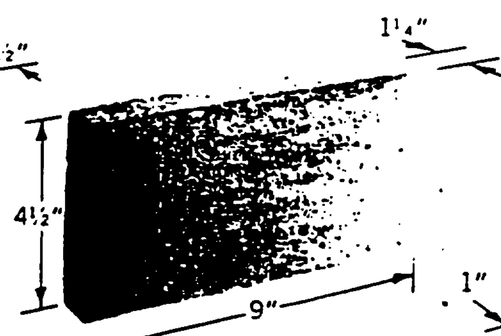
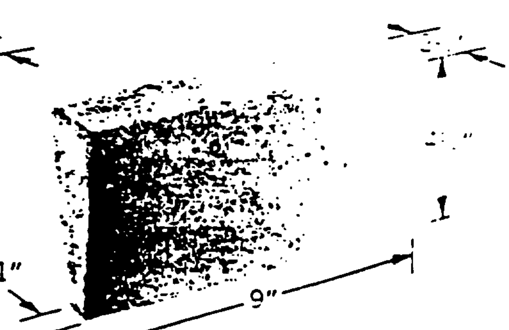


NO. 1 WEDGE

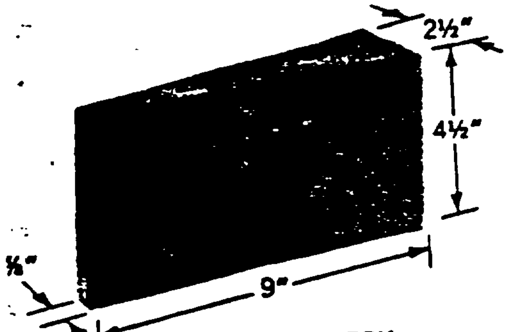


SPLIT BRICK



NO. 3 ARCH

ire Brick and Sil-O-Cel Insulating Brick



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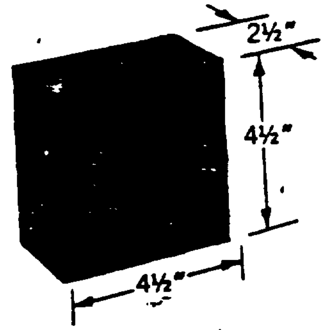
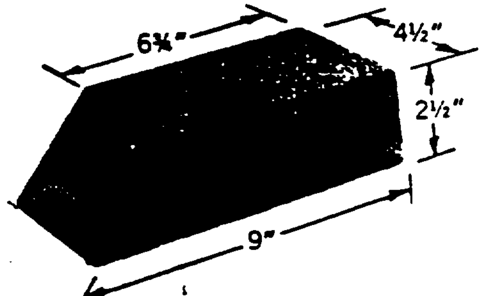
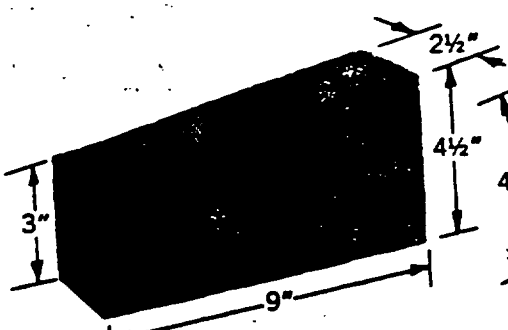


BAT



END SKEW



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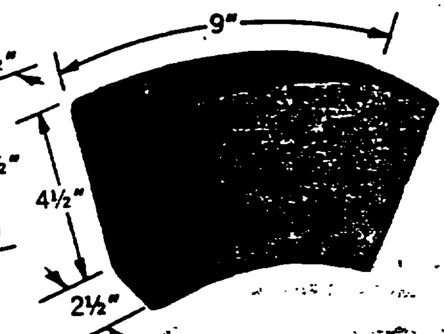
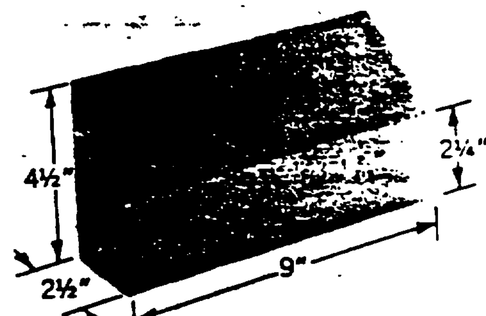
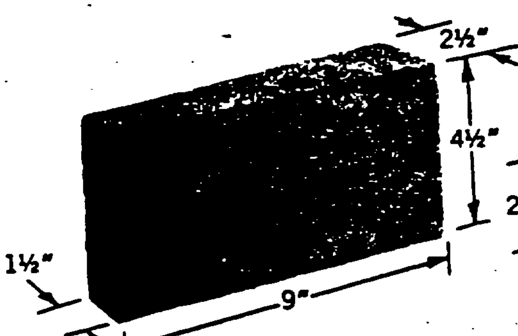


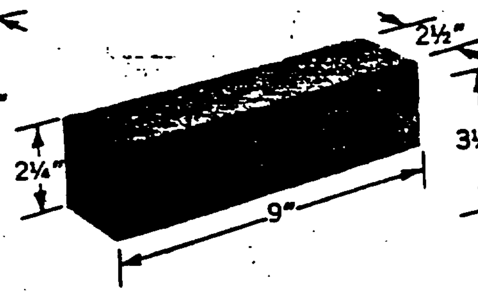
CIRCLE BRICK



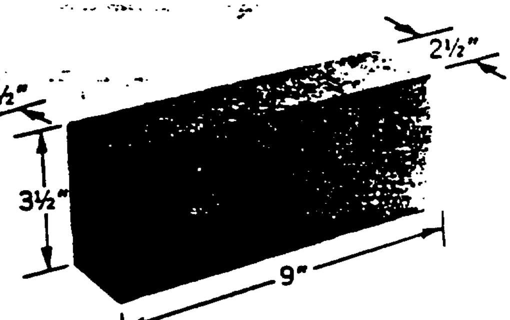
SIDE SKEW



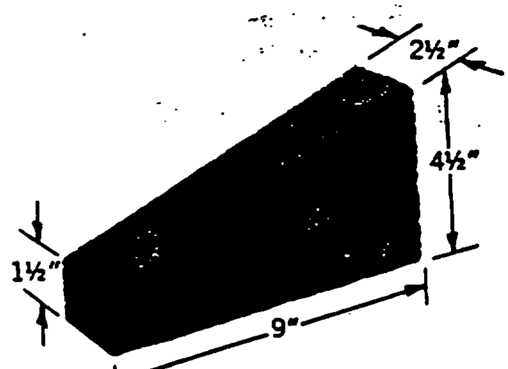
NO. 2 WEDGE



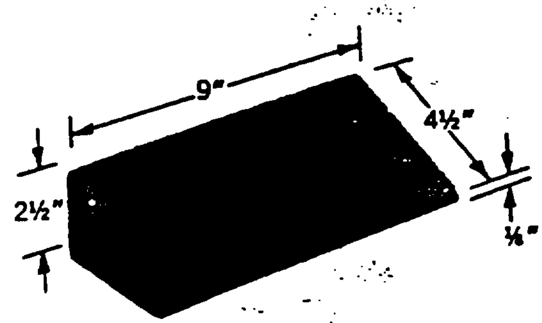
SOAP



SMALL 9-INCH BRICK



EDGE SKEW

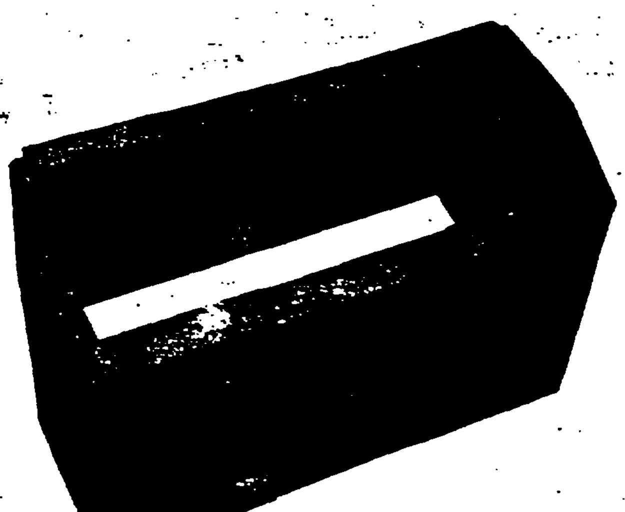


FEATHER EDGE

Special Shapes

In addition to the production of all standard brick shapes, Johns-Manville also manufactures many special shapes direct from 9" x 24" slabs. These shapes normally would have to be molded and processed as specialty items.

Below, special shape is cut from standard slab and then stacked on pallet with similar pieces. Illustration at bottom of page shows how 20 of these pieces are assembled to make a particular product.



Information on Packaging and

CARTONS

Johns-Manville Insulating Fire Brick and Sil-O-Cel Insulating Brick are packed in standard cartons which contain either 20 or 25 brick per carton. Shipping weights per carton are:

JM-3000	76 lbs. (20 brick)
JM-28	67 lbs. (20 brick)
JM-26	76½ lbs. (25 brick)
JM-23	48 lbs. (25 brick)
JM-20	46 lbs. (25 brick)
JM-1620	41 lbs. (25 brick)
Sil-O-Cel Super	63 lbs. (25 brick)
Sil-O-Cel C-22	62 lbs. (25 brick)
Sil-O-Cel 16L	54 lbs. (25 brick)

Each J-M brick is clearly marked with the brick type designation for quick, correct selection on the job.

PALLETS

Carload shipments of standard sizes and shapes of Johns-Manville Insulating Fire Brick and Sil-O-Cel Insulating Brick should be ordered in pallet-load units. Palletizing is done according to the basic recommendations on packaging and loading standards of the Refractories Institute Palletizing Committee. Standard Pallets measure 48" x 36" and will take 48 cartons totaling 1200 brick, except for JM-28 and JM-3000 which total 960 brick per pallet.

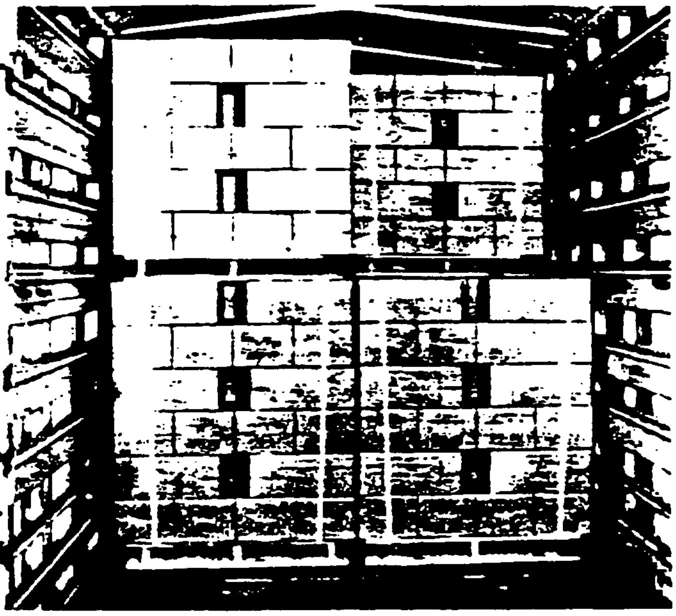
In a 40-foot rail car there are usually 24 pallet loads of material with the doorway filled with loose cartons. The number of loose cartons varies, but it is usually about 150 cartons.

In a 50-foot rail car there are usually 30 pallets, with the doorway filled with approximately the same number of loose cartons as in the 40-foot car.

If there is a large quantity of JM-28 and JM-3000 brick in the car, there will be about 2 less pallets than used with other brick, because the JM-28 and JM-3000 pallets are slightly larger than those used for other brick. There are 8 cartons on a course of JM-28 and JM-3000 instead of 6 as in the other brick. (The 48" x 36" size referred to above is the dimension of the pallet only and does not allow for any overhang of the cartons.)

Special palletizing is available to our customers if the standard method is not suitable for their particular requirements.

Palletized Shipments



Construction Details

Types of Straight Wall Construction

RECOMMENDED CONSTRUCTIONS—The most common constructions where J-M Insulating Fire Brick is used are those consisting of all headers or of alternate header and stretcher courses. These constructions are recommended unless other factors influence the type of wall used.

PERMISSIBLE UNSUPPORTED HEIGHT—Unsupported wall 4½" thick. should be no higher than 3 ft. Unsupported wall 9" thick, tied in by combinations of header and stretcher courses, can be used up to 8-ft. heights; 13½" walls under same conditions are suitable up to 12-ft. heights.

HEADER COURSES

ALL HEADERS—Many 9"-thick Insulating Fire Brick walls are built of all-header courses. This is especially true of bell-type annealing furnaces. Advantages are a reasonably stable wall with the back side of all brick under comparatively low temperatures. Hence, a preferred construction for walls operating near their temperature limit.

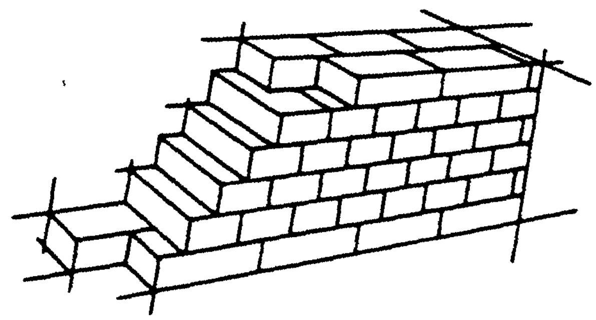
MAINLY OF HEADERS—This type of wall possesses many of the advantages of one constructed entirely of headers, but has greater rigidity. This wall is usually laid with three to four header courses to each stretcher course.

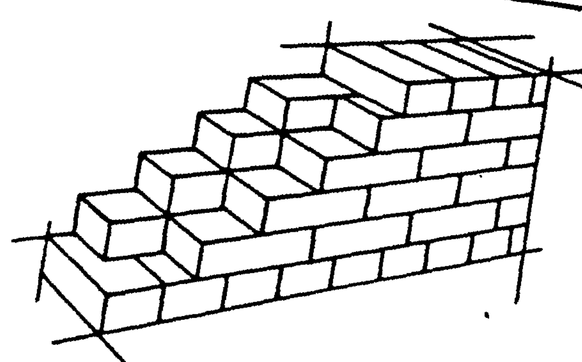
STRETCHER COURSES

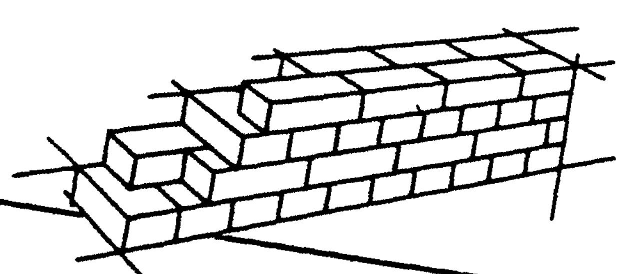
ALL STRETCHERS—Not very rigid and is not recommended except for walls under 3 ft. in height, or walls having other means of support, such as suspended walls or veneer courses between a heavier wall and exterior casing. Even for walls under 3 ft. high other types of construction are preferable.

MAINLY OF STRETCHERS—This type of wall is extensively used where the brick are subjected to slagging or other erosive action. The advantage of this type is that the exterior face can be repaired by applying a 4½"-skin wall tied into the remaining brick work.

ALTERNATE HEADERS AND STRETCHERS—Walls of both 9" and 13½" thicknesses constructed of alternate headers and stretchers make a very stable wall and is considered "good practice." Walls of this type are most common in mill-furnace construction, especially where dense fire brick is used.







Curved Walls

Most curved walls are used as linings of stacks or of circular pit type furnaces. An exception is occasionally encountered in the side walls of furnaces made in the form of a curve to give greater stability than can be obtained with straight walls.

ADVANTAGES — A properly constructed curved wall is much more stable than a straight wall, thickness for thickness. Therefore such walls can generally be constructed higher than straight walls.

When walls of sufficient curvature are enclosed in a casing (such as in a stack lining), the wedging action of the brick prevents them from falling toward the inside and the casing prevents them from falling outward, so the only limiting factor on height is the ability of the brick to carry the weight of the overhead material under operating conditions.

BRICK SHAPES – Curved wall sections are usually constructed by using circle brick and key brick either alone or in combination. When necessary, arch and wedge brick can also be used, but are much less desirable.

When using insulating fire brick to make curved walls or roofs, it is always preferable to use specially cut brick to fit the curvature rather than a combination of straight brick and standard shapes as is customary practice with dense fire brick.

CONSTRUCTION GUIDE

Wall Thickness	Recommended Brick	Other Possible Brick
4½"	Circle	Arch brick are sometimes used but are not recommended
9"	Key	Combination of circle and key brick may be laid up, using any combinations used for straight walls
13½" and heavier	Key	Same as for 9" brick. If necessary wedge brick can be used on low walls but their use is not recommended

MAXIMUM HEIGHT – On walls where the curvature is sufficient to make the wall self-supporting, the height is limited only by the ability of the brick in the lowest course to carry the weight of the courses above. Since the crushing strength of all refractories varies with temperature, the safe height of such linings will depend upon the type of brick used and operating temperature.

Division Walls

Occasionally, furnaces are designed having heating chambers side by side, with a common wall between. This construction is usually more expensive than two separate walls and is subject to the weaknesses outlined below.

OPERATING TEMPERATURE—In the ordinary single furnace, only one side of each wall is heated, thus resulting in a temperature drop from the inside to the outside. The outside of the brick remains strong, while the hot exposed sections may be approaching their softening point.

TYPE OF BRICK—Because of the high operating temperature, a higher quality brick may be required for a division wall than on the remainder of the furnace. In addition, the brick in the interior of the division wall will be subjected to the same temperature as the exposed brick, so the same high quality brick used on the exposed portion should also be used in the center of the wall.

CONSTRUCTION—In Fig. 1, the skewbacks are supported by a solid course of refractory brick. Fig. 2 illustrates the skewbacks supported by channels resting on brick spacers. This construction, either with or without flues, permits one arch to be repaired without disturbing the other. However, it is necessary to space out the brick between the channels to dissipate the heat.

The air flues in the center of the division walls (Fig. 3) allow the heat to escape to the outside air. They are formed when laying the brick, providing openings that are either vertical or horizontal, or both. Where horizontal flues are used alone, air is frequently blown through by mechanical means or by connection to a vertical flue or stack at one end.

THICKNESS—The thickness of division walls should be at least 4½" greater than for ordinary walls. If the wall is to support two sprung arches, the thickness should be no less than the width of the two skewbacks involved.

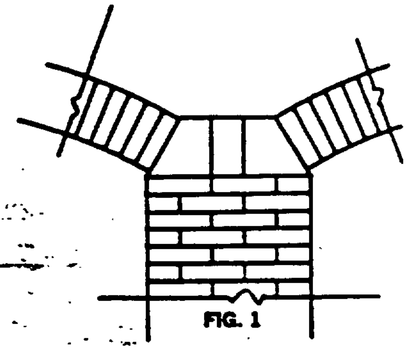


FIG. 1

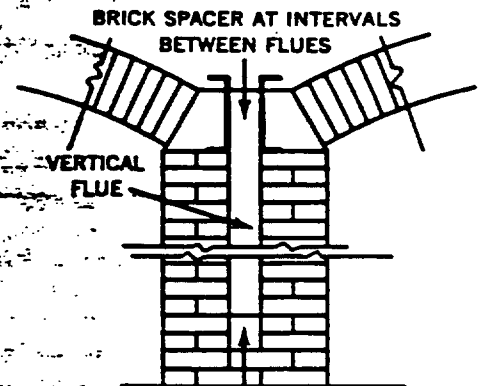


FIG. 2

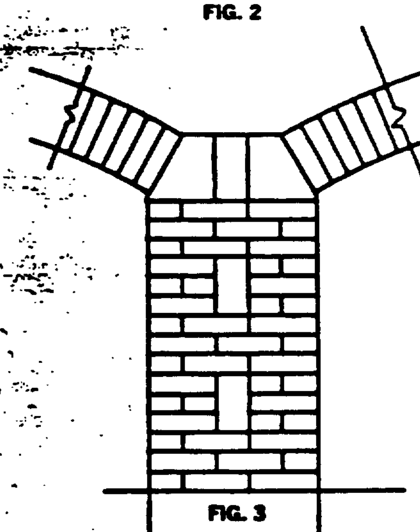


FIG. 3

Sprung Arches

Sprung arches are the most common type of arch used in furnaces. They are fairly easy to erect and require the least elaborate mechanical means of support.

These arches rest at both ends on skewbacks which transmit the arch stresses to the supporting parts of the furnace. The "built-up" skewback of cut standard 9-inch brick is the most accepted form, but the special one-piece skewback is also widely used. Since movement of the skewbacks may cause failure of the arch, furnaces must be rigidly constructed.

Sprung arches for direct exposure can be made from insulating fire brick or dense fire brick. The same practices governing proper arch construction apply to both types of brick. Although insulating fire brick may have less strength per unit of weight than some types of fire brick, they serve for as wide a span, because any deficiency in strength is overcome by lower weight and more uniform sizing of the insulating fire brick. This uniformity results in an even distribution of the load over all the brick in the arch.

BRICK SHAPES USED—Since dense fire brick are moulded to size and burned and cannot be machined readily, standard sizes were adopted for arch, wedge and key brick; designating them No. 1, No. 2, and No. 3 arch. Arches are built using a combination of No. 1, 2, and 3 brick and straights in quantities sufficient to turn a given circle.

J-M Insulating Fire Brick, however, are machined to size after firing and are furnished with the correct taper for any specific arch. This results in a sturdier construction and simplifies the laying operation, as only one brick size is involved, although, when necessary, the standard shapes can be used. The standard shapes used for various arch thicknesses are:

Arch Thickness	Shapes and Combinations
4½"	Arch brick or a combination of arch and straight.
6¾"	Large 9" arch or combination of large 9" arch and large 9" straight.
9"	Wedge brick or a combination or wedge and straight. (Construction of key brick or combination of key and straight are not common as the load is placed on the narrow face of the brick. This construction is only used where special conditions make it desirable.)
Over 9"	Constructed, necessarily, of special wedge brick. However, 13½" wedge brick are furnished as standard by some manufacturers.

RISE OF ARCHES—The minimum rise for an arch should be 1½" per foot of span. Arches with a rise of 1.608" per foot of span are common, as this rise results in an included angle of 60 degrees with the inside radius equal to the span. Wherever possible, however, for wide spans, it is recommended that the rise be made at least 1¾" per foot of span.

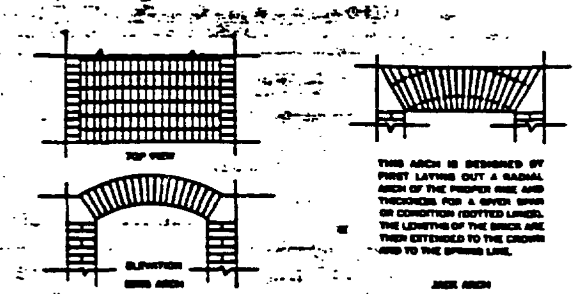
The maximum rise of an arch has generally been set as 3" per ft. A rise of 3" per ft. will be sturdier than one with less rise. Therefore, as great a rise as possible is recommended within the limits of 1¾" minimum to 3" maximum per foot of span.

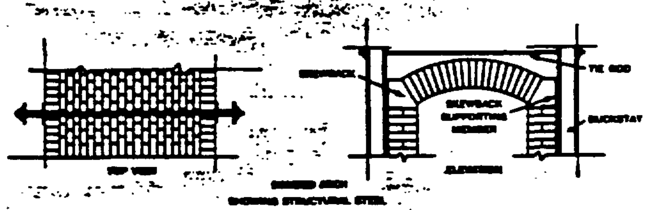
TYPES OF SPRUNG ARCHES—The "bonded" arch is the most commonly used arch and the best for most conditions, because the entire construction is tied together. If one or several bricks fail in the bonded arch, the load will be taken by the brick on either side and the arch will remain in place until replacement is made.

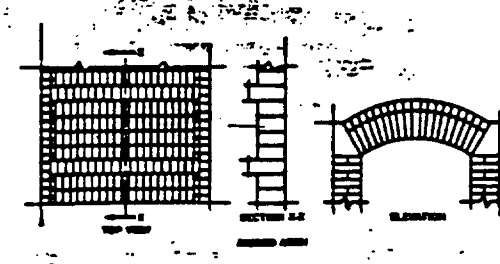
With the "ring" type arch, however, if one brick in a ring fails, the entire ring drops, thus making repair difficult. The chief advantage of this type arch is ease in laying, especially when a combination of standard shapes is used.

The "ribbed" arch is used chiefly for open hearth furnaces. The ribs strengthen the arch and give it stability after the intermediate brick have eroded away.

"Jack" arches are very seldom used except over openings, since they are costly and possess few advantages over the other types.







Domes and Crowns

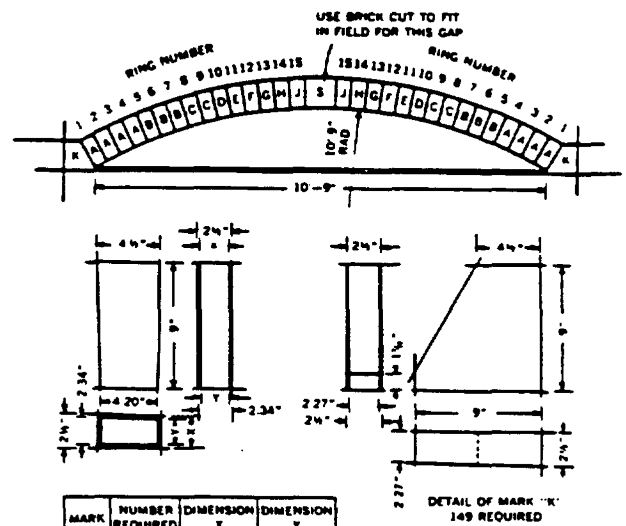
A dome or crown differs from a sprung arch in that a sprung arch describes a portion of a cylinder, while a dome or crown describes a portion of a sphere.

The recommended thickness of a J-M Insulating Fire Brick dome is 9", made up of key brick used in combination with wedge key and arch key brick. Each brick is color coded at the factory on the large end of the shape for quick identification on the job.

All brick have the same key cut to accommodate the difference between the inside and outside arch lengths of the dome. In addition, some brick also have a wedge taper and others an arch taper. The brick are laid up in 4½" rings until the dome is closed except for the hole in the center. During construction, a template is frequently used. This consists of a wood frame attached to a pipe vertically positioned directly below the top of the dome. The template is free to rotate around the vertical pipe and, having a shape that conforms to the final inside surface of the dome, acts as a guide for each brick course.

TYPICAL DOME SKEWBACK

The drawings (at right) show a typical dome skewback. These skewbacks are the same as those used in sprung arches except that they are tapered so they can be laid in a circle of the proper diameter.



MARK	NUMBER REQUIRED	DIMENSION X	DIMENSION Y
A	636	2.34"	2.19"
B	368	2.28"	2.13"
C	193	2.22"	2.07"
D	80	2.15"	2.01"
E	69	2.10"	1.96"
F	57	2.01"	[illegible]
G	45	1.89"	1.77"
H	35	1.68"	1.57"
J	24	1.29"	1.21"

10 STRAIGHT BRICK 9" x 4½" x 2½" REQUIRED FOR CENTER PLUG-MARK "S"
APPROXIMATELY 500 LB. OF 1626 CEMENT REQUIRED

Suspended Arches and Walls

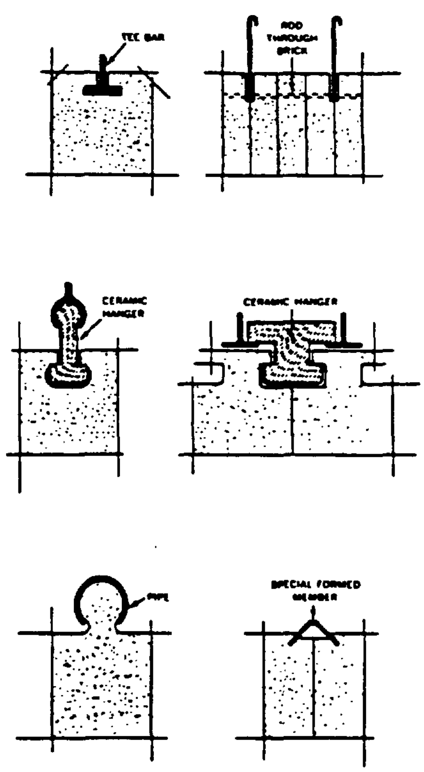
A suspended arch or wall is one which is not self-supporting, but which is held in place mechanically. This support is usually obtained by metal hangers fitting into holes or grooves, or over projections on the brick. In some constructions, special ceramic shapes are also used for this purpose.

While there are literally hundreds of different types of suspended arch constructions, a few of the more popular types are: Pipe, Tee Bar, Rod, Special Formed Member, and Ceramic Hanger.

There are two types of suspended walls: *Air-cooled* —Where there is a lane for the flow of air directly in back of the refractory; and *Insulated*—Where insulation is placed directly behind the refractory. Both the air lane and the insulation serve to protect the metal structure from high temperatures.

WHY USED—The main reasons for using suspended arches and walls are:

(1) It is possible to erect wide span flat arches and thin, lightweight walls with high thermal efficiency and structural stability. The height of the wall or width of the arch is limited only by



the ability of the structural members to carry the load.

(2) To permit the use of special furnace designs making possible the use of special conveying mechanism or control of combustion or radiation. With self-supporting walls and sprung arches or domes, the variation in furnace shapes is quite limited, while with suspended construction, a shell of any desired size or shape may be constructed of structural steel and then lined with refractory.

(3) A saving in overhead space, especially on wide-arch spans.

(4) To permit the construction of large, removable sections.

(5) To act as occasional anchorage in otherwise self-supporting walls.

ADVANTAGES

Repair costs are generally lower, because of the ease with which brick can be removed and replaced, and also because repairs can be confined to the brick which are actually damaged. In some cases, there is the further advantage in that hot repairs can be made without loss of production.

In suspended arches, the main load is carried on the structural steel while the refractories carry relatively light loads and therefore have less tendency to deform at high temperatures than in other arch and wall structures. Definite allowance can conveniently be made to take care of thermal expansion, both horizontally and vertically, to avoid stresses which can cause breaking. Provision can easily be made for ventilation or for water-cooling as conditions may require.

If the weight of the roof is supported by suspended construction, the top courses of the walls may necessarily be tied to the furnace binding by metal hangers or clips to keep the walls from bowing inward.

DISADVANTAGES

The chief disadvantage to suspended construction is its cost. For equal thickness, the cost of most suspended construction will be higher than the cost of self-supporting brickwork. This is brought about not only by the cost of supporting steel work but also by the additional cost of necessary special shapes. Many suspended constructions also are unable to stand as much mechanical abuse as self-supporting brickwork.

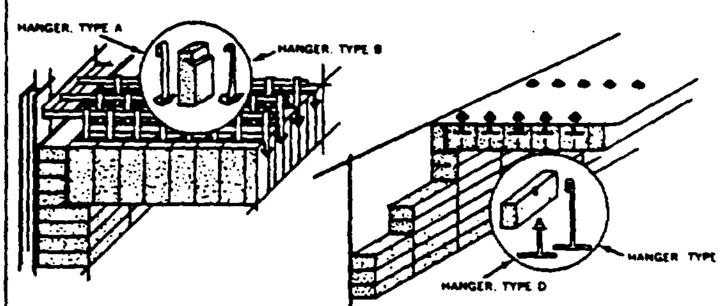
THICKNESS

The thickness of suspended-arch and wall construction is limited only by the manufacturing limits of the brick shapes. Most common thicknesses in insulating refractories are 4½" and 9". Very few suspended arches or walls are constructed with a thickness less than 4½" or more than 9".

SIZE OF UNITS

Brick shapes for suspended arches and walls require absolute uniformity of size to assure close fitting and to eliminate the possibility of air infiltration and gas leakage. The most common insulating fire brick unit for this construction is the 2½" series straight, although many suspended constructions employ 9" large brick. The large brick are used to reduce the amount of steel work and hangers required. In most cases, the use of large brick results in a lower overall cost of steel, labor and refractories than when the 2½" size is used.

NOTE: *Where suspended construction is used, only one insulating fire brick of sufficient thickness to obtain the desired insulating effect should be used. Do not use a combination of insulating refractories and back-up insulation, as such construction will dam up the heat on the hangers and cause trouble.*



TYPICAL CONSTRUCTIONS OF SUSPENDED ARCHES AND WALLS

Periodic Kiln Domes

Round periodic kilns are widely used in structural clay plants which manufacture such products as ceramic tile, brick, pipe and other clay ware. These kilns vary in diameter from 15 to 40 feet, typically constructed as shown in figure 2. The rise is usually 2½" to 3" per foot of span. The sidewalls are normally constructed of dense fire brick although a layer of insulating fire brick is recommended to effectively reduce heat transfer through this area. The kilns are either coal, gas, or oil fired.

Calculation of Brick Quantities and Shapes

1. Refer to Figure 1, "Kiln Dome Layout For Calculation Data." The following calculations are based on the trigonometric relationships shown in this figure.
2. Determine the length of the outside arc L_0 from the ℄ of the dome to the base of the dome.
   L_0 (inches) $= \frac{2\pi R_0 \times \frac{1}{2} \text{ Dome Angle}}{360^\circ}$
3. Since the brick are laid the 4½" way, the total number of courses is $\frac{L_0}{4.5}$. The center hole will reduce the number of courses just calculated by ½ its diameter in inches divided by 4.5.

4. Determine the angle α formed by a single brick (projected to the dome center). See Figure 1.
$$\frac{\alpha}{360} = \frac{4.5}{2\pi R_0};\ \alpha = \frac{360\ (4.5)}{2\pi R_0}$$

5. At this point, the total number of courses as determined in step 3 may be checked by
$$\frac{\tfrac{1}{2}\text{ Dome Angle}}{\alpha} = \text{Total number of courses (less center hole).}$$

6. *All* brick in the dome are key cut, and the key taper is determined by
$$\frac{X}{4.5} = \frac{R_1}{R_0};\ X = \frac{4.5R_i}{R_0} = (4.5'' \rightarrow X'')$$
Key cut on all brick.

7. Set up a table of eleven columns across and of a length equal to the number of courses. The first column indicates the course number.

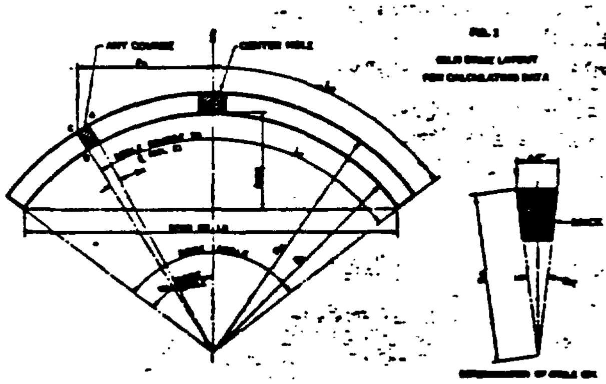
8. In Column 2 list the angle between the vertical ∠ of the dome and the farthest edge of each course (see Figure 1). This angle is ½ of the Dome Angle minus the sum of α's to each course. For example, for a 120° Dome, course No. 1 is 60.000° — 0° = 60.000°; Course No. 2 is 60.000° minus α; Course No. 3 is 60.000° — 2 α; etc.

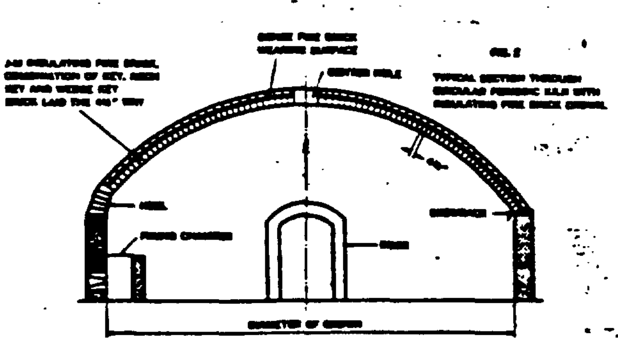
9. Convert the decimal portion of each angle to minutes of a degree to facilitate determining its size or use decitrig tables.

10. In Column 3 list P_0, the horizontal distance from the ∠ to the lower edge of each course on the outer arc (Point C on Fig. 1) $P_0 = R_0 \sin$ Col 2 angle. Use a calculator and 5 place trigonometric tables.

11. In Column 4 list the circumference (in a horizontal plane) of the loci of point C about the ∠. This circumference $C_0 = 2\pi P_0$.

12. In Column 5 list the difference $(C_0 - B_1)$ between the outside circumference of each course, C_0 (Column 4) and the inside circumference (Point B — Fig. 1) of the inside edge of the same course about the ∠. This inside circumference
is B_1, $C_0 - B_1 = \left(1 - \frac{R_1}{R_0}\right) C_0$.
This is derived as follows:
$\frac{B_1}{R_1} = \frac{C_0}{R_0}$; $B_1 = \frac{R_1}{R_0} C_0$ (similar triangles)
Therefore $C_0 - B_1 = C_0 - \frac{R_1}{R_0} C_0 = C_0\left(1 - \frac{R_1}{R_0}\right)$
$\left(1 - \frac{R_1}{R_0}\right)$ is a constant.





13. In Column 6 list the total number of brick per course. This is C_0 (Column 4) divided by 2½", the width of the outside end of each brick regardless of shape. To speed calculation by avoiding a division for each course, remember that $C_0 = 2\pi P_0$, so that Total Number of brick per course =
$\frac{2\pi P_0}{2.5}$ $\left(\frac{2\pi}{2.5}\text{ is a constant, } 2.51328\right)$.

14. In Column 7 list the number of wedge keys required per course. The difference in circumferences, $C_0 - B_1$ (Col. 5) must be satisfied by inserting a number of wedge-cut brick in each course. For example, if a (2½" — 2") wedge cut is selected, each wedge key tapers ½", so if $C_0 - B_1$ is 10" for a course, 20 wedge keys must be used to turn the circle of that course. Therefore Column 7, Number of
$$\text{Wedge Keys} = \frac{C_0 - B_1}{\text{wedge-cut taper}}$$

15. In Figure 1, note that for any course, Point C swings a larger circle about the ∠ than Point A, the upper outer edge of the same course. Point A is, however, the same as Point C for the next higher course. So, to determine the difference in circumference between the loci of points A and C, use C_0 course No. 1 minus C_0 course No. 2, C_0 course No. 2 — C_0 course No. 3, etc. This difference is listed for each course in Column 8.

16. In Column 9 list the number of arch key required per course. The difference in circumferences shown in Column 8 between Point C and Point A must be satisfied by inserting a number of arch cut brick in each course. For example, if a (2½" — 2") arch cut is selected, it tapers ½". So, if the difference in circumferences in Column 8 is 10" for a course, 20 arch keys must be used. Therefore, Col. 9, number
$$\text{of arch keys} = \frac{\text{Column 8}}{\text{Arch-Cut Taper.}}$$

It is necessary, sometimes, to use two or more degrees of arch taper on the arch key brick. The key taper remains the same, but on courses approaching the top of the dome, the arch taper is increased so that the difference in circumference (Column 8) can be satisfied with fewer arch key brick. This is important in the upper courses because there are so few brick per course.

17. In Column 10 list the total number of arch key and wedge key for each course. This figure is the sum of Column 7 and Column 9.

18. In Column 11 list the number of key brick required per course. After the arch and wedge requirements have been met, all the remaining brick in a course are keys. Therefore, Column 11 = Column 6 minus Column 10.

Hydraulic-Setting Refractories

(Castables and Gunning Mixes)

Johns-Manville offers a wide range of refractories for forming monolithic linings. All of these materials are of the highest quality and each performs a specific service to industry.

This classification refers to castable refractories that, when tempered with water, will develop structural strength by reason of a hydraulic set. These refractories are composed principally of alumina or aluminum-silica aggregates, using hydraulic-setting cement.

Castables are furnished in dry form, are mixed with water on the job, and poured or cast in place like portland cement concrete. When casting or pouring, certain rules must be observed. It is essential to use water suitable for drinking, in the correct ratio, with a short mixing time and quick installation. For best results, a vibrator should be used when the castable is placed in the form. Care should be taken to limit the vibration, as excessive agitation will force the binder and fines to the surface.

Where the castable is poured in contact with porous surfaces, such as insulating fire brick or block insulation, it is necessary to coat the surface to prevent the water escaping from the mix. This can be done by using oil, grease or waxpaper as a coating.

Depending upon atmospheric conditions, installed castables will harden in less than 8 hours, but they should have approximately 24 hours of water curing to assure proper hydration of the binder and to remove heat generated by the chemical reaction. High ambient temperatures lessen curing time, while low temperatures prolong it. Castables should not be installed at freezing temperatures or allowed to freeze until thoroughly cured.

In many industrial furnace operations, it is often desirable to build or repair sections of refractory furnace linings by gunning or "slap-troweling" applications.

GUNNING is done with a pneumatic gun that applies gunning mixes which are hydraulic-setting refractories. These are applied at high velocity and pressure to form dense, homogeneous linings.

Gunning mixes are used to advantage in vessels, stacks, ash pits, tanks, slab-heating furnaces and individual boilers. Densely-compacted linings can be gunned quickly and easily with the use of forms.

There are two types of guns available: dry and wet. With the dry type, the mix is forced through the hose and the right amount of water is added at the nozzle. The wet type combines water and mix in the hopper to produce a wet mix which is then forced through the hose and ejected from the nozzle.

"SLAP-TROWELING" is used in locations where it is not suitable or economical to employ gunning procedures. "Slap-troweling" means the cement is thrown or forced into place with the use of a large-size trowel. The cement is mixed with water to a stiff consistency for easy application. The proper consistency can quickly be found by trial and error.

■ *J-M Firecrete* CASTABLE REFRACTORIES

DESCRIPTION: Johns-Manville produces nine types of castable refractories to meet practically every requirement for temperatures through 3000F. Each of these refractories is economical and efficient in the service range for which it is recommended. All harden rapidly and are highly resistant to spalling.

AVAILABLE TYPES:

3X Firecrete—A high alumina refractory for service to 3000F. It is used extensively in ceramic kilns for casting cartops, doors and special shapes of all description. Suitable for casting shapes and linings 2-inch thick or more.

H. T. Firecrete—An economical, high alumina refractory for service to 2800F. Suitable for casting shapes and linings 2-inch thick or more.

Standard Firecrete—An economical, aluminum silicate refractory for service to 2500F. It is a general-purpose castable, developing high strength on air curing. Suitable for casting shapes and linings 1-inch thick or more.

L. W. Firecrete—A lightweight, aluminum silicate refractory for service to 2400F. This castable combines unusually high insulating value with exceptional strength. Recommended for casting shapes and linings 2-inch thick or more.

CA Insulating Firecrete—A high purity, lightweight refractory for service to 2600F. Developed especially for use in controlled atmosphere applications. Recommended for casting shapes and linings 2-inch thick or more.

JM-20 Firecrete—A lightweight, economical, aluminum silicate refractory for service to 2000F. This castable combines unusually light weight, high insulating value and strength. Recommended for casting shapes and linings 2-inch thick or more.

2200 CA Insulating Firecrete—A high purity, lightweight refractory for service to 2200F in controlled atmosphere applications. This castable supplements CA Insulating Firecrete or JM-20 Firecrete. Recommended for casting shapes and linings 2 inches thick or more.

Lo-D Firecrete—Designed primarily for use as a back-up insulating refractory in naval boilers. Service to 2500F.

C-31 M Refractory Cement—A chrome base castable refractory for service to 3000F. Used in boilers.

ADVANTAGES:

Hardens Rapidly Firecrete permits casting and use of any desired shape within 24 hours.

Resists Spalling All nine types are highly resistant to spalling.

Negligible Shrinkage Firecrete has no drying shrinkage and only negligible fire shrinkage at recommended temperatures.

Easy and Economical to Use The adaptability of Firecrete makes possible the easy construction of monolithic furnaces, linings and the like which would otherwise require the use of special shapes or involve costly cutting and fitting of brick.

Specification Data

■ *Physical Properties**

	3X	H.T.	STD.	L.W.	CA Insulating	JM-20	C-31 M Refractory	2200 CA Insulating Firecrete	Lo-D
Highest Recommended Service Temperature	3000F	2800F	2500F	2400F	2600F	2000F	3000F	2200F	2500F
Pyrometric Cone Equivalent	33 (3173F)	30 (3002F)	16 (2669F)	15 (2615F)	32½ (3135F)	14 (2552F)	36 (3290F)	16-17 (2740F)	
Weight									
As Placed	148 pcf	131 pcf	130 pcf	109 pcf	109 pcf	96 pcf	193 pcf	97 pcf	100 pcf
Oven Dried at 220F	134 pcf	113 pcf	116 pcf	80 pcf	80 pcf	62 pcf	183 pcf	66 pcf	48 pcf
After 5-Hr Firing at 1750F	130 pcf	110 pcf	110 pcf	75 pcf	75 pcf	58 pcf	177 pcf	57 pcf	44 pcf
Crushing Strengths After 5-Hr Firing at:									
220F	3500 psi	700 psi	1310 psi	630 psi	580 psi	500 psi	2920 psi	310 psi	80 psi
1200F	2680 psi	560 psi	1190 psi	595 psi	475 psi	490 psi	1780 psi	320 psi	60 psi
1750F	2350 psi	300 psi	780 psi	490 psi	595 psi	410 psi	1300 psi	375 psi	80 psi
2200F	2490 psi	580 psi	1190 psi	690 psi	650 psi	365 psi	1690 psi	380 psi	110 psi
2400F	2950 psi	1500 psi	2130 psi	1690 psi	840 psi	(B)	3850 psi	(B)	260 psi
Linear Change After 5-Hr Firing at:									
1200F	0.2%	0.1%	0.0%	0.2%	0.1%	0.4%	0.2%	0.1%	0.7%
1750F	0.1%	0.2%	0.2%	0.3%	0.2%	0.4%	0.2%	0.1%	1.0%
2200F	0.2%	0.1%	0.6%	0.5%	0.3%	(B)	0.3%	0.7%	2.6%
2400F	0.7%	–0.6% (A)	–1.6% (A)	1.2%	0.8%	(B)	0.5%	(B)	4.2%
2800F	0.9%	–0.9% (A)	(B)	(B)	(B)	(B)	1.9%	(B)	(B)

*The figures given in this table are average values obtained in accordance with accepted test methods

(A) Minus sign denotes expansion.

(B) Above recommended temperature limit.

Calculated Chemical Analysis

Material Composition	3X Firecrete	H.T. Firecrete	Standard Firecrete	L.W. Firecrete	JM-20 Firecrete	C-31M Cement	CA Ins. Firecrete	2200 CA Ins. Firecrete	Lo-D Firecrete
SiO_2	39.9	39.3	40.6	46.2	31.2	4.7	40.1	27.0	32.3
Al_2O_3	53.0	50.3	43.8	36.0	38.4	31.7	51.0	53.9	41.5
Fe_2O_3	0.6	4.0	4.7	5.6	4.8	0.8	0.8	0.4	2.5
TiO_2	1.5	2.0	2.2	1.5	1.5	0.3	1.2	0.8	0.5
CaO	2.7	4.0	7.8	8.9	21.4	4.7	4.7	15.8	17.5
MgO	0.1	—	0.1	—	0.5	15.4	0.1	0.2	1.8
K_2O	—	—	0.4	—	0.2	—	0.1	0.4	0.1
Na_2O	—	—	—	—		—			
FeO	—	—	—	—	—	12.3	—	—	—
Cr_2O_3	—	—	—	—	—	28.5	—	—	—
Misc.	—	0.4	0.1	0.9	—	—	—	—	trace
Ig. Loss	0.2	—	0.3	1.2	0.8	0.7	1.1	1.0	2.8

Thermal Conductivity

CONDUCTIVITY: BTU IN. PER SQ FT PER F PER HR

MEAN TEMPERATURE, F

	800	1000	1200	1400	1600	1800	2000
3X Firecrete	—	7.0	7.2	7.5	7.8	8.4	8.4
H.T. Firecrete	—	4.45	4.76	5.08	5.41	5.74	—
Standard Firecrete	4.16	4.34	4.59	4.88	5.19	5.52	—
L.W. Firecrete	1.99	2.09	2.21	2.36	2.56	2.82	—
CA Insulating Firecrete	—	2.57	2.70	2.90	3.12	3.33	3.85
JM-20 Firecrete	1.43	1.50	1.57	1.65	1.75	1.87	—
C-31 M Refractory Cement	—	6.0	6.1	6.3	6.5	6.7	6.9
2200 CA Insulating Firecrete	—	1.50	1.57	1.65	1.75	1.87	1.98
Lo-D Firecrete	—	.96	1.16	1.26	1.36	1.46	1.56

Compliance with Government Specs

Lo-D Firecrete complies with MIL-C-19794A

Packaging Information

- 3X Firecrete .... 100-lb bags
- H.T. Firecrete .... 100-lb bags
- Standard Firecrete .... 50 or 100-lb bags
- L.W. Firecrete .... 100-lb bags
- CA Insulating Firecrete .... 100-lb bags
- JM-20 Firecrete .... 80-lb bags
- C-31 M Refractory Cement .... 100-lb bags
- Lo-D Firecrete .... 50-lb bags
- 2200 CA Insulating Firecrete .... 80-lb bags

J-M Firecrete APPLICATION INSTRUCTIONS

Mixing: Firecrete hardens rapidly, therefore water should not be added until the job is ready for application. Only clean, fresh water should be used. The amount of water will vary depending upon the size, shape and type of installation. Mix thoroughly after addition of water and adjust to proper percentage. Avoid an excess of water in order to obtain maximum structural strength in the refractory concrete. If cast against a porous material it is necessary to waterproof, or thoroughly wet, the surface to prevent water being taken from the refractory mixture.

Casting: Forms for casting shapes can be made of either wood or metal. Wooden forms should be coated with shellac to prevent the absorption of water. If necessary, wooden forms can be burned away without damage to the refractory. If more than one shape is to be cast, heavy metal forms are more satisfactory. They should be smooth and coated with oil or grease to permit the easy removal of shapes. The refractory mixture should be "rodded" with a blunt-end tool until all corners are filled and air pockets eliminated. The use of vibrating equipment is recommended.

Curing and Firing: Firecrete air-hardens sufficiently in six hours to permit the removal of forms if necessary. For linings or large shapes, it is preferable to air cure for 12 hours or longer before firing. In firing, apply heat slowly and without interruption until temperature is brought above service-operating conditions.

Preparation of Door Frames: A door which is less than 4 sq ft in area generally requires no reinforcing to hold the refractory in place. On larger doors, however, it is necessary to provide the refractory with some means of anchorage. Rods with bent ends or bolts with washers and nuts are generally used. Although such anchorage is necessary, best practice suggests that it be kept at a minimum, both in thickness and number.

All bolts or rods, spaced on about 24" centers, should extend through approximately one-half the thickness of the refractory and, where possible, be placed in a staggered construction. The maximum diameter of the bolts or rods generally used is ½". Anchors should not be placed at the corners of the door. Wrap rods with friction tape to allow for expansion.

Storage: Firecrete should be stored in a cool, dry place as exposure to moisture will cause the material to harden.

ESTIMATED POUNDS OF DRY MATERIAL REQUIRED
PER CU FT OF CONSTRUCTION
(no allowance made for waste)

Type of Firecrete	Lbs/cu ft
3X Firecrete	130
H. T. Firecrete	110
Standard Firecrete	110
L. W. Firecrete	75
CA Insulating Firecrete	75
JM-20 Firecrete	58
2200 CA Insulating Firecrete	57
Lo-D Firecrete	44
C-31 M Refractory Cement	175

ESTIMATED POUNDS OF WATER REQUIRED PER
100 LBS OF CEMENT

Type of Firecrete	Lbs water/ 100 lbs of Cement
3X Firecrete	12
H. T. Firecrete	18
Std. Firecrete	17
L. W. Firecrete	45
CA Insulating Firecrete	44
JM-20 Firecrete	66
Lo-D Firecrete	110
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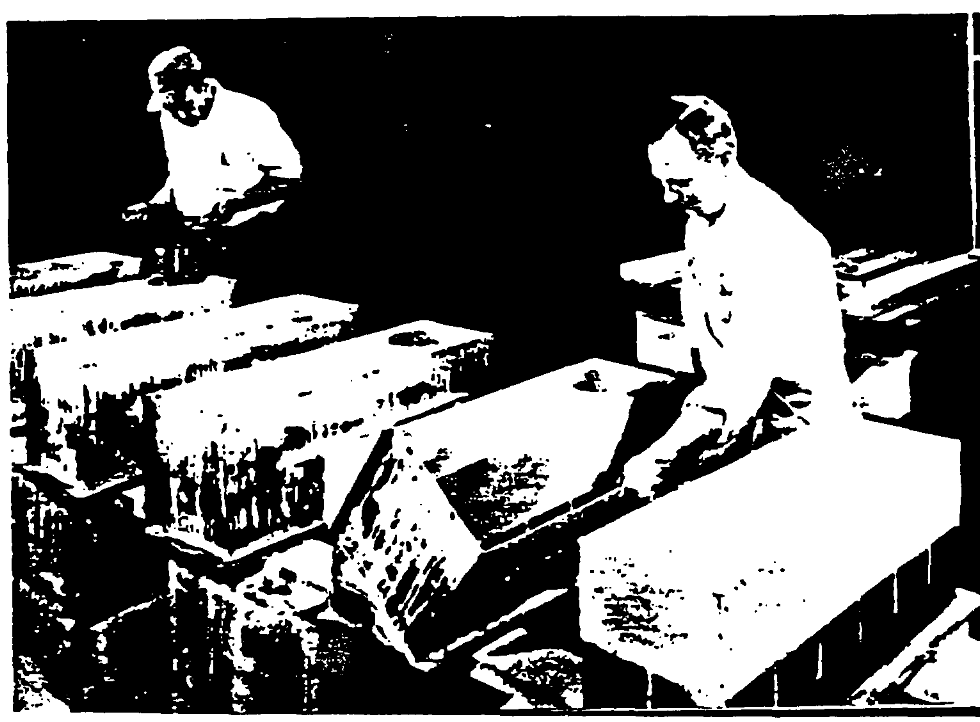

J-M Blazecrete (FOR GUNNING AND SLAP-TROWELING APPLICATIONS)

DESCRIPTION: Four types of dry monolithic, hydraulic-setting refractories have been developed and produced by Johns-Manville for gunning and slap-troweling applications.

These four refractories are especially adaptable for gun application in building new refractory linings and repairing old ones. They adhere readily with a minimum of loss when "shot" in place. Mixed with water at the gun nozzle, they are pneumatically projected with great force, resulting in a dense, homogeneous lining.

Blazecrete is equally effective for heavy patching by troweling, especially where brickwork has eroded deeply. It eliminates the laborious ramming or tamping required with "plastics", and patches need not be prefired.

AVAILABLE TYPES:

3X Blazecrete—High alumina refractory for service to 3000F. Particularly adaptable for gun applications and for heavy patching by slap-troweling.

Standard Blazecrete—Aluminum silicate refractory for service to 2400F.

L. W. Blazecrete—Lightweight aluminum silicate refractory for service to 2000F. Used extensively for stack linings, heaters and other applications where gunning mix with low rebound loss is required.

C-2 Refractory Cement—High strength aluminum silicate refractory for service to 2300F. Used to advantage in making a protective abrasion-resistant refractory surface over L. W. Blazecrete.

USES: Recommended for lining or patching forge furnaces, ashpits, cyclones, heaters, boilers, oil refining equipment, furnace bottoms, ladles and similar applications. L. W. Blazecrete is extensively used on tanks, structural steel and skirts for fire protection purposes.

Specification Data

*Physical Properties**

	3X	STD.	L.W.	C-2 Cement
Highest Recommended Service Temperature	3000F	2400F	2000F	2300F
Pyrometric Cone Equivalent	33 (3173F)	16 (2669F)	14 (2552F)	15 (2608F)
Weight Slap Troweled:				
As Placed	148 pcf	132 pcf	104 pcf	140 pcf
Oven Dried at 220F	133 pcf	116 pcf	69 pcf	126 pcf
After 5-Hr Firing at 1750F	130 pcf	110 pcf	65 pcf	120 pcf
Weight Gunned:				
As Placed	153 pcf	134 pcf	117 pcf	142 pcf
Oven Dried at 220F	142 pcf	124 pcf	76 pcf	134 pcf
After 5-Hr Firing at 1750F	140 pcf	118 pcf	73 pcf	128 pcf
Crushing Strengths After 5 Hours Firing at:				
220F	570 psi	1350 psi	500 psi	6200 psi
1200F	700 psi	1070 psi	500 psi	4700 psi
1750F	790 psi	1130 psi	600 psi	2600 psi
2200F	1040 psi	1480 psi	(A)	2700 psi
2400F	2390 psi	2870 psi	(A)	(A)
Linear Shrinkage After 5 Hours Firing at:				
1200F	0.0%	0.1%	0.3%	0.2%
1750F	0.0%	0.4%	0.6%	0.2%
2200F	0.2%	0.6%	(A)	0.1%
2400F	0.2%	0.4%	(A)	(A)

*The figures given in this table are average values obtained in accordance with accepted test methods.
(A) Above recommended temperature limit.

Calculated Chemical Analysis

Material Composition	3X Blazecrete	Standard Blazecrete	L.W. Blazecrete	C-2 Cement
SiO_2	38.0	41.8	33.6	40.0
Al_2O_3	53.9	43.1	38.0	33.4
Fe_2O_3	1.7	4.2	4.1	7.9
TiO_2	2.6	2.2	1.3	—
CaO	2.0	6.7	19.9	13.6
MgO	—	0.1	0.4	—
K_2O	—	0.3	0.3	1.1
Na_2O	trace		—	0.2
Misc.	trace	0.1	—	0.1
Ig. Loss	1.3	1.5	2.0	0.5

Thermal Conductivity

CONDUCTIVITY: BTU IN. PER SQ FT PER F PER HR

Mean Temperature F	3X Blazecrete	Standard Blazecrete	L.W. Blazecrete	C-2 Refractory Cement
800	—	3.89	1.26	—
1000	4.10	3.95	1.43	3.40
1200	4.30	4.05	1.59	3.50
1400	4.68	4.24	1.76	3.80
1600	5.40	4.57	1.92	4.30
1800	6.35	5.09	2.08	5.10
2000	7.68	—	—	5.90

Packaging Information

3X Blazecrete .... 100-lb bags
Standard Blazecrete .... 100-lb bags
L.W. Blazecrete .... 80-lb bags
C-2 Refractory Cement .... 100-lb bags

Preparation of Surface All surfaces should be clean and free of loose scale or other foreign material. When Blazecrete is applied to worn brickwork or other refractories, the surface should be chipped to expose raw solid material. Metal should be cleaned by wire brushing, steam, or sandblasting to provide a satisfactory surface.

Reinforcement As a general rule, reinforcement is not required when Blazecrete is gunned on a sloping or flat surface because gravity will hold it in place. However, on vertical walls or overhead areas, except for patching, reinforcement should be used to hold the refractory in place.

Where continuous reinforcing is unnecessary, rods with bent ends or bolts with washers and nuts should be used. All bolts or rods, spaced on about 24" centers, should extend through approximately one-half the thickness of the refractory and where possible be placed in a staggered arrangement. Use bolts or rods with a maximum diameter of ½". Friction tape wrapped around the bolts or rods will permit expansion of the metal under heat.

For continuous reinforcement, welded wire fabric or hexagonal steel grating is recommended. A wire fabric should be spaced midway in the refractory and held in place with suitable studs, lag bolts, or other means. When more than one type material is to be applied, include a reinforcing mesh in each layer. For thin linings, hexagonal steel grating ¾" or 1" thick with openings approximately 1¾" x 1¾" x 14 gauge should be tack welded to the equipment and the refractory applied flush to the surface of the hexagonal mesh.

Gunning Follow the standard methods of gunning as recommended by gun manufacturers. It is helpful to pre-moisten Blazecrete before placing it in the gun hopper. This can be done by first putting the Blazecrete in a concrete mixer and adding a small amount of water. After thorough mixing, the Blazecrete should be just slightly damp, but not enough to ball up. Pre-moistened Blazecrete tends to take on additional water at the gun nozzle more readily and the amount of dust and rebound is kept to a minimum. Some guns premix water with the cement before reaching the gun nozzle.

Do not apply refractory through grating or mesh with openings of less than 4" if the shell of the vessel or the insulating surface is more than 1" from the underside of the mesh or grating. A given area should be finished if there is to be a lapse of time before the entire job is completed. When work is resumed, the contact surface of the material which has already been applied should be roughened, cleaned and wet.

When Blazecrete is used in double layers, the first layer should still be wet when applying the second layer. Do not use rebound material.

Troweling Mix Blazecrete thoroughly with clean, fresh water until a stiff consistency is obtained so that it can be readily placed by slap-troweling.

Curing and Firing It is preferable to air cure Blazecrete for 12 hours or longer before firing. Heat slowly and without interruption, bringing temperature above the service operating conditions.

Product type	Estimated Pounds of Refractory Required for 1 Cubic Foot (No allowance made for waste)	Estimated Pounds of Water Required for 100 lbs. of Cement
3X Blazecrete	130 (slap-troweling) 140 (gunning)	14
Standard Blazecrete	110 (slap-troweling) 118 (gunning)	18
L.W. Blazecrete	65 (slap-troweling) 73 (gunning)	53
C2 Refractory Cement	120 (slap-troweling) 140 (gunning)	15

purpose of J-M Refractory Cement in laying re brick is to bond together many relatively small nits into a stable, strong and gas-tight structure. he nature of the cement or mortar used, and the anner applied largely determine the strength and fficiency of the refractory masonry.

Use of the proper mortar for the particular condi-ion involved assures correct bonding, protection of joints against slag, resistance against passage of gases, and reduction in spalling difficulties.

To fulfill the many different service requirements, J-M provides several different types of mortars or cements which are classified under "Ready-Mixed, Air-Setting" and "Dry, Heat-Setting."

Ready-Mixed, Air-Setting Cements (Mortars)

BLAKITE REFRACTORY CEMENT

A highly refractory, ready-mixed, air-setting cement which possesses high water-retention properties, making it adaptable for laying insulating fire brick. Furnished in a consistency suitable for shallow patching, Blakite can also be used for laying fireclay, super duty and high alumina refractory brick. It is dark gray in color. Temperature to 3200F.

SUPER BLAKITE

Used for coating over vertical industrial boiler tubes, shallow patching, and laying brick. Temperature to 3000F.

HELLITE REFRACTORY CEMENT

A general purpose, air-setting cement which is finely ground, ready-mixed, plastic and pink in color. Used for setting hard brick with troweled or dipped joints, for wash-coating and especially for shallow patching, either hot or cold surfaces. Can be used up to 3000F.

NO. 20 REFRACTORY CEMENT

An air-setting cement, gray in color, for use where an extra hard air set is desired. Used up to 2700F for setting hard brick with a rubbed joint, and for wash-coating. When desired to use old fire brick as a patching material or monolithic fill, No. 20 is thinned with water and the crushed brick added.

Bonding brick: All types of air-setting cements retain easy workability even though kept in storage for long periods. These mortars can be thinned with water to suit the porosity of the brick to be bonded. Full directions are furnished with each cement shipment.

To obtain maximum workability and best results, the mortars should be thoroughly mixed before using. If a thinner consistency is desired, small quantities of water are slowly added—re-mixing thoroughly after each addition until desired consistency is obtained. An excess of water should be avoided.

Wash-coating brick: When Hellite, No. 20 and No. 32 (see below) are used for wash-coating, the setting should be thoroughly cleaned and the cement mixed with sufficient water to bring it to a thin grout consistency. The mixture is applied to the face of the brickwork with a stiff brush or broom, working it well into the cracks and pores in the brick. It is important to apply the mixture thinly in order to prevent flaking.

When old settings have to be scarified in cleaning, it is necessary to thoroughly remove all dust particles before wash-coating. This can be accomplished by carefully blowing out dust with an air gun or by hosing out the crevices and washing the walls with water.

Dry, Heat-Setting Cements (Mortars)

NO. 31 & NO. 32 REFRACTORY CEMENT

The above mortars are heat-setting used for laying hard brick. No. 31 is recommended for thick joints and is a coarse material. No. 32 is similar to No. 31 Cement, but has a finer grind. It is recommended for dipped joints. Recommended up to 3100F.

When preparing No. 31 and No. 32 cements, water is mixed with the cement to provide the proper consistency. Clean, fresh water is required; the quantity depending upon the porosity of the brick which can best be found by trial. The mortar should be thoroughly mixed and free from lumps. Maximum workability is obtained by allowing the mortar to "temper" after mixture with water. Long periods of tempering will not cause deterioration.

Dry, Air-Setting Cements (Mortars)

NO. 26 REFRACTORY CEMENT

A coarse, dry cement which takes a medium air set. Used for setting fire brick with a medium bond joint. In special cases also recommended for hot or cold shallow patching, cement gun work and rammed linings. For temperatures to 2900F.

Calculated Chemical Analysis

Wet Cements*

Material Composition	#20 Cement	Hellite	Firelite	Blakite	Super Blakite
SiO_2	90.8	49.6	85.4	48.8	48.1
Al_2O_3	5.1	37.8	6.4	43.2	43.1
Fe_2O_3	—	2.5	0.1	1.2	1.6
TiO_2	—	2.2	—	1.5	1.4
CaO	—	0.6	—	0.3	0.3
MgO	—	0.1	—	—	—
K_2O	—	1.4	—	0.8	0.9
Na_2O	3.3	1.8	6.1	2.4	2.7
Misc.	0.8	0.4	—	—	—
Ig. Loss	—	3.6	2.0	1.8	1.7

*Analysis is on a dry basis.

Packaging Information

Blakite and No. 20 Refractory Cement—200, 100, 50, 25, 15, 10 and 5-lb containers

Super Blakite and Hellite—200, 100 and 50-lb containers.

No. 26, 31 and 32—100-lb bags.

J-M Lightweight Refractory Aggregates and Fills

Johns-Manville lightweight aggregates and fills serve for making insulating refractory concretes and as granular fills for packing irregular or otherwise inaccessible spaces to provide insulation on high-temperature equipment.

These lightweight aggregates and fills include the following products: JM-Zelie, JM-2400, Sil-O-Cel C-3, Sil-O-Cel Insulating Powder and Sil-O-Cel Coarse Grade. Sil-O-Cel Insulating Powder and Coarse Grade are used as fills only.

When used as fills, the products are worked into place in their original dry form. When used as an insulating refractory concrete for various operating conditions, the aggregates (JM-Zelie and 2400) are mixed with calcium aluminate cement. Sil-O-Cel C-3 can be used when mixed with either calcium aluminate cement or portland cement. The insulating refractory concrete is used for constructing foundations and bases of heated equipment, furnace doors, and many special shapes such as baffles and dampers.

All of these products are invaluable for the conservation of heat where other forms of insulation cannot be economically installed because of surface irregularities or lack of space. They are also excellent for the many industrial requirements which demand satisfactory insulating refractory cements.

Specification Data

Name	Composition	Temperature limit, F	Approx. density to which fills are normally packed, lbs per cu ft	Packaging
JM-2400 L.W. Aggregate	al. silicate	2400	50	80-lb bags
JM-Zelie L.W. Aggregate	al. silicate	2400	31	50-lb bags
Sil-O-Cel C-3	calcined, coarse-graded diatomaceous silica	2000	31	50-lb bags
Sil-O-Cel Insulating Powder	finely ground diatomaceous silica	1600	17	50-lb bags
Sil-O-Cel Coarse Grade	similar to Sil-O-Cel Insulating Powder, but coarsely ground	1600	22	50-lb bags

J-M Insulating Refractory Concretes

The lightweight aggregates (JM-Zelie and 2400) and Sil-O-Cel C-3, in the form of insulating refractory concretes, can be formed into any shape desired. The tables following give typical mixtures based upon average values obtained from uniform, well-tamped or cast insulating concrete. In every case, excessive water is detrimental to the strength of the insulating concrete and should be avoided.

Sil-O-Cel C-3 Insulating Concrete

	Tamping Consistency*	
	Sil-O-Cel C-3 mixed 4 to 1 by Volume	
	with Portland Cement	with Calcium Aluminate Cement
Loose Density, Sil-O-Cel C-3, lb per cu ft.	23 to 28	23 to 28
Approx. Ratio by Weight (Sil-O-Cel C-3 to cement).	50-50	50-50
Mixing Water by Weight, percent	86	80
Yield, Dry Mix per cu ft, lb	50.5	54
Maximum Service Temperature, F.	1800	1800

*Avoid excessive water.

JM-Zelie L. W. Concrete

	JM-Zelie mixed 3 to 1 by Volume with Calcium Aluminate Cement	
	Tamping Consistency*	Casting Consistency*
Loose Density, JM-Zelie, lb per cu ft.	41	41
Approx. Ratio by Weight (JM-Zelie to cement).	57-43	57-43
Mixing Water by Weight, percent	65	68.5
Yield, Dry Mix per cu ft, lb	62	58
Maximum Service Temperature, F.	2000	2000

*Avoid excessive water.

Sil-O-Cel C-3 Insulating Concrete: First thoroughly mix Sil-O-Cel C-3 with water (16 gallons of water per 100 lb of Sil-O-Cel C-3), then add portland or calcium aluminate cement and thoroughly mix with the wetted Sil-O-Cel C-3 to the desired working consistency.

The homogeneous mixture is then placed in the required form, reinforced if necessary, and tamped with a heavy metal tamper until the required thickness is obtained. Sufficient force must be used in tamping to provide a uniform, coherent mass, free from voids. The form is then covered with a damp cloth and kept wet for not less than 48 hours, then dried slowly in a warm, well-ventilated place, and finally subjected to a slow initial heat until all the water has been eliminated.

When a mechanical mixer is used, part of the water should be poured into the mixer before the dry Sil-O-Cel C-3 is added, and the inside of the drum thoroughly flushed. (This prevents the Sil-O-Cel C-3 from balling-up in lumps and sticking to the walls.)

The dry Sil-O-Cel C-3 and remaining water should then be put in the mixer and thoroughly mixed. From this point, the procedure is the same as described above.

With a mechanical mixer, each batch of Sil-O-Cel C-3 Insulating Concrete should be completed in from four to five minutes.

JM-Zelie L. W. Concrete: The aggregate and calcium aluminate cement are first thoroughly mixed. Then water is added slowly to obtain the desired tamping or casting consistency. For higher temperature conditions, JM-2400 L. W. Aggregate can be used. This aggregate is generally handled in the same manner as JM-Zelie Aggregate.

■ *J-M Cerafelt* REFRACTORY FIBER FELT

DESCRIPTION: J-M Cerafelt is a lightweight, refractory-fiber insulation notable for its excellent thermal and chemical stability. Made predominantly of alumina and silica, it combines lightness, heat resistance, low conductivity and high sound-absorption qualities.

AVAILABLE FORMS: Furnished in densities ranging from 3 to 24 lbs. per cu. ft. Also available in loose form (J-M CERAFIBER) in 25-lb. bags.

USES: Recommended for a great variety of high temperature industrial applications such as insulation protection in repairing open hearth roofs; on cover-type annealers to fill openings for electrical access; expansion joints in kilns, furnaces and boiler walls.

ADVANTAGES

High Heat Resistance

Will withstand continuous exposure to a full 2000F.

Low Thermal Conductivity

Unusually low conductivity at high temperatures due to opacity of basic fibers to infra-red radiation.

Light Weight

Weighs as little as 1/40 equal volume of hard fire brick.

Chemically Stable

Non-alkaline and chemically stable. Contains no corrosion-promoting agents.

■ *Thermal Conductivity*

CONDUCTIVITY: BTU IN. PER SQ FT PER F PER HR

Density	MEAN TEMPERATURE, F							
lbs per cu ft	300	400	500	600	700	800	900	1000
3	.40	.48	.57	.68	.80	.93	1.08	1.25
4	.38	.44	.52	.61	.71	.82	.94	1.07
6	.36	.41	.47	.54	.62	.70	.79	.89
8	.34	.39	.45	.51	.57	.64	.72	.81
10	.33	.38	.43	.49	.55	.61	.68	.76
12	.33	.37	.42	.47	.53	.59	.65	.72
14	.33	.37	.41	.46	.51	.57	.63	.69
18	.32	.36	.40	.45	.50	.55	.60	.65
24	.31	.35	.39	.44	.48	.53	.58	.62

■ *Standard Densities & Thicknesses*

Type	Density* lbs per cu ft	Available Thicknesses,* Inches 1/8	3/16	1/4	3/8	1/2	3/4	1	1½	2
CRF-300	3				0	0	0	0	X	X
CRF-400	4			0	0	0	0	0	X	
CRF-600	6			0	0	0	0	X	X	
CRF-800	8	0	0	0	0	0	0	X		
CRF-1000	10	X	X	X	X	X	X	X		
CRF-1200	12	X	X	X	X	X	X	X		
CRF-1400	14	X	X	X	X	X	X			
CRF-1800	18	X	X	X	X	X				
CRF-2400	24	X	X	X	X	X				

*Other thicknesses and densities available on request
0 denotes availability of 4' and 8' sheets and 26' rolls
X denotes availability of 4' and 8' sheets only
Standard width is 42 inches

Glossary of terms relating to refractories

Abrasion of Refractories.—Wearing away of refractory surfaces by the scouring action of moving solids.

Air-Setting Refractory Mortar.—A composition of finely ground materials, marketed in either a wet or dry condition, which may require tempering with water to attain the desired consistency and which is suitable for laying refractory brick and bonding them strongly upon drying and upon subsequent heating at furnace temperatures.

Bloating of Refractories.—Substantial swelling produced by a heat treatment that causes the formation of a vesicular structure.

Bond Fire Clay.—See Fire Clay, Plastic or Bond.

Burn (*n*).—The heat treatment to which refractory materials are subjected in the firing process.

Burning (Firing) of Refractories.—The final heat treatment in a kiln to which refractory brick and shapes are subjected in the process of manufacture for the purpose of developing bond and other necessary physical and chemical properties.

Calcine or Calcines (*n*).—Refractory material, often fireclay, that has been heated to eliminate volatile constituents and to produce desired physical changes.

Calcining of Refractory Materials.—The heat treatment to which raw refractory materials are subjected, preparatory to further processing or use, for the purpose of eliminating volatile chemically combined constituents and producing volume changes.

Corrosion of Refractories.—Destruction of refractory surfaces by the chemical action of external agencies.

Diaspore Clay.—A rock consisting essentially of diaspore bonded by fire clay.

Dolomite, Calcined Refractory.—Raw refractory dolomite that has been heated to a temperature sufficiently high and for a long enough time to decompose the carbonate structure and remove volatile constituents.

Dolomite, Dead-Burned Refractory.—Raw refractory dolomite that has been heated with or without additives to a temperature sufficiently high and for a long enough time to decompose the carbonate structure so as to form calcium oxide and periclase in a matrix that provides resistance to subsequent hydration and recombination with carbon dioxide.

Double-Screened Ground Refractory Material.—A refractory material that contains its original gradation of particle sizes resulting from crushing, grinding, or both, and from which particles coarser and finer than two specified sizes have been removed by screening.

Erosion of Refractories.—Wearing away of refractory surfaces by the washing action of moving liquids.

Erosion of Refractories.—Wearing away of refractory surfaces by the washing action of moving liquids.

Firebrick.—A broad term covering any type of refractory brick used more narrowly to mean fireclay brick.

Firebrick, Insulating.—A refractory brick characterized by low thermal conductivity and low heat capacity.

Fire Clay.—An earthy or stony mineral aggregate which has as the essential constituent hydrous silicates of aluminum with or without free silica, plastic when sufficiently pulverized and wetted, rigid when subsequently dried, and of suitable refractoriness for use in commercial refractory products.

Fire Clay, Nodular.—A rock containing alun ous or ferruginous nodules, or both, bonded by fire clay.

NOTE.—In some districts such clays are called "burley" or "burley flint" clay.

Fire Clay, Plastic or Bond.—A fire clay of sufficient natural plasticity to bond nonplastic materials.

Fireclay Plastic Refractory.—A fireclay material tempered with water and suitable for ramming into place to form a monolithic furnace lining that will attain satisfactory physical properties when subjected to the heat of furnace operation.

Flint Fire Clay.—A hard or flint-like fire clay occurring as an unstratified massive rock, practically devoid of natural plasticity and showing a conchoidal fracture.

Grog.—A granular material produced from calcined or burned refractories, usually alumina-silica.

Grog Fireclay Mortar.—Raw fire clay mixed with calcined fire clay, or with broken fireclay brick, or both, all ground to suitable fineness.

Ground Fire Clay.—Fire clay or a mixture of fire clays that have been subjected to no treatment other than grinding or weathering, or both.

Ground Fireclay Mortar.—A refractory mortar consisting of finely ground raw fireclay.

Molten Cast Refractory.—A solidified material made by melting refractory ingredients and pouring into molds.

Mortar, Heat Setting.—A refractory mortar of finely ground materials whose potential strength is dependent on use at furnace or process temperatures.

Mortar, Refractory.—A finely ground preparation which becomes plastic and trowelable when tempered with water and is suitable for laying and bonding refractory brick.

Mullite Refractories.—Refractory products consisting predominately of mullite ($3Al_2O_3 \cdot 2SiO_2$) crystals formed either by conversion of one or more of the sillimanite group of minerals or by synthesis from appropriate materials employing either melting or sintering processes.

Permanent Linear Change.—The per cent dimensional change in length (based on original length) of a refractory specimen free of externally applied stresses, after being subjected to a prescribed heat treatment.

Plastic Refractory.—A refractory material, tempered with water, that can be extruded and that has suitable workability to be pounded into place to form a monolithic structure.

Porosity.—The percentage of the total volume of a material occupied by both open and closed pores.

Pyrometric Cone Equivalent (*PCE*).—The number of that Standard Pyrometric Cone whose tip would touch the supporting plaque simultaneously with a cone of the refractory material being investigated when tested in accordance with the Method of Test for Pyrometric Cone Equivalent (PCE) of Refractory Materials (ASTM Designation: C 24).

Quartzite (Ganister).—For refractories, a rock consisting predominantly of the mineral quartz suitable for the manufacture of silica brick and characterized by a high SiO_2 content and a low percentage of impurities.

NOTE.—Confusion sometimes results from the use of the term ganister because it is also applied in some parts of the United States to crushed firebrick or to a mixture of crushed firebrick or silica rock with clay for use in tamped linings.

Ramming Mix.—A refractory material, usually tempered with water, that cannot be extruded but that has suitable properties to permit ramming into place to form a monolithic structure.

Refractories (*n*).—Materials, usually non-metallic, used to withstand high temperature.

Refractories, Acid.—Refractories containing a substantial amount of silica that may react chemically with basic refractories, basic slags, or basic fluxes at high temperatures.

Refractories, Basic.—Refractories whose major constituent is lime, magnesia, or both, and which may react chemically with acid refractories, acid slags, or acid fluxes at high temperatures.

NOTE.—Commercial use of this term also includes refractories made of chrome ore or combinations of chrome ore and dead-burned magnesite.

Refractories, Neutral.—Refractories that are resistant to chemical attack by both acid and basic slags, refractories, or fluxes at high temperatures.

Refractoriness.—In refractories, the property of being resistant to softening or deformation.

Refractory (*adj*).—Resistant to high temperature.

Reheat Behavior.—The changes in length or volume taking place in a fired refractory when subjected to a reheat test.

Reheat Test.—The prescribed heat treatment of a fired refractory free of externally applied stresses to determine its linear or volume stability by measurements before and after the heating.

Shrinkage.—The decrease in dimension of a refractory material during manufacture or service.

Silica Fire Clay.—A refractory mortar consisting of a finely ground mixture of quartzite, silica brick, and fire clay of various proportions.

NOTE.—Sometimes called silica cement by the trade.

Silicon Carbide Refractories.—Refractory products consisting predominantly of silicon carbide.

Slagging of Refractories.—Destructive chemical reaction between refractories and external agencies at high temperatures resulting in the formation of a liquid.

Spalling of Refractories.—The cracking or rupturing of a refractory unit, which usually results in the detachment of a portion of the unit.

Spalling of Refractories, Mechanical.—The spalling of a refractory unit caused by stresses resulting from impact or pressure.

Spalling of Refractories, Structural.—The spalling of a refractory unit caused by stresses resulting from differential changes in the structure of the unit.

Spalling of Refractories, Thermal.—The spalling of a refractory unit caused by stresses resulting from nonuniform changes of the unit produced by a difference in temperature.

Stopper Head.—A rounded refractory shape, usually made from clay and graphite, providing a valve head seating into a nozzle brick, this assembly forming a metal flow control for bottom-pouring ladles.

Thermal Expansion.—The reversible change in size of materials due to termperature changes.

Unburned Brick.—Brick manufactured by processes that do not involve firing of the finished product.

Zircon Refractory—Refractory products consisting substantially or entirely of zirconium orthosilicate ($ZrSiO_4$).

Zirconium Oxide Refractory.—Refractory products consisting substantially of zirconium dioxide.

COLOR-TEMPERATURE CONVERSION

The cover of this catalog illustrates graphically the approximate relationship between color and temperature in the common furnace operating ranges.

Johns-Manville
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Offices in all Large Cities

IN-481A 12-63

LITHO IN U.S.A.