THE CERAMIC TILE INDUSTRY IN CANADA

AND

THE PRACTICALITY OF ADDITIONAL MANUFACTURING FACILITIES

DEPARTMENT OF REGIONAL ECONOMIC EXPANSION

PEAT MARWICK AND PARTNERS

DECEMBER, 1974

PEAT MARWICK AND PARTNERS

Management Consultants

1155 Dorchester Blvd. W.
Montreal, Quebec H3B 2J9
Phone (514) 866-4961

December 30, 1974

Mr. P. W. Trubey
Regional Development Officer
Department of Regional
Economic Expansion
800 Place Victoria
Montreal, Quebec

Dear Mr. Trubey:

Enclosed are twenty-five copies of our report on the ceramic tile industry in Canada and the practicality of additional manufacturing facilities.

After an extensive analysis of the domestic production and marketing situation and brief review of the principle producers in Britain and Germany, we conclude that there is room for additional domestic production capacity in Canada. The current domestic production capability which is equivalent to approximately 25% of the domestic demand could be increased up to 70 - 80% of the domestic demand over the next several years. Because of the apparent lack of the industry to expand on its own, the Government should act as the principle instigator to bring about this logical expansion of domestic production capacity.

While we have made a number of presentations to you on the status of our findings, throughout the study, we enclose herein our report with the necessary detailed findings.

We would like to acknowledge the co-operation received from your office during the conduct of the assignment.

Yours truly,

PEAT, MARWICK AND PARTNERS

/lg

THE CERAMIC TILE INDUSTRY IN CANADA

and

THE PRACTICALITY OF ADDITIONAL MANUFACTURING FACILITIES

THE DEPARTMENT OF REGIONAL ECONOMIC EXPANSION

December, 1974

THE DEPARTMENT OF REGIONAL ECONOMIC EXPANSION

THE CERAMIC TILE INDUSTRY IN CANADA

and

THE PRACTICALITY OF ADDITIONAL MANUFACTURING FACILITIES

TABLE OF CONTENTS

TABLE OF CONTENTS

APPENDICES

TABLES

TABLE OF CONTENTS

I - SUMMARY

The Canadian ceramic tile industry has seen its share of market decline to an all time low of around 25% this year. After the bankruptcies of several manufacturers a few years ago, there are now only five plants in operation in Canada, three of which are affiliated with foreign manufacturers. Another is owned by a developer/distributor of a full line of floor coverings, and the fifth has just entered the market. North American imports of ceramic tiles have increased steadily and dramatically both in Canada and in the United States.

Our analysis explores the reasons behind this phenomenon in order to develop recommendations on the overall practicality of Canadian production. Our presentation of findings includes three major sections, the Market, Manufacturing, and Conclusions and Recommendations. Detailed analyses are included as Appendices.

OBJECTIVES

The specific objectives of our consulting assistance program are to study the present status of the ceramic tile industry and to assess the practical opportunities in Canada for the further development of domestic manufacturing capacity. The complete terms of reference as described by the Ministry of Regional Economic Expansion are included as Appendix A.

SCOPE

This study comprises wall tiles, floor tiles, mosaic tiles, quarry tiles and any other special forms of ceramic tiles. It analyzes the marketing and manufacturing techniques of domestic and major overseas producers, and touches on the domestic raw material situation with particular attention to suitability and availability. The various influencing factors analyzed during the study are presented from the perspectives of the market, the various manufacturing processes and the economics of production.

CONCLUSIONS

Our principal conclusion is that additional production capacity is warranted. Other conclusions include

- the total Canadian ceramic tile market for 1974 is estimated to be 85 million square feet ($29 million) and is forecast to grow over the next five years at a rate of 7-8% per annum.
- approximately 64% of the Canadian market is concentrated in Quebec and Ontario. The major growth markets are the large decorative floor tiles for residential use and exterior quarry tiles for commercial, industrial and institutional applications.
- the major exporters to Canada are Japan (under 2½") and the United Kingdom and Italy (over 2½").
- the Canadian market is served mainly by five domestic manufacturers (including resale of imported tile) and one large independent importer.

- while the extent and quality of clay deposits along the St. Lawrence river basin have yet to be ascertained (beyond the scope of this study) it appears that such deposits are suitable for the manufacture of ceramic tile and could be exploited for new facilities located in this region of Quebec.

- Except for the International Brick & Tile Co., Canadian manufacturers use old equipment and carry out very little research and development. Their glazing techniques are not adequate for current market demands.

- Canadian suppliers are under-promoting their markets. Part of the success underlying greater European acceptance of ceramic tiles has been the ability of producers in conjunction with tile trade associations to educate the public on the use of ceramic tiles as a dynamic decorative factor.

RECOMMENDATIONS

Our major recommendation is that DREE should strongly encourage the expansion of the domestic ceramic tile production capability up to a capacity which is equivalent to approximately 70 - 80% of domestic consumption. Details of this recommendation are as follows:

- location of new facilities should be as close as possible to suitable clay deposits and metro markets which gives such sites as the Montreal region a preferred position.

- the minimum capacity for a new plant should be 8 to 10 million sq.ft. for a single product line manufacturing facility and 15 to 20 million sq.ft. for a multiple line facility.

- new plants are preferred as opposed to expanding existing domestic facilities due to the relatively high cost production techniques of domestic producers.

- the preferred company to establish new production facilities in Canada is an organization with a proven marketing, manufacturing, and distribution record with preference to one which is familiar with North American markets,
- government (both federal and provincial) should encourage the development of joint ceramic tile promotional programs to better aquaint the Canadian consumer with the distinct advantages of this product.

TABLE 1

APPARENT DOMESTIC

CONSUMPTION OF CERAMIC TILES

YEAR	DOMESTIC SHIPMENTS		IMPORTS		TOTAL CONSUMPTION	
	QUANTITY (SQ. FT. 000)	VALUE ($000)	QUANTITY (SQ. FT. 000)	VALUE ($000)	QUANTITY (SQ. FT. 000)	VALUE ($000)
1963	14,779	5,183	15,639	3,243	30,419	8,426
1964	18,717	6,297	18,560	3,894	37,277	10,191
1965	15,928	6,056	22,901	4,743	38,829	10,799
1966	11,862	5,706	21,862	4,408	33,724	10,114
1967	12,995	5,492	23,654	4,686	36,649	10,178
1968	12,117	5,286	25,367	4,952	37,484	10,238
1969	15,571	6,538	35,568	7,572	51,139	14,110
1970	13,558	5,755	30,195	6,320	43,753	12,075
1971	15,323	5,952	30,734	5,159	46,057	11,111
1972	17,941	7,091	51,004	11,378	68,945	18,469
1973			50,547	13,104		
(Average compound rate of growth)	2.2	3.5	14.0	15.0	9.5	9.1

SOURCE: Statistics Canada - July 1974

PEAT,
MARWICK
& PARTNERS

II - THE CANADIAN MARKET

The total Canadian market for ceramic tiles (all types) was approximately 69 million square feet in 1972 for a value of $18 million. The 1974 consumption may easily exceed 85 million square feet (equivalent to $29 million). Cumulative imports for 1974 to September were 52 million square feet. Domestic production for 1974 is estimated to be in the order of 19 million square feet. Approximately 64% of the market is concentrated in Quebec and Ontario. Between 70% and 80% of ceramic tiles are used on floors with the balance being used on walls.

The current gap between domestic market requirements and domestic production is now in the range of 66 million square feet and is expected to increase in the future if no additional manufacturing facilities are added. Apparent domestic consumption of ceramic tiles is illustrated in Table 1, opposite.

PRODUCT DEFINITION

A ceramic tile is defined as a pressed or extruded flat piece of clay, usually less than $1\frac{1}{4}$" in thickness, fired above red heat and used for flooring, wall and ceiling facing. Sizes of ceramic tiles vary from approximately 3/4" x 3/4" to 12" x 12" and more.

Squares and rectangular variations are most common but other geometric or special interlocking shapes are also used. Different types of tiles have different thicknesses.

Classification Problem

Classification of ceramic tiles is difficult. While their names usually imply their end use, most of these products are used interchangeably.

For example, in Canada, wall tiles are limited mainly to interior wall use. However, crystalline glazed wall tiles have been used in substantial quantities on residential bathroom floors, and mosaic tiles are used on both floors and walls.

Ceramic tiles which are often called floor tiles are used on interior and exterior walls. For these reasons we have chosen to use practical merchandizing definitions, that are easy to recognize from a consumer's point of view.

Wall Tiles

Ceramic tiles that have a facial area of six square inches or more are often called wall tiles. Wall tiles are almost always glazed, that is, covered with impervious, fused surfaces. These surfaces are smooth or textured and may be plain, coloured or patterned. Wall tiles are usually 1/8" to 1/4" thick, and have been traditionally made with white biscuit. This trend is decreasing as the applicators and the consumers have been educated to accept a non-white biscuit. These tiles are almost always installed singly.

Floor Tiles

Floor tiles are usually thicker 1/4" to 3/4" and may be as large as 12" x 12" or more. They are glazed or unglazed, with either a glossy or matt finish, and may be plain, coloured, or have complicated silk-screen patterns.

These tiles constitute the largest portion of tiles made and may have special features such as a slip-resistant or a frost-resistant finish for specific uses. Floor tiles are made increasingly with non-white biscuit as this composition is less expensive and stronger than tiles made with white biscuit.

TABLE 2

DOMESTIC SHIPMENTS AS % OF ESTIMATED MARKET

1962	50.1%
63	48.3
64	49.8
65	40.4
66	34.6
67	33.1
68	31.9
69	30.0
70	30.5
71	32.8
72	25.7

Mosaic Tiles

A ceramic tile having a facial area of less than $2\frac{1}{2}$" x $2\frac{1}{2}$", is called a mosaic tile. Generally this tile is $\frac{1}{4}$" thick, and is usually produced in rectangular shapes which are fitted together to form various designs.

Quarry or Paver Tiles

These tiles are generally thicker than floor tiles and are plainer. They are used mainly on non-residential floor and wall surfaces and are less expensive than both floor and wall tiles. While quarry tiles may be made of white or non-white bodies, the latter is preferred because of its cost and strength.

DOMESTIC PRODUCTION

Domestic shipments of ceramic tiles were relatively constant during the last decade. Annual shipments have grown at the average annual compound rate of approximately 2.2%, increasing by 3.2 million square feet from 14.7 million square feet, in 1963 to 17.9 million square feet in 1972. For the same period the sales value has increased more rapidly, at the average compound rate of 3.5% per annum.

Due to the slow growth in Canadian output of ceramic tiles and the rapid market growth for these wall and floor surfaces, the market share for domestic ceramic tile shipments in terms of square footage has been declining rapidly. By 1972, the market share for domestic production declined to 26% compared with 50% in 1962. (Table 2, opposite). The remainder of the market was supplied by imports.

TABLE 3

CERAMIC TILES MANUFACTURED IN CANADA

COMPANY	TYPE	SHAPE	SIZE	SURFACE	COLOUR	COMMENTS	APPROX. MFG. CAPACITY Sq.Ft.(1,000)
MAPLE LEAF CERAMIC INDUSTRIES (MONTREAL)	Wall tile, Mosaic glazed and unglazed	Square. Scored tiles which give mosaic appearance	$4\frac{1}{4}$" x $4\frac{1}{4}$"	Smooth glazed	few plain colours	owned by Olympia & York, developers, and distributors of imported tiles and of most surface covering material	6,000
H&R JOHNSON (CANADA) SOVEREIGN POTTERS LTD. (HAMILTON)	Wall tiles	Square, rectangle, octagon & special shapes	6" x 6" $4\frac{1}{4}$" x $8\frac{1}{2}$"	smooth textured glazed	plain colours, mixed colours patterned.	Imported biscuit from the U.K. is glazed in Canada	1,500
D.A. WHITE FRONTENAC TILE DIV. (KINGSTON)	Floor tiles Mosaic glazed and unglazed	Square, rectangle hexagon rounds	2" x 8" 4" x 8" 2" x 12" 4" x 12"	anti-slip hard finish glazed, unglazed	few colours	closely associated with H&R Johnson	[e] 4,000 to 5,000
CERATEC (ST. LAWRENCE CERAMICS) (QUEBEC CITY)	Wall tiles	Square	$4\frac{1}{4}$" x $4\frac{1}{4}$"	Smooth glazed	plain colours	closely associated with Villeroy and Boch Ltd. of Germany	4,500
INTERNATIONAL BRICK & TILE (EDMONTON)	Floor & wall tiles	rectangle	4" x 8"	glazed	plain colours	Entering the market this year - using mainly Canadian raw material and flyash	[e] 2,000

[e] estimated

Domestic manufacturers produce basic types of tiles required for floor and wall surfaces in interior and exterior applications. They tend to focus their attention to the "average tile". Not only are most of the tiles in the medium size range but, even more pronounced is the tendency towards a conservative range of colours and designs. To our knowledge only H&R Johnson has recently introduced production of blended colours and patterned tiles.

Industry sources, both domestic and foreign, expressed the opinion that the quality of the Canadian tiles is at least equal to, and often higher than that of similar tiles which are imported from leading European manufacturers.

While the domestic tile suffers from a basic cost disadvantage (price f.o.b. factory is in the order of 5-40% higher than the landed cost of imported tile), it relates closely to the colour (generally pastel) and decor requirements of sanitary ware manufacturers such as Crane or American Standard. Thus, the domestic tile currently enjoys a competitive situation in bathroom applications.

Canadian Producers and their Product Lines

There are five major manufacturers of ceramic tiles in Canada. Maple Leaf Ceramic Industries (1967) Ltd., Sovereign Potters Ltd. - H&R Johnson, Canada, D.A. White & Co. Limited Frontenac Floor and Wall Tile Division, Ceratec Inc. (formerly St. Lawrence Ceramics Ltd.), and International Brick and Tile Ltd. Table 3, opposite, illustrates their major product lines and their estimated manufacturing capacity.

Maple Leaf Ceramics Industries, located in Montreal, and Ceratec of Quebec City, manufacture a limited range of plain tiles in a variety of colours. Their competitor, H&R Johnson (Canada) Ltd., located in Hamilton, Ontario, glazes wall tile biscuit imported from the United Kingdom. These tiles are mainly plain and are available in many colours. The most popular size is $4\frac{1}{4}$" x $4\frac{1}{4}$" but sizes of 6" x 6" and $8\frac{1}{2}$" x $4\frac{1}{4}$" are also available. In addition to plain tiles, this manufacturer supplies tiles in which soft colours blend with a white background ($4\frac{1}{4}$" x $4\frac{1}{4}$"). Recently, the company introduced patterned tiles.

Frontenac Floor and Wall Tile Division, manufacture three lines (Morocco Versatile, Pioneer, Calvertex) of floor tiles which can also be used as wall tiles. All three come in few colours and in a variety of shapes and sizes. Their surfaces are glazed or unglazed and they can be applied to interior or exterior surfaces in any climate. Frontenac Tile wants to capitalize on the present shortage of quarry tiles.

International Brick & Tile have entered the ceramic floor tile/ quarry tile segment of the Canadian market. They are using a new raw material base (fly ash mixed with a white body) and began to market their products in Western Canada this Fall.

These manufacturers, except for International Brick & Tile, complement their own production with an extensive line of imported tiles in order to satisfy market demands. They market imports through their own channels of distribution and therefore compete in many instances with their own Canadian made products. For example, D.A. White Co. Ltd., imports and distributes Johnson glazed and spacer tiles, and Heatherbrown

Welsh tiles from Dennis Ruabon Limited in the United Kingdom. Ceratec of Quebec City markets tiles manufactured by Villeroy & Boch of Germany. Maple Leaf Industries of Montreal is owned by Olympia whose imports and products are varied in origin and line, including other surface covering materials such as vinyl asbestos, carpet, linoleum, and imported European tiles.

CANADIAN IMPORTS

Most of the ceramic tiles distributed and installed in Canada are imported from Italy, United Kingdom, Germany, Japan and countries such as The Phillipines, South Korea, and more recently, Brazil.

In Europe, Italy is the largest manufacturer of ceramic tiles and employs 40,000 people, exporting (to many countries) 376 million square feet of tiles in 1970. The country has a long established tradition in the production of tiles and can provide a large variety of types, shapes, sizes and colours for practically all applications. Italian tiles are more decorative than most products from any other origin and usually have outstanding designs, sometimes created by famous artists and designers. Similarly, the United Kingdom and Germany produce a wide range of high quality wall and floor ceramic tiles. Canada imports tiles in a limited range of sizes and colours which are, however, well adapted to the needs of the main segments of the building construction market.

H&R Johnson of the United Kingdom has a subsidiary (H&R Johnson of Canada) in Canada which imports ceramic tile biscuits from the parent

TABLE 4

CERAMIC TILES IMPORTED TO CANADA

Country of origin	Type	Shape	Size	Surface	Colour & designs	Comments
(Europe)						
Italy	All types	All shapes	Mainly large 4"x4", 6"x6" 12"x12" and larger	Plain, textured special surfaces	Wide range from simple to sophisticated hand painted	Very decorative outstanding designs, usually high quality
Germany	Floor and Wall Quarry tiles	Rectangle square	Mainly large	Glazed and unglazed	Medium range	Top quality comparable to Canadian
U.K.	Floor and Wall Quarry tiles	Square rectangle hexagon	Limited range from 4"x4" to 9"x6"	Hard surface glazed anti-slip	Limited range but expanding	Price competitive, high volume
Spain	Floor and Wall	All shapes	Mainly large up to about 12"x12"	Glazed and unglazed	Decorative	Relatively high quality tiles influenced by Italian manufacturers
(Orient)						
Japan	Floor and Wall	All shapes	Small	Glazed and unglazed	Mostly plain, some decorative	High volume production largest mosaic exporter
Korea	Mainly mosaic	Square	Small	Glazed and unglazed	Few plain colours	Low priced tiles based on Japanese technology. General preferential tariff (13%)
(South America)						
Brazil	Floor and Wall	Rectangle Square	Mainly large	Glazed and unglazed	Decorative	Companies that export get government subsidies. Brazil benefits from the general preferential tariff (13%)

company and glazes them in Hamilton, Ontario. Several industry spokesmen indicated that these semi-finished tiles are included in the total import figures from the U.K. Their distributor, D.A. White, also imports Johnson space and floor tiles and Heatherbrown Welsh Quarry Tiles.

Japan maintains the largest share of Canadian mosaic ceramic tile imports. Traditionally price competitive, Japan dominates imports of small size wall tiles, especially mosaic tiles. It also supplies a significant quantity of larger wall tiles. Its market share, however, has been constantly decreasing because of a diminishing price differential with other imports, lack of the required designs, and increased competition from developing countries with less expensive labour and preferential tariffs. Characteristics of ceramic tiles imported to Canada are illustrated in Table 4, opposite.

Sources

Imports supply approximately 75% of the domestic ceramic tile market. In 1973, 50.5 million square feet of ceramic tiles valued at $13.1 million, were imported into Canada. During the last decade the quantity of imported tiles has been growing at the high average compound rate of approximately 14% per annum, increasing from a low of 15.6 million square feet in 1963 to a high of 50.5 million square feet in 1973. During the same period, the value of these imports has risen at the rate of approximately 15%, increasing from a low of $3.2 million in 1963 to a high of $13.1 million in 1973.

Statistics Canada classifies imported ceramic tiles into two

TABLE 5

% SHARE OF IMPORT MARKET SEGMENT
FOR IMPORTED CERAMIC TILES UNDER $2\frac{1}{2}$"

	1963	1964	1965	1966	1967	1968	1969
Japan	95.1%	95.7%	97.7%	98.4%	97.1%	93.8%	94.2%
Germany	2.9	2.8	1.9	0.8	1.4	3.1	2.8
U.S.	0.9	0.7	0.3	0.6	1.0	1.5	0.9
Italy	0.5	0.4	0.04	0.1	0.4	0.9	1.2
Other	0.6	0.4	0.06	0.1	0.1	0.7	0.9

	1970	1971	1972	1973	Sept. 1974
Japan	93.1	90.2	87.3	83.0	66.0
Germany	2.7	4.1	3.6	3.2	3.7
U.S.	0.8	0.8	1.4	1.0	3.9
Italy	2.6	4.3	6.7	6.9	12.3
South Korea	–	–	–	2.4	4.6
Other	0.8	0.6	1.0	3.5	9.5

Source: Statistics Canada

PEAT, MARWICK
& PARTNERS

categories according to their size: $2\frac{1}{2}$ square inch and under, and $2\frac{1}{2}$ square inches and over.

Small Tiles

In 1973, approximately 43% of imported ceramic tiles were of the small size variety. While traditionally, Japan has dominated imports of small tiles to Canada as it supplies more of these tiles than any other nation of the world, its share of Canadian imports has decreased from 95% in 1963 to 83% in 1973.

On the other hand, Italy which provided 0.5% of the Canadian import market segment in 1963 is number two in 1974 providing 12% of the small tile imports. This improvement is attributed to the increased use of automation, which reduces substantially factory costs, and to an aggressive export campaign. At the same time Korea, spurred by abundant natural resources, Japanese technology, a low cost labour force, and increased government encouragement programmes, has penetrated the Canadian Market as of last year with an impressive 2.4% of small tile imports. The Korean ceramic industry has grown from a 1971 export total of $800,000 to $10 million in 1973. Korea also benefits from the preferential tariff system for developing nations. Imports of small tiles are illustrated in Table 5, opposite.

Large Tiles

Large tiles represent the most important and the fastest growing segment of the ceramic tile market. It is in this segment where foreign domination is the most obvious, particularly in the floor tile area of the market.

In the category of tiles over $2\frac{1}{2}$" square in size, the United Kingdom has been traditionally a major producer and exporter of ceramic tiles to Canada. However, its share of total Canadian imports steadily declined from a high of approximately 74% in 1964 to a low of 33% in 1972. As of September 1974, the United Kingdom shipped approximately 31% of the large tile imports to Canada and has lost its first place position to Italy. As discussed earlier, it has been suggested that the imported biscuits which go into final glazing at Sovereign in Hamilton are included in figures for United Kingdom imports.

The reasons for the decline of British imports could be a combination of their less competitive pricing due to an increasing labour cost problem and greater Canadian consumer acceptance of the more decorative Italian styles.

More significant yet are the relative changes in the Canadian imports from Japan and Italy. From 1970 to September 1974, these countries altered their Canadian importation from 31% to 9% and 10% to 33% respectively. Germany which had been averaging around 4.5% over the past ten years provided 9% of imports as at September 1974. We are faced with the trends of Japanese products becoming less competitive and less attractive to a consumer who may choose between those and the more decorative European tiles. European producers have increased their degree of automation (not being able to rely on inexpensive labour) and have introduced attractively decorated ceramic tiles into North American markets.

TABLE 6

% SHARE OF IMPORT MARKET SEGMENTS
FOR IMPORTED CERAMIC TILES OVER 2 1/2"

	1962	1963	1964	1965	1966	1967	1968	1969
United Kingdom	34.8%	71.7%	73.6%	63.7%	58.9%	46.7%	51.9%	48.7%
Germany	6.7	4.0	4.1	3.0	2.4	4.3	5.1	3.9
Japan	51.6	18.4	15.7	7.0	31.5	38.9	32.9	31.4
United States	3.0	1.4	1.9	0.8	0.6	1.6	2.2	1.9
Others	2.8	3.0	3.3	1.1	3.4	2.0	1.3	4.6

	1970	1971	1972	1973	Sept. 1974
United Kingdom	48.7	43.1	32.9	36.3	30.9
Germany	7.0	6.4	5.7	10.8	8.8
Japan	30.8	23.7	22.7	12.7	8.6
United States	1.5	1.6	1.4	0.7	0.8
Italy	10.3	18.0	19.7	22.7	32.7
Spain	*neg.	0.4	4.0	6.6	11.6
Philippines	–	0.5	4.8	3.7	–
Brazil	1.7	*neg.	*neg.	1.4	3.5
Other		6.3		5.0	3.1

*NEGLIGIBLE

Source: Statistics Canada

One should also note on Table 6, opposite, the entries of Spain and Brazil which, from negligible quantities in 1970, exported to Canada 12 and 3.5% respectively in the first 9 months of 1974. Spain has basically the same products as Italy since most of the plants there are either subsidiaries of Italian companies or have been developed with Italian technology. The Spanish ceramic tile industry has an advantage over the Italian industry in that most of its plants are closer to better quality raw materials and benefit from less expensive labour. Spain also supplies comparable decorative tiles and maintains an export position with Italy.

As far as Brazil is concerned, its advantages are threefold: availability of raw materials, Italian inspired technology and inexpensive labour. It is to be noted that Brazil benefits from a preferential tariff. In addition, it has been reported that its government provides subsidies to exporting companies. Mexico which also benefits from the preferred tariff has not yet entered the Canadian market in a large scale. It is, however, the second exporter into the United States and it can be assumed that as soon as it can fill American orders, it will try to sell the Canadian market as well.

Impact On Domestic Producers

Canadian manufacturers did not respond to the growing needs of the domestic market either in terms of volume or in terms of quality and design. Their product lines are conservative, fragmented and inadequate for the broad range requirements of the market.

The reasons for the dramatic increases in imports after 1962 are found largely in the differences in prices at which imported and domestically produced tiles could be purchased by distributors and contractors within the Canadian market and differences in design. According to industry sources, imported tiles have been available to domestic purchasers at prices 5% to 40% lower than the prices of comparable types and qualities of domestic tiles. It appears, however, that this gap is narrowing.

An analysis of statistical information indicates that the average prices of domestic tiles were higher than the prices of imported products. In 1969, the average factory price of ceramic tiles produced in Canada was approximately $.42 per sq.ft. and the apparent factory price of the imported products averaged $.21. In 1972 these figures changed to $.40 for domestic tiles and $.22 for imports. Imported tiles retain their price advantage even with the addition of duty charges and higher transportation costs. Federal sales tax is applied to both products.

Tariffs

All ceramic tiles imported to Canada are dutiable. The amount of tariff depends on the type of tile and the type of tariff. British Preferred Tariff levies a duty of 12% for unfinished products and 15% of landed value of finished tiles and is applied to imports from the United Kingdom . Most Favoured Nation Tariff is applied to imports from Italy, Japan, West Germany, Spain, Portugal, etc. For this tariff, levied duty is 20%. A General Preferential Tariff of

TABLE 8

UNITED STATES IMPORTS

1973

('000 sq.ft.)

Countries	Ceramic Wall & Floor Tiles	Mosaic Tiles	Total
Japan	35,746	59,210	94,956
Mexico	17,971	2	17,973
Italy	16,727	328	17,055
U.K.	15,232	247	15,479
Phil R	6,219	84	6,303
Spain	4,111	78	4,189
West Germany	2,506	24	2,530
Columbia	1,606	22	1,628
Brazil	1,277	197	1,474
Other	1,620	6,863	8,483
Total	103,015	67,055	170,070

Source: U.S. General Imports and Imports for Consumption 1973

TABLE 7

TARIFFS INTO CANADA

	Finished	Unfinished	Raw Materials
Earthenware Tiles:			
U.K.	15%	12 1/2%	Free
Germany) Japan) Italy) U.S.) Spain)	20%	20%	Free
Philippines) South Korea) Singapore) Hong Kong) Brazil) Columbia) Mexico)	13%	12 1/2%	Free

Source: Government of Canada - Customs Tariffs

13% is used for determination of duties from developing countries such as Brazil, South Korea. Table 7 , opposite, summarizes the tariff situation for earthenware tiles. There is very little or no duty on raw materials which is a direct advantage to the domestic manufacturers on the one hand but provides no indirect incentive to exploit local deposits. Appendix B, describes in more detail, the tariff items for ceramic tiles and their raw materials.

AMERICAN IMPORTS

The ceramic tile industry in the United States has seen nearly half of its approximately 40 tile makers close their doors in the past ten years, even though the demand for tile continues to increase. Here again we see a trend to importation that is similar to the one in Canada. In 1967 there were no imports into the United States. In 1971, 27% of the wall tiles and 60% of the mosaic floor tiles sold were imported. Illustrated opposite as Table 8 , are the points of origin of American imports for 1973.

The reasons for the increase of imports in the United States are similar to the ones found in Canada namely price competition and the lack of decorative designs by domestic producers.

However, the American ceramic tile industry, contrary to its Canadian counterpart, does not suffer from a high cost of raw materials since local deposits are used by tile makers. The United States exports a large amount of raw materials in different stages of refinement and supplies almost all imports into Canada.

To our knowledge, the Americans have not taken advantage of all the European technological advances even in their German and British subsidiaries, and are trying to make it on their own, so to speak.

Mexico is the second largest exporter to the U.S.A. which may be explained by the existence of good raw material deposits in the North-east, improved technology and quality control (with an Italian influence and sometimes assistance) and the proximity of markets served - mainly Southeast and south central U.S. The Mexican tile producers have marketing offices in the southern states to service their clients.

Italy is a very close contender for second place despite the difference in transportation costs in its disfavour. The United Kingdom is in fourth position and suffers from having no special tariffs as it does in Canada.

Although the ceramic tile industry has accused importers of unlawful dumping and/or pricing practices and has launched several complaints, we are not aware of any proven charges, be it with Japan, the United Kingdom or the Philippines. The United States import tariff for all non-communist countries is 24½% for these products.

CUSTOMERS

In Canada, there are three major influences involving the choice of ceramic tiles: the architect and specification writer, who serve all building construction markets, large and small developers who are involved in residential, commercial and sometimes industrial building construction, and home owners who are the final users of residential property.

Architect and
Specification Writer

Architects and specification writers are involved in virtually all types of building construction. Their influence is particularly significant in the choice of building decorative surfaces (the wall and floor surfaces). The architect firm tends to place importance on a high quality finish with low long term maintenance expense.

Many institutional buildings are publicly owned. Building supplies are purchased through competitive bids open to suppliers and subject to public scrutiny. In most cases there is a requirement for Canadian content in building materials. Thus the Canadian manufacturers have a distinct advantage in this segment of the ceramic tile market as they receive preferential treatment in competitive bid situations. This fact may in part contribute to the lack of marketing aggressiveness by the Canadian producers.

Developer/Contractor

This market is characterized by medium and large sized enterprises depending on the size of the projects undertaken. Large developers usually hire a general contractor who has overall charge of the project, and subcontractors for a specific type of work, such as the application of ceramic tiles. The developers themselves sometimes act as general contractors, and award contracts directly to trade sub-contractors.

Large developers such as Cadillac, Olympia & York and Bramalea have considerable buying power due to volume requirements for building materials. Very cost-conscious, they maintain relatively sophisticated mehtods of procurement. Their pre-purchase activity is extensive, involving cost and quality control.

Trade sub-contractors who did not have previous working relationship with the developer are subject to exacting controls which include technical and reliability capabilities.

While ceramic tile requirements are specified by an architect, the developer makes decisions which are based on total "installed price".

Smaller contractors buy their ceramic tile supplies somewhat differently. Usually they construct higher priced houses in smaller quantities and require higher quality tiles which are particularly suited to the taste of their customers.

Home-Owner

The home-owner, a final user has a relatively small influence on the choice of ceramic tiles.

In most cases he buys a finished house with installed wall and floor covering surfaces. If he purchases a new house he may select tiles from a limited range of products presented to him by the developer.

The ceramic tiles sold to home-owners are, therefore, oriented towards the decoration and the renovation market, often on a do-it-yourself (DIY) basis.

Home-Owner

The consumer is highly sensitive to availability and presentation of the product. Since he usually has no real knowledge of ceramic tiles and their installation, the product must be presented advantageously, with sufficient information on the package, at the point of display, or in an appropriate booklet.

H&R Johnson of the United Kingdom developed modular merchandising concepts for the DIY Market, which provides tiles, grout, adhesive and simple tools needed for their installation. The booklet which is supplied to retail stores provides instructions for tiles installation and shows new decorative ideas for use with ceramic tiles. This concept was introduced to Canada and marketed through D.A. White and Co., under the brand name of Crystal. Natilco, Canada's largest importer, uses similar techniques in its showrooms and promotional literature.

Historically, the existing home-owner market has been small. People did not have the time to work on their houses and the concept of home improvement and sophistication was not present. Recently, however, this market has grown rapidly and has become very significant.

DISTRIBUTION

As a result of the market needs, the distribution network for ceramic tiles evolved into three basic segments: the manufacturer, the wholesaler, the sub-contractor and the retail level. There are no major differences in the utilization of these distribution elements among domestic and foreign manufacturers.

Domestic Producers

Canadian manufacturers sell ceramic tiles through their own wholesaling outlets. These distribution outlets usually maintain all the manufacturer's lines and sometimes competing and non-competing lines of ceramic tiles of foreign manufacturers.

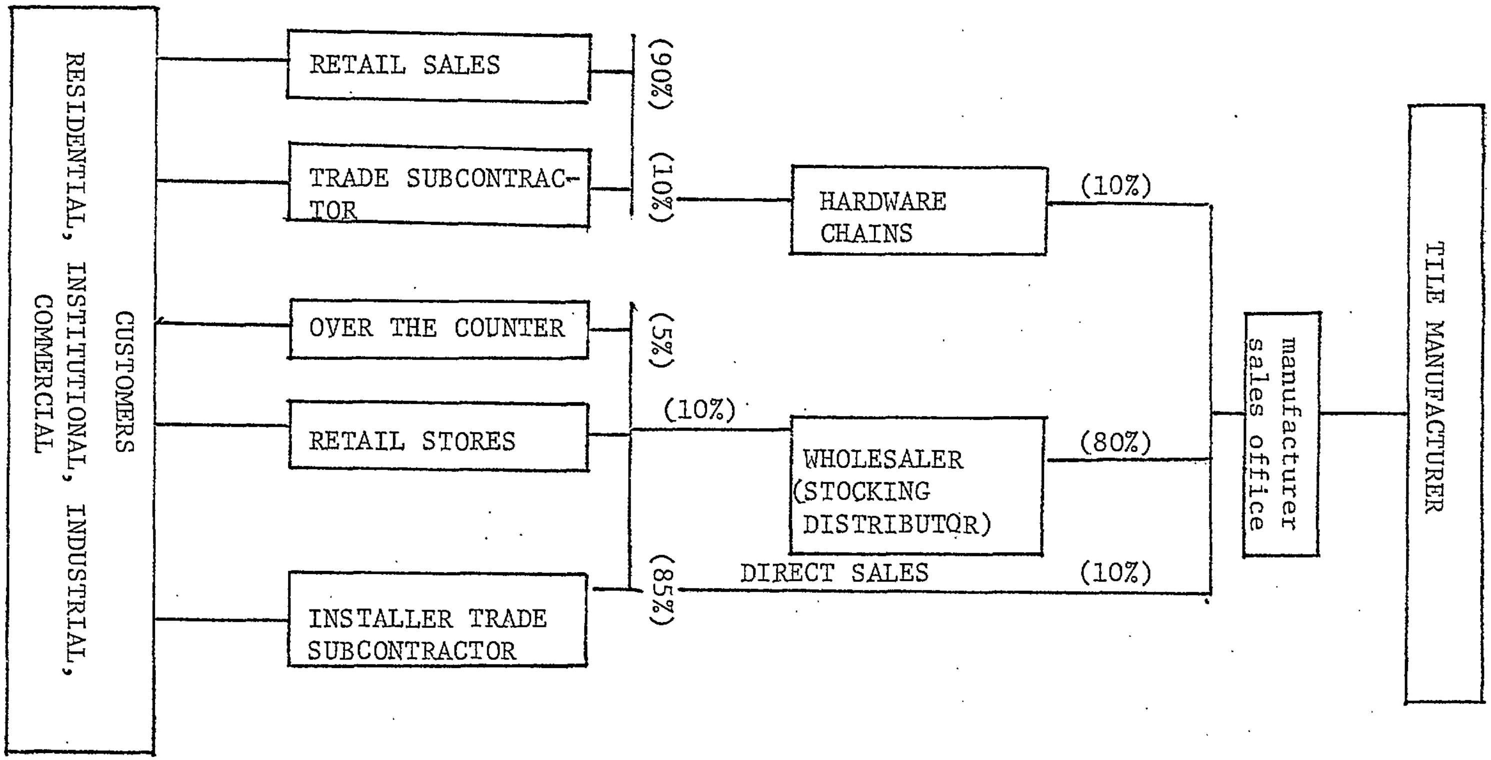
Most of the sales offices are equipped with showrooms and warehouses, which also carry tile related items, such as cements, adhesives and bathroom accessories. In some cases, they also sell competitive floor and wall covering surfaces.

The sales office sells to the wholesaler, (stocking distributor), the hardware buying group and directly to the installer, retail stores or over the counter.

FIGURE 1

DISTRIBUTION PATTERN FOR DOMESTIC CERAMIC** TILES

(Based on one Canadian manufacturer)



All figures are estimated

PEAT, MARWICK & PARTNERS

Installers usually have a good knowledge of products as they search for bargains, be it quality, design or price, or a combination of these.

Examples of distribution systems of the domestic manufacturers are presented herein. Ceratec (St. Lawrence Ceramics) markets its products through the company owned distribution centres that maintain stock of ceramic tiles and other building supplies. In addition to its own products, the company distributes imported tiles from Villeroy and Boch in Germany. Maple Leaf Industries distributes ceramic tiles through its own distribution network - Olympia - of which it is a subsidiary. Their sales offices with warehouses and showrooms are located in Montreal, Toronto, Quebec, Hamilton, Trois-Rivières, London, Ottawa and Winnipeg. Olympia sells not only competitive imported tiles but also competitive floor and wall surfaces, such as vinyl asbestos and carpets.

Figure 1, <u>opposite</u>, illustrates the distribution pattern for domestic tiles.

<u>Wholesalers</u>

At the wholesale level, the manufacturers distribute approximately 80% of their products through independent stocking distributors.

The remaining 20% is divided equally between hardware chains and direct sales. In recent years, the hardware chains have increased their share of business and they represent significant competition to the independent distributors with regard to retail sales of ceramic tiles.

Retailers

Stocking distributors sell 85% of their volume to the trade sub-contractors, and the balance directly to retail outlets.

In recent years, hardware chains and home improvement centres have become more popular as points of tile distribution for the DIY market. It is expected that large department stores will cater to the DIY market. Manufacturers such as Sovereign Potters and D.A. White Frontenac Floor and Wall Tile Division are attempting to adapt the approach of H&R Johnson in Britain to achieve this kind of distribution. Natilco is also offering its marketing strategy to distribute imported tiles through department stores.

Imported Tiles

A slight variation in the distribution of imported tiles is that the ceramic tile importer fulfills a role similar to that of the wholesaler of the domestic product. One of the larger importers in Canada has sales approaching $3 million. While it sells mostly to the trade subcontractor, it also sells to smaller wholesalers, hardware outlets and directly to the cost-conscious final user. For example, the company owns various display stores where both the trade and the consumer public can go to select, purchase and obtain advice. These stores appeal also to the do-it-yourself (DIY) market.

Importers supply approximately 60% of the market. The remainder, is imported directly by wholesalers and hardware chains that have sufficient volume to justify bulk purchasing abroad. In some cases, foreign manufacturers sell directly to large trade sub-contractors.

The importers usually represent more than one manufacturer. Generally they maintain many lines of non-competitive tiles. As mentioned earlier, most Canadian tile manufacturers also act as importers, distributing at least one line of imported tiles. In cases where the Canadian manufacturer has a foreign parent, the Canadian manufacturer carries exclusively the parent company's line.

PRE-ASSEMBLING
AND PACKAGING

Most ceramic tiles are sold and set as single units. While this conventional method of application is still popular, the use of preformed larger units is increasing.

At this time, the majority of mosaic tiles is sold mounted on sheets, usually 1' x 2' in size.

The use of preformed panels of other tiles is also increasing. For example, Agrob Co. of Germany is supplying floor tiles in sheet form where the tiles are joined together with spots of soluble plastic. These panels have 15 single tiles each. The company claims that flexible sheets of floor tiles have greater accuracy in the mass and cleaner joint sections. The spot plastic is rot-proof. Agrob Co. claims that the use of this method for floor tiles can reduce the required laying time by more than half.

Panels are more popular for mosaic tiles. They are either "face-mounted", on paper cemented to the face of the tile with a water-soluble adhesive, or "back-mounted" permanently on material cemented to the back of the tile. The back-mounted tile is usually sold at higher prices than the face-mounted tile because its production requires more costly mounting materials and more labour. Nevertheless, the cost saving which the back-mounted tile affords the contractor when installing the tile generally exceeds the additional charge for face-mounting.

Of the systems now available, two are tub surrounds, and the third consists of interior wall panels. Both tub surround systems feature internal corner trim strips which permit up to 5/8" adjustment to fit most standard tub recesses, thus eliminating measuring and cutting of panels.

One of the tub surrounds consists of three 5 ft. high panels. The other tub surround extends tiling to 6 ft. above the tub, has a tile drop-ceiling and consists of seven panels. The interior wall panel system can be used wherever tiled wall surfaces are desired. Panels are 4 ft. square and are particularly applicable to large areas. Mosaic floor sheets come in 2' x 2' pre-grouted with polyurethane.

American Olean of the United States, a division of National Gypsum Company, developed an improved method of ceramic mosaic floor installation and wall panel systems, which do not involve grouting on the job. Each sheet of tile is factory grouted and bonded to a $\frac{1}{2}$" polyurethane backboard. It is not affected by warm or cool temperatures and can be applied to any surface.

The additional cost of the sheet form preparation per square foot is compensated by the quicker method of laying and thus saving in time and labour costs.

Packaging

There are no exceptional concepts regarding packaging and delivery of the ceramic tiles. All manufacturers in Canada use standard cardboard packaging for most of their tiles. Subsequently, boxes are palletized and strapped. Some manufacturers claim simpler loading of rail cars and sales advantages from the added protection of shrink film polyethylene.

Tile manufacturers also use automatic systems which dispense ceramic tiles from pallets. Labour savings are again the prime objective for research in new methods of packaging and handling.

Most European manufacturers appear to prefer the cardboard carton for the packing of wall tiles since these are more delicate to handle and can be easily chipped. Shrink wrapping is used for storage and handling of cardboard cartons. H&R Johnson introducted cellophane windows into their packages for fast, easy sampling of the tiles.

Co-operative Marketing Arrangements

Co-operative arrangements between ceramic tile manufacturers and sanitary ware manufacturers are limited to colour coordination. Tile manufacturers follow seven basic colours of sanitary-ware. In addition, they supply tiles for new designs of bathroom and sometimes participate in the development of new decorative ideas. We did not find any evidence of more involved arrangements abroad.

Trends in Installation
and Packaging

A number of firms are developing pre-fabricated wall units. Villeroy & Boch, for instance, have developed pre-fabricated panels for the exterior cladding of buildings. This has been very well received by architects for public buildings.

The market strategies of the United Kingdom/German firms reflect a strong interest in the do-it-yourself market. There is a growing recognition of this market in Canada. Increased efforts are being made within the various tile marketing programs to include more comprehensive tile libraries within the various outlets to provide a greater appeal to the do-it-yourselfer.

NON-CERAMIC SURFACES COMPETITION

While ceramic tiles compete with one another, their main competitors are non-ceramic floor and wall surfaces.

For mosaic tiles, the most competitive materials are homogeneous vinyl and vinyl asbestos. Other competing surfaces include steel, aluminum, and hardboard sheets enameled with simulated tile designs.

The chief alternatives to wall tiles are water-proof fabric and paper.

Ceramic floor tiles compete with wood, terrazo, linoleum, vinyl tiles and carpets. Outdoors they may be substituted for concrete stairs, cement slabs, on floors, and for bricks, marble, and steel, cladding on walls.

In recent years, trends towards consumption of synthetic wall and floor finishes are down slightly as builders are substituting ceramic tiles. Most of the synthetic coverings are less expensive to buy. Ceramic tiles, however, as a medium of architectural expression and with long-term efficiency in mind, offer the following properties which are difficult to substitute.

Sanitation: Ceramic tiles have distinctive sanitation advantages over other surface materials which are especially important to hospitals, schools, offices and other types of construction of crowded areas, as well as residential housing.

Fireproofing: Is becoming a factor of greater importance as safety and health regulations are more stringent and require fireproof construction. Plastic related surfaces often present serious fire hazards.

Decoration: Is one of the strong advantages of ceramic tiles over other floor and wall surfaces. The range of colours, patterns, textures and sizes give architects an opportunity for expression, and design flexibility in both interior and exterior applications.

Maintenance: Ceramic tiles do not fade and keep their colours almost indefinitely. The fact that they do not yellow over time contributes to their economic attractiveness on a medium to long-term basis.

Cost Comparison

Traditionally, the choice between ceramic tiles and other surfaces was determined by the initial installation cost. Recently, this choice often considers both installation and maintenance costs.

TABLE 9

COST COMPARISONS FOR DIFFERENT WALL AND FLOOR FINISHES

Floor Finishes		Initial Cost Per sq.ft.	Initial Cost Index	20 years Maintenance Cost per sq. ft.	Total Cost per sq. ft.	Total Cost Index
Ceramic Mosaic Tile		1.75	1.00	2.00	3.75	1.00
Regular Terrazzo		1.20	.69	2.00	3.20	.85
Quarry Tile Thin Set	*	1.50	.86	2.00	3.50	.93
Linoleum A Gauge	*	.71	.41	3.93	4.64	1.24
Carpet-Medium Grade	*	1.25	.71	6.20	7.45	1.99
Seamless Flooring	*	.90	.51	3.96	4.86	1.30
Vinyl Asbestos Tile	*	.47	.27	3.45	3.92	1.05

* .08 cents per sq. ft. is included for machine finished structural slab.

Wall Finishes		Initial Cost per sq. ft.	Initial Cost Index	20 years Maintenance Cost per sq. ft.	Total Cost per sq. ft.	Total Cost Index
Glazed ceramic tile (adhesive set)	**	1.40	1.00	1.40	2.80	1.00
Ceramic Mosaic Tile	**	1.95	1.39	2.00	3.95	1.41
Spray Coating-Thermo Setting	**	.51	.36	2.41	2.92	1.04
Vinyl Acrylic	**	.28	.20	2.11	2.39	.85
Concrete Block-Painted Structural Glazed		1.16	.82	4.13	5.29	1.89
Tile 2"	**	2.82	2.01	2.39	5.21	1.86

** add .98 cents per sq. ft. to each of these initial installed costs to provide the structural back up wall for comparison

Source: Frost-Fernandez Associates in cooperation with the Terrazzo,Tile and Marble Association of Canada 1968

Cost indices have been prepared by Peat, Marwick and Partners.

Ceramic tiles have higher initial costs (tile itself and installation), but lower maintenance cost than any other wall and floor surface. Especially important to educational institutions, hospitals and commercial constructions, they are easy to clean and wear indefinitely.

Initial and maintenance cost comparisons of different wall and floor surfaces were made by independent consultants - Frost, Fernandez Associates in cooperation with the Terrazzo, Tile and Marble Association in Canada in 1968.

A recent conversation with the Terazzo, Tile and Marble Association of Canada, leads us to believe that the relative costs of 1968 would be more or less valid today, as all prices have tended to increase evenly. The Association, however, is considering repeating the study in the spring of 1975, in order to make available a more current comparison.

The 1968 study results are summarized in Table 9 , opposite. Initial cost represents the cost of completed work ready for use (e.g. cost of ceramic tiles plus cost of installation). Maintenance costs represent cumulative costs of maintenance during a 20 year period in areas of medium use.

The initial cost of non-ceramic surfaces is lower than that of ceramic tiles. This initial cost disadvantage of ceramic tiles is offset by low maintenance costs and long life expectancy which usually equals the life of the building. Other floor finishes have higher maintenance costs and require more frequent replacement.

FORWARD MARKETS

Canadian demand on a per capita basis is still very much below the high per capita demand in Europe and especially Italy. However, there are strong signs of increasing demand by the Canadian consumer.

Trends in Ceramic Tiles

Ceramic tiles are generally considered, in North America, as a luxury product although there is evidence that this is changing. The largest share is installed in higher priced residential, commercial and institutional buildings. The decorative attributes of ceramic tile have allowed for more extensive use of colour and decoration by the designer.

Flexibility of material and colouring provides ceramic tiles with a "natural" versus a "mechanical" look of plastic, glass or steel counterparts. It also gives an opportunity for greater architectural expression. The introduction of new patterns, silk screened and glaze effects, moreover, contribute to making ceramic tiles more competitive than alternative materials. In addition, ceramic tiles are relatively maintenance free, sanitary and stain resistant.

Traditionally in Canada, ceramic tiles have been used mainly in bathrooms. Recently more tiles are used as surfacing materials in other areas of residential housing such as halls, patios and kitchens. The average household surface covered with ceramic tiles is estimated to be in the order of 150 square feet.

An important trend which will increase in years ahead is the use of ceramic tiles for building exteriors, (e.g. shopping centres, commercial buildings, walls, tunnels, swimming pools). A variety of weather-proof colours are available for building exteriors only through ceramic tiles. The external use of ceramic tiles has been increasing in European and South American markets and is becoming evident in Canada and in the United States.

The effective use of ceramic wall and floor tiles is governed to a large extent by economics and knowledge of what the product can do.

The installed cost of ceramic tiles was traditionally one-third material and two-thirds labour. Major applicators inform us that this ratio is getting closer to 50-50 as improved adhesives are introduced to the market.

The industry constantly searches for less expensive product forms and methods of installations. Substantial cost reduction exists through pre-fabrication, "do-it-yourself", or use of larger units.

Cost abatement also exists through reduction of thickness. The production of thinner tiles involves less raw material, efficiency in packaging, and lower cost of transportation and installation.

Consumption per Capita

In Canada, the use of ceramic was historically limited to the bathroom. Generally, plain tiles ($4\frac{1}{4}$" x $4\frac{1}{4}$") were used on walls and mosaic tiles were applied on floors. Wider use of the product for commercial, institutional and industrial construction was introduced in the late fifties and early sixties.

In the period of 1963 to 1972 the usage of ceramic tile per capita of population was growing at the average compound rate of 7.8% per annum in terms of quantity. In the same period, all building construction was growing at the average real compound rate of 3% in terms of value which confirms the trend towards the extended use of tiles in new construction.

The consumption of ceramic tiles on a per capita basis is shown in the tabulation below:

CANADIAN
CONSUMPTION OF
CERAMIC TILES
PER CAPITA

YEAR	POPULATION (000)	CERAMIC TILE CONSUMPTION (sq.ft. 000)	CONSUMPTION PER CAPITA (sq.ft.)
1963	18,931	30,419	1.60
1966	20,015	33,724	1.68
1971	21,569	46,057	2.13
1972	21,830	68,945	3.15

To give some perspective to the chart, one notes that the per capita consumption in Europe is approximately 15 square feet and in Italy is close to 50 square feet.

Market Promotion

Tile manufacturers in Italy, on their own or through their powerful and well organized trade associations, were able to educate the construction industry and the consumer in the broad range of uses of ceramic tile as a decorative medium. Kitchens, living quarters, dining rooms and bedrooms are now considered as logical applications for tile. Designers have learned to harmonize tile colours, shapes and designs with the total decor of a home. As a result, "the ceramic industry has now gained a prominent place in the structure of the national economy", remarked Claudio Leonelli, President of the Modena Chamber of Commerce.

In Great Britain we find the same approach. When Polycell launched their Kervit process made tiles in 1962, they stimulated the DIY market by promotional techniques. This market is still exhibiting a rising growth role. In contrast with the simple eight colours with which the market was created, there is now a wide range of plain colours and patterned tiles, RE and REX fittings for these and an increasing variety of mosaic panels. A vigilant eye is kept on fashion trends in order that the future needs of the ever growing DIY market may be accurately identified in terms of ceramic tile.

In the United States, the Tile Council of America is made up of nineteen American Tile Manufacturers, who finance it through their contributions, in addition, to the royalties received from patents. Expenditures will total $2½ million for the three year period of 1972, 1973, 1974. Fifty-five percent of this budget is used for advertising and promotion, thirty-five percent for research and ten percent for architectural services. Their marketing goal is to extend the uses of ceramic tile by the various people influencing the choice of wall or floor covering. Their publicity programme reaches 60 million people. An affiliated organization, the Promotion Funds Association, a clearing house for trade information, is available to them. This group is preparing a television commercial, that would be available to organizations in the tile trade. Recently the National Tile Promotion Federation produced a promotional film. All such associations operate under the umbrella of the Ceramic Tile Institute, which acts as overall coordinator.

In Germany, tile manufacturers introduced the idea of decorative obsolescence and promoted to the DIY market as a means to change style of decors easily and inexpensively. At the same time, they too, through trade associations, educate consumers in extending the application of ceramic tiles to other areas of the house. They launched a direct attack on the use of wallpaper, paint, carpet and linoleum by introducing the fashion concept in ceramic tile uses.

Five Year Forecast

Based on the current trend towards increasing ceramic tile acceptance by the Canadian consumer, along with the collective judgments of the many interviews conducted within the industry, we estimate a likely average annual growth rate in the total market of between 7-8% per annum over the next 5 years. A pessimistic growth rate would be

5-6% per annum, while an optimistic growth rate would be 9-10% per year. Using the most likely growth rate, we estimate that the domestic market will increase from 85 million square feet in 1974 (estimated) to between 119 and 125 million square feet in 1979.

111 - MANUFACTURING

In the manufacturing section we examine closely what is required to produce ceramic tiles. Several sections discuss the more important aspects of this process. The raw materials used in the manufacture of the tiles are analysed, together with the locations and availability of supply in Canada and the U.S.A.. Following the establishment of the market potential, availability of raw materials is a most important consideration.

We then examine ceramic glazes and the glazing process. The surge in demand for decorative tiles in the last ten years has brought about some interesting changes in the application of glazes to tiles.

Finally we deal exclusively with the manufacturing process from the time the raw materials are received in the factory until the tiles are packed and warehoused awaiting shipment. The principal technological developments are highlighted with detail descriptions in the appendices. We examine the Canadian scene and make comparisons with overseas manufacturers, demonstrating the differences in production techniques. We also compare, in percentage terms, the main cost components in the manufacture of tiles for domestic and overseas producers.

RAW MATERIALS

After establishing that there is an opportunity for additional domestic ceramic tile manufacturing capacity, an important consideration is the availability of suitable raw materials at an economic cost to the manufacturer. In this context we shall examine:

- the type of materials which can be used in the manufacture of ceramic tiles and the magnitude of recipes which can be used to suit the local conditions and requirements of the manufacturer,
- the availability of these materials in Canada and the United States of America, and
- the major economic decision which the manufacturer has to take - whether to buy direct from an independant mine producer or to mine and produce the majority of his own raw materials.

Classification

The main raw materials used in tile bodies are ball clays, kaolin, silica, feldspar, nepheline syenite, limestone, dolomite, talc, wollastonite and pyrophyllite.

Ball Clays

A general definition of a ball clay would be a sedimentary clay of fine-grain size usually containing some organic matter and having good plasticity, high green strength and white or cream color after firing. The main function of the ball clay is as a binder to impart clay strength and workability to a tile. Tile bodies require clays of high strength since, by being made from the dry pressing of dust, they do not have the clay strength required by plastic bodies in which the particles are bonded much closer together.

Besides increasing the green strength, the practical potters give definite reasons for the inclusion of ball clay into whiteware bodies, namely the increased workability of the body in the plastic state, especially when jiggering, and the increased fluidity imparted to casting slips when even a small amount of ball clay is added.

It is generally found that ball clays, because of their iron oxide and titania content, impair to some extent the whiteness of fired bodies. Even small amounts decrease the translucency, in many cases so markedly that ball clays are completely eliminated from much of the highly translucent ware. Ball clays have a greater variability than kaolin and thus make exacting slip control difficult.

Kaolin

Kaolin is a relatively pure clay, white when dry and white when fired. It has many uses besides being the most important ingredient in whiteware. Kaolin is found in two types of deposit: as residual kaolin, where the clay is found replacing the pegmatite rock (a coarse-grained granite rock consisting largely of feldspar and quartz) from which it was formed by weathering or other alterations, and as sedimentary kaolin, composed of clay particles transported from the original point of formation by stream action and settled in deposits at the bottom of bodies of relatively quiet water. Since residual kaolin is formed 'in situ', it is a direct product of rock decay, and therefore we seldom find a pure kaolin end product, but instead a mixture of kaolin, partially decomposed feldspar, and unaltered rock minerals. The purity of the kaolin, therefore, depends on the purity of the parent rock, the completeness of decay, the amount of unwanted components lost by solution, and the amount of impurities brought in from other sources. In very few cases, we do find residual kaolin deposits that have a high proportion of clay minerals, for undecomposed rock fragments are usually present in large quantities. Therefore, it is not unusual to mine 10 tons of deposit to obtain 1 ton of pure clay, although in some mines larger percentages of clay are removed.

Silica

Silica may be introduced as quartz or flints or sand. It is the main filler in the tile body and the main control of the thermal expansion, an all important property of the tile bodies. England is practically the only country using ground calcined flints, most other countries use ground quartz. Flint has the advantage that it converts at fairly low temperatures to crystobolite, and by virtue of this reduces the danger point in firing between 500 and 600 degrees C. Also with calcined flints an amount of crystobolite has been found in calcination. Quartz on the other hand is more stable. It is not usual to be able to add more than 30 per cent to the tile body without running into firecracking tendency unless the firing schedule is lengthened considerably.

Feldspar

Feldspar is the most universally used flux. Careful selection is important because the rate of fusion is determined by the relative quantity of sodium and potash. Potash spars give a more steady fusion.

Nepheline Syenite

Nepheline Syenite is now gaining favour as a flux over felspar because of its better firing characteristics and slower fusion. The lower fusibility and increased fluxing action permit the formulation of bodies maturing at lower firing ranges. Direct substitution of nepheline syenite for potash felspar lowers moisture expansion and increases the shrinkage and mechanical strength.

Limestone

Most English manufacturers are now using limestone in the anorthite type of body to reduce the firing contraction. This material forms eutectics with the silica which means that the finishing firing temperatures must be under very strict control, otherwise excessive contractions can take place with over-firing.

Dolomite

Dolomite is intermediate in composition between limestone and $CaCO_3$ and magnesite MO_3. It is again a flux for use with the tile body. Italian tilers make great use of dolomite due to the proximity to the Dolomites. As the name implies, there is an abundance of this material.

Talc

Talc is being used in two ways: an amount of 50 percent or more with no felspar; or amounts up to 10 per cent with small amounts of felspar. Wall tile bodies of low moisture expansion, and high resistance to delayed crazing can be developed by the use of tremolytic or lime bearing talc in conjunction with other materials such as pyrophyllite. It has also been noted that bodies containing more than 15% talc have a tendency to absorb the glaze. Quite often special glazes, high in alumina, must be developed for the high talc bodies.

Wollastonite

Wollastonite is now being used especially in the United States as a replacement for flint and lime and in some cases has been used in the ratio of 70 per cent wollastonite and 30 per cent clay. It is claimed that wollastonite permits faster firing and greater resistance to thermal shock. It has very good whitish colour and one of its main advantages is that it has a very low moisture expansion which helps considerably in delayed crazing. Both clay and fired shrinkage is low, thus helping size problems.

Pyrophyllite

Pyrophyllite is another material in the family of hydrous aluminium silicate, and like wollastonite, is used as a substitute for part or all of the flint or feldspar. It will give increased firing range with lower thermal expansion and a decrease in crazing resistance.

Summary

Tiles are made in almost every corner of the world and the tile making bodies vary considerably between different countries. In Canada and the United States, many of the ten principal materials previously described are used in the manufacture of both wall and floor tiles. With floor-tile bodies some typical body compositions are shown in the following table, where it will be seen that these triaxial bodies have a high feldspar content of 50 to 60 per cent. When fired between cones 9 and 12, a vitrified body results with zero absorption. Of course, stains may be introduced into these bodies to give a variety of soft colours.

COMPOSITION OF FLOOR-TILE BODIES, BY PERCENT

Material Recipe	1	2	3	4
Feldspar	58	58	60	55
Flint	9	8	-	15
Florida kaolin	23	22	26	-
Georgia kaolin	9	10	12	6
Talc	-	2	2	-
Whiting	1	-	-	-
Kentucky ball clay	-	-	-	5
English china clay	-	-	-	19
Firing condition, cone no.	10	9	12	9

The following table indicates considerable variation in composition of wall tile bodies. Very few triaxial bodies are now used, while others contain talc. Still others contain pyrophyllite and wollastonite. At present, in this country, the majority of wall-tile bodies are high in talc (60 to 80 percent). The triaxial bodies are fired to between cones 6 and 10 (two-fire), but the high-talc bodies may be matured at cones 03 to 1 with the rather high absorption of 8 to 18 percent.

COMPOSITION OF WALL-TILES BODIES, BY PERCENT

Material Recipe	1	2	3	4	5	6	7	8
Feldspar	11	3	4	-	-	-	-	-
Flint	33	25	20	-	-	--	-	-
Pyrophyllite	-	15	15	-	-	-	-	-
Florida kaolin	10	-	10	10	-	-	-	-
Georgia kaolin	17	22	21	15	-	-	-	-
Ball clay	29	25	20	25	40	28	30	30
Talc	-	10	10	30	60	67	50	70
Wollastonite	-	-	-	20	-	5	20	-
Firing Conditions, cone no.	10	6	5	01	03	03	03	03

Waste Materials

Flyash

Flyash is an unavoidable waste product resulting from combustion of coal at electric power generating stations. Its recovery and disposal has always been one of the most serious and persistent problems faced by electric utilities. Re-cycling of ash into valuable manufactured products is of obvious benefit not only to the power utilities but to society as a whole.

The flyash ceramic process was originally developed at the University of West Virginia's Coal Research Bureau. Inventors of the process, Harry Shafer Jr. and Charles Cockrell left West Virginia

University in 1971 to join International Brick and Tile to prove the commercial viability of the process.

The company holds patent rights on a process for the manufacture of brick, tile, and other ceramic products from flyash. A commercial-scale demonstration brick plant based on the process was opened in 1972 by International Brick and Tile, adjacent to Calgary Power's coal-burning power station at Wabamun, 35 miles west of Edmonton.

In 1974, the new tile plant began commercial production of paving and quarry tiles which are used commonly for floor surfacing and walls in pedestrian traffic areas, such as shopping malls and university and other institutional buildings. There is at present no significant manufacturer of low moisture absorption paving tile in Canada and the demand is presently being met almost entirely by imports. We have examined some of the samples of production using this flyash process and found them comparable with other ceramic floor quarry tiles in this field.

Window Glass/White Sanitary &
Tableware/Electrical Porcelain

The Kervit Casting Process is another approach to the manufacture of ceramic tiles using waste/scrap materials. These materials comprise sanitary ware and electrical porcelain scrap, glass cullet, and various fired scrap resulting from the process itself. The body of the tile is composed of approximately 90% of these materials which have already been through a firing process and are therefore substantially transformed into their final state. The remaining 10% of the body is china clay used for the purpose of ensuring suspension in the slip state.

The process is very different from the conventional dust-pressed one in its raw material approach, its complete casting method, the use of ceramic moulds which carry the product through the kiln, and the rapid single firing technique. A full description of the plant and the manufacturing process is given in Appendix H.

Canadian Sources

Deposits of minerals useful to the ceramic industry such as ball clays, common clays and shales, silica, nepheline syenite, feldspar, talc, pyrophyllite, limestone and lime, are relatively common in Canada. Many types of these minerals have been discovered in the various provinces across the country, but the development of some of these deposits has been partly or wholly restricted because of such factors as limited markets, escalating production specifications, transportation costs to distant markets, and the entrenchment of certain imported minerals.

Nevertheless, some Canadian tile manufacturers have discovered local clays which they have been able to use economically with other materials to produce ceramic tiles. Details of these local discoveries in various Canadian provinces of the raw materials used in ceramic tile manufacture are given in Appendix C, together with locations of deposits in the United States. Suffice to say, we feel that there are suitable clays and associated geological materials available in Canada for the manufacture of ceramic tiles. It remains the responsibility of the manufacturer to locate suitable deposits, test fire the samples and prove their economic viability, as part of his overall feasibility study of tile manufacture.

Buy/Produce Criteria

Criteria established for the manufacturer's decision of whether to buy or produce raw materials must consider one very important fact. Ceramic tiles are a heavy commodity to transport and consequently the costs of delivery to the market have an important impact on the overall price of the tile. The manufacturer must aim to have his manufacturing plant as close as possible to the consuming market. Ideally his raw material sources should also be close to his manufacturing plant.

In his research, the manufacturer will ask himself the following questions:

(a) Where are the markets which I am going to supply?

(b) How near to these markets can I find the supply of my basic raw materials?

(c) What will the transportation cost be from the place of manufacture to the market?

(d) If the supply source has to be mined what extent are the raw materials reserves (no. of years supply) and what will the ex mine head cost be?

(e) What is the geological consistency of these reserves?

(f) What will the transportation costs be from the mine head to the manufacturing plant?

(g) Can I, the manufacturer buy these raw materials from the independant mining producers at a cheaper price; with consistent delivery and quality of product and cheaper delivery costs to the manufacturing plant?

These questions and the answers which he is seeking will lead him to examine two possible solutions:

(a) Locate a local supply of raw materials which he can mine at an economical cost, or

(b) Find an outside mine contractor who will deliver to him a consistent supply of raw materials at an economical cost.

Local Clays

Mining and refining of clays is an important preliminary step in manufacture of most ceramic products. As technical advances have been made in manufacturing to improve quality and to lower costs, it has been equally important to improve techniques of mining and processing of all raw materials including clay. The application of scientific engineering principals to mixing and refining has been necessary to ensure a long range reserve of uniform clays adaptable to many different ceramic processes at minimum cost.

The principle stages in this type of operation are discussed below.

(a) Exploration and Mapping

Deposits are sometimes first located by outcropping in wells, test holes and ditches or other eroded areas.

It has been many years however, since firms were fortunate enough to find a deposit in such a manner.

Common procedure today is to reach a lease or purchase agreement with a land-owner and then to drill systematically that property to determine the presence or absence of clay. In the final analysis it is always necessary to put down test holes in a systematic pattern to determine the nature and extent of the deposit.

(b) Detailed Drilling

Having proven that a sufficiently large deposit of high quality clay is present it is recommended that holes are then placed on 50-foot centers to give a more detailed picture of the deposit. Samples are taken at 1-foot intervals in each hole and particle size pattern, deflocculation curves, casting qualities, dry modules, screen analysis, chemical analyses when necessary, and fired properties are determined and permanently recorded along with the hole number and depth at which the sample was taken. Fired specimens of each sample are filed for future reference along with the permanent logs that were taken by the drilling crew.

In conjunction with the exploration, and at the same time as drilling, the local engineer surveys and definitely locates all test holes, plotting them on maps of the property which picture the operating area.

These maps should be revised and brought up-to-date quarterly, enabling the manufacturer to determine accurately where mining has been done and to correct the material actually mined against drill hole samples and tests. Further use of the maps and drill hole information enables him to plan the mining areas so that he can at any future date accurately forecast the mining area, assuming only the present rate of mining.

Generally speaking, it is a desirable policy to plan the mining of the entire deposit of clay on any given property before the initial opening pit is stripped. This enables the manufacturer to average out the amount of overburden to be removed and to set up a projected cost figure, ensuring an efficient operation. Having explored, tested and mapped a property, careful study is given to the opening of the pit to take advantage of the lay of the land, location of waste dumps, quality and quantity of clay. It must be kept in mind always that the pit will be worked for many years. Overburden removal is perhaps the largest single expenditure in clay mining and many factors are involved. For instance, waste dumps should be so placed that they are nearby but in such a location that there is no danger of wash-back.

(c) Backfilling

Whenever possible, backfilling is done as soon as possible after the raw materials have been removed. This serves two purposes:

1. Backfilling is usually easier at this time because the dirt is closer to the scene of operation.

2. It restores the land for future use.

Overburden removal should be planned in such a manner that it is removed only once, since repeated movement of the same dirt serves only to increase the costs. For this reason, the stripping program should be planned years in advance, and the overburden is moved only once.

If this work is to be done most efficiently, a variety of methods to move dirt are available. The overburden can be removed best by casting with a long boom dragline, while other material can be best bulldozed and still other material may be hauled by scrapers. The cost of backfilling the site to its original condition should be costed in the production cost analysis by prospective producers.

(d) Mining

In the mining of clay, drag-lines offer several distinct advantages. Among them is the fact that the machine does not have to sit directly on the clay, thereby avoiding possible contamination from the tracks and the fact that the operator can mine more selectively. The thinner more stratified deposits of clay are definitely best mined by dragline. As the clay is mined it is placed in dump trucks for conveyance to storage sheds.

(e) Storage

An important requisite for proper handling of clay is adequate storage, free from contamination. The amount of storage should be sufficient to make the mining operation independent of weather, allowing the firm to adequately plan the mining from each pit, in order that mining can be done most efficiently and with a minimum of lost time.

Lump clay from the pit should be dumped into a clay shredder which consists of a bowl suspended over a revolving slotted plate to which knives have been attached. The weight of the clay forces the clay against the knife, and as each little piece is cut off, it drops through the slot onto a belt flipper and is thrown into storage. This method ensures a thorough blending of the clay as it goes into the shed. Examination of any clay deposit overlain by a stratum of lignite shows clearly that the clay varies from very dark immediately at the lignite contact, to progressively lighter the deeper one goes in the clay. By storing shredded clay, the firm ensures that it will get thoroughly mixed and uniform material.

(f) Quality Control

Certain quality control checks are routine. The local engineer should check deflocculation properties, fired properties, titration characteristics and residues, plus any

and wollastonite, put through a second shredder, and lifted by a bucket conveyor to roller mills that grind it to the proper particle size. Moisture content is reduced to 1%± 1/2 per cent. At this point, 90% of the material must be fine enough to pass through a 325-mesh screen. Finally, it is conveyed to one of three overhead hoppers and eventually loaded into sealed aluminium truck pods or into railcars. Truck shipments would normally be unloaded at a customer's plant by blowing the material into silos, using a compressed air unit permanently installed on the truck. Railcar shipments, naturally are unloaded in diverse ways. One company bypasses silos completely, using the railcar as live storage.

The mine contractor usually maintains a well-equipped laboratory where a sample of every shipment is analyzed prior to release for its flow, pressing, firing and colour characteristics. Tiles are pressed and fired in a small electric kiln under conditions identical to the customer's cycle. When material arrives at a tile plant, its moisture content is adjusted, and it is ready to press.

Benefits that emerge from uses of a pre-blended material are:

- better flow and die fill characteristics,
- better control of fired tile thickness, size, warpage and weight,
- reduction of waste due to cracks and lamination,
- lower raw material cost.

Although the mine contractor supplies a completely controlled material together with a report and/or sample of each shipment, it is advisable for the tile manufacturer to have its laboratory analyse the material for moisture content, particle size, and density, fired shrinkage and fixed colour before committing the raw material to its production.

CERAMIC GLAZING

An orthodox ceramic glaze is a mixture of materials that, when heated sufficiently, will form a permanently hard layer of glass over a ceramic article, rendering a porous body impermeable, or adding brilliance and smoothness to a body that is already virtually nonporous and impermeable. During firing, a glaze must reach the degree of viscosity that will enable it to shape itself evenly over the surface of a ceramic article without running off edges and corners. The temperature at which it behaves in this way, producing a glass surface that is free from bubbles, pinholes, craters, and waviness, is called the maturing temperature. Ceramic articles treated in this way are described as glost ware and the process of firing is known as glost firing.

Unlike a glass, however, a glaze does not have an independent existence and its compatibility with the body to which it is to be applied is an important consideration in compounding a glaze, as well as the more obvious factors of appearance and durability.

Raw Materials

Glaze compositions vary enormously, the exact recipe depending on many considerations, including the thermal expansion required of the glaze, whether it is to be colourless or coloured, whether it is to be transparent or opaque, and the firing temperature at which it must mature and fuse with the body. Perhaps the only safe generalization is that all glaze mixes contain ingredients that will supply:

- the amphoteric (neutral) oxide, alumina
- silica and often another acidic oxide, boric oxide,
- some basic oxide or oxides (often three or four different ones) that will flux with the silica (and, where it is used, also with the boric oxide) to form a glassy material.

Before a glaze is fired, it must lie evenly over the surface of the ceramic article in the form of a fine homogenous powder. In general, the only practical way of achieving this is to mix all the powdered ingredients with water to form a slip that can be sprayed into the ware, or into which it can be dipped. This implies that all the ingredients must be insoluble in water, since if it were only possible to use water-soluble ingredients, which is not the case, no such solution could give a sufficient density of glaze materials to produce a coating of the required thickness.

For glazes that must mature at temperatures of between 1020^{o} and 1100^{o} it happens that some of the most widely used ingredients are, in fact, water-soluble in their raw state. Among the most important is borax, needed to provide boric oxide, which has a powerful effect in reducing the fusing temperature. Such ingredients must first be rendered insoluble in water by a process called fritting, and all glazes that involve this process are known as fritted glazes. Glazes that must mature at temperatures in excess of about 1150°C can be made entirely from ingredients that are first insoluble in water. They therefore involve no fritting, and are known as raw glazes.

To make a frit that will supply a low-temperature glaze with boric oxide, water-soluble borax is mixed with other ingredients, such as Cornish stone, flint, feldspar, and sand, and strongly heated in an intermittent or continuous frit kiln, rather like a small glass tank. The heated mixture fuses to form a glass (the frit) consisting largely of silicates and borosilicates. As the hot glass frit flows from the kiln it is quenched in cold water so that it can later be milled to the particular size required.

Other very widely used ingredients of low-temperature glazes are compounds containing lead oxides, which not only reduce the fusing temperature but also impart to the glaze a high refractivity, and thus a brilliance, not easily achieved in any other way.

The composition of a fired glaze can be expressed in terms of the percentage by weight of the various oxides it contains, and the following shows the composition of an earthenware glaze, maturing at a temperature somewhere in the region of 1050°C:

	Percentage by Weight
Silica (SiO)	36.0
Boric Oxide B_2O_3)	8.5
Alumina (Al_2O_3)	5.5
Lime (CaO)	3.0
Litharge (PbO)	44.0
Sodium oxide (Na_2O)	3.0

However, low-temperature glazes can be made without lead, often by increasing the boric oxide content. The composition of a leadless earthenware glaze, also intended for firing at 1050°C, might be as follows:

	Percentage by Weight
Silica (SiO_2)	54.5
Boric Oxide (B_2O_3)	18.0
Aluminia (AlO_3)	10.5
Lime (CaO)	8.5
Sodium Oxide (Na_2O)	2.5
Potassium Oxide (K_2O)	6.0

Some of the ingredients used in a glaze mix contribute to two or more oxides, so that a factory recipe usually looks very different from an analysis of the fired glaze. A particularly simple looking one for a leadless glaze with a maturing temperature of between 1040°C and 1090°C, is 80 percent by weight of a particular borosilicate frit plus 20 per cent of china clay. However, it has to be remembered that the frit itself is made from a mixture of borax, quartz, feldspar, chalk and china clay. One recipe for a lead glaze of the same maturing temperature is 80 per cent lead-silicate frit, 12 1/2 per cent china clay, 6 per cent quartz and 1 1/2 per cent feldspar.

Raw glazes, often called feldspathic glazes, mature at temperatures in excess of 1150°C and are used for products that undergo only a single firing. High glost-firing temperatures restrict the range of ingredients that can be used on the mix. Some ingredients of low-temperature glazes would make the glaze too fluid at temperatures above 1150°C; others, such as lead and borax, would volatilize. Among the most common ingredients of raw glazes are feldspar, sand or quartz, whiting (calcium carbonate), barytes (Barium sulphate), and zinc oxide. A typical recipe is:

	percentage by weight
Feldspar	35
Quartz	30
Whiting	15
Clay	7
Zinc oxide	5
Barytes	5
Dolomite	3

All the glazes so far mentioned are colourless and transparent. Some products, such as sanitary ware, call for a brighter and white glaze. This brighter and white glaze is normally achieved by adding several per cent of tin oxide. Tin oxide, used in white glazes for many centuries, is very expensive. Today it is often replaced by two or three times the quantity of cheaper zirconium silicate, either raw or in the form of a high-temperature zircon frit.

Colour Matching

Coloured glazes are made by adding various colouring compounds, mainly oxides, to the glaze mix. Cobalt oxide, for instance, is used to give various shades of blue; chronium oxide and copper salts are among the compounds used for green or green-blue shades; lead oxide and antimony oxide with traces of certain other oxides give shades of yellow, and so does titanium mixed with chronium; selenium and cadmium sulphide used together give red; manganese dioxide and iron give browns. However, the ceramist can rely on no simple rule such as x gives yellow, y gives red, z gives blue. The colour obtained depends not only on the colouring oxides used but also on the composition of the base glaze into which they are put, the firing temperature, and the atmosphere in the glost kiln. Chromium, for example, which normally gives green or green-blue, will produce a delicate pink when combined with tin oxide in an opaque glaze; copper oxide which gives dark greens and blues when fired in an oxidizing atmosphere, can, under suitable conditions in a reducing atmosphere, produce extremely brilliant red.

Close control of colour and color-matching is both important and difficult. Until recent years it was done subjectively, by eye. Today, it is increasingly done with the help of sensitive colour-measuring apparatus.

Preparation

Whatever glaze recipe the ceramist uses he must ensure that all the ingredients are brought to a fine powdery state. If the particles are too fine, however, the glaze will crawl,which means that instead of spreading evenly over the surface of the article during firing, it will move rather like water on a greasy surface, covering some areas but leaving others uncovered. If, on the other hand, the particles are too coarse it will be difficult to keep them suspended in water in the glaze slip. Particle size will also affect how the glaze matures. Glazes composed of coarse particles mature less readily than those composed of finer ones.

While frits are sometimes ground separately, it is common practice to mix all the ingredients together and wet-grind them to the required particle size in much the same way as feldspar is ground. But since, in the case of a glaze mix, it is particularly important to avoid contamination and specking, the grinding cylinder is usually lined not with porcelain or quartz but with rubber. While the grinding balls may be of quartz, they are very often of alumina, which gives much higher grinding speeds. After grinding, the mixture must be purified by means of a magnet and sieved.

The proportion of water added to the ingredients, as well as the fluidity of the glaze slip, must be carefully controlled. The exact value required for each of these things depends on how the glaze is to be put on and the nature of the ceramic body to which it is to be applied.

The fit of a glaze depends on its own thermal expansion and that of the body it covers. The thermal expansion of a ceramic body is determined partly by its chemical composition and such physical factors are particle size, and partly by its firing treatment. That of the glaze is determined almost entirely by its composition. As the glaze, after reaching maturing temperature, begins to cool, it will become more and more viscous and eventually rigid. From then on down to room temperature both glaze and body will go on contracting, and the glaze must, of course, shrink to the same final extent as the body to which it is then rigidly attached. If the glaze has a lower thermal expansion than the body, its tendency will be to shrink less in cooling; but because it must in fact shrink just as much, it will be under compression. Glazes under compression are very strong, and actually add to the strength of the body. If the glaze has a higher thermal expansion than the body, its tendency will be to shrink more in cooling, but because it must in fact shrink only as much, it will be under tension. Glazes under tension are weak, and very likely to craze (show a network of cracks). The ceramist therefore aims at achieving a glaze that is under compression; but it must not be excessively so, otherwise it will tend to peel or flake off.

If a glaze with a lower thermal expansion than the body were applied to a perfectly flat tile, the difference in stresses between the glazed and unglazed sides would pull the tile out of shape, leaving it slightly convex on the glazed side. Therefore, tiles are rendered slightly concave during biscuit firing, and the glaze later applied to the concave surface.

Application

The traditional method of applying a glaze to almost all articles was, as we have seen, by dipping them in the glaze slip.

Wall tiles, which are glazed on one side only, call for modifications in dipping techniques. Today they are commonly conveyed mechanically, on two parallel strings, through a waterfall of glaze slip, which covers only their upper surface and edges. Little mechanical fingers clear the slip from the edges as they move on. They then pass under radiant-heat driers, which very rapidly dry the glaze so that the tiles can be removed from the conveyor. With the waterfall technique, as with any dipping technique, the slip must be constantly agitated to prevent the differential settling of particles of various weight and size.

Spraying, another method of application, lends itself to far better control of the thickness of the glaze coating, since several coats can be added if necessary and the thickness can be varied from point to point.

Spraying can be either semi-mechanized or wholly mechanized. Where it is semi-mechanized the articles move along on a conveyor, passing through one or more glazing stations which direct a spray of glaze onto them. In each glazing booth, air-extraction plant prevents dried particles from filling the atmosphere. Spray that misses the article goes onto a wall at the back of the booth that is continuously "waterfalled". The waste glaze is then pumped back, the water extracted from it, and the glaze material salvaged. Where spraying is wholly mechanized (mainly for smaller articles), the ware passes through a short tunnel in which sprays of glaze are directed onto it.

Decorative Printing

The acceptance by the consuming public of decorative tiles brought about a rapid development of technology which would produce tiles with high quality artistic patterns. Three major applications have emerged in this field which are discussed below.

Seriography (Silk Screen Method) had its origin in the textile industry at the beginning of the 20th century. The chief characteristic of seriography is the thickness of the printing and hence the covering power of the printed colour. This characteristic is ideal for the techniques usually applied to ceramic ware. A full description is given in Appendix D.

Stamp-printing

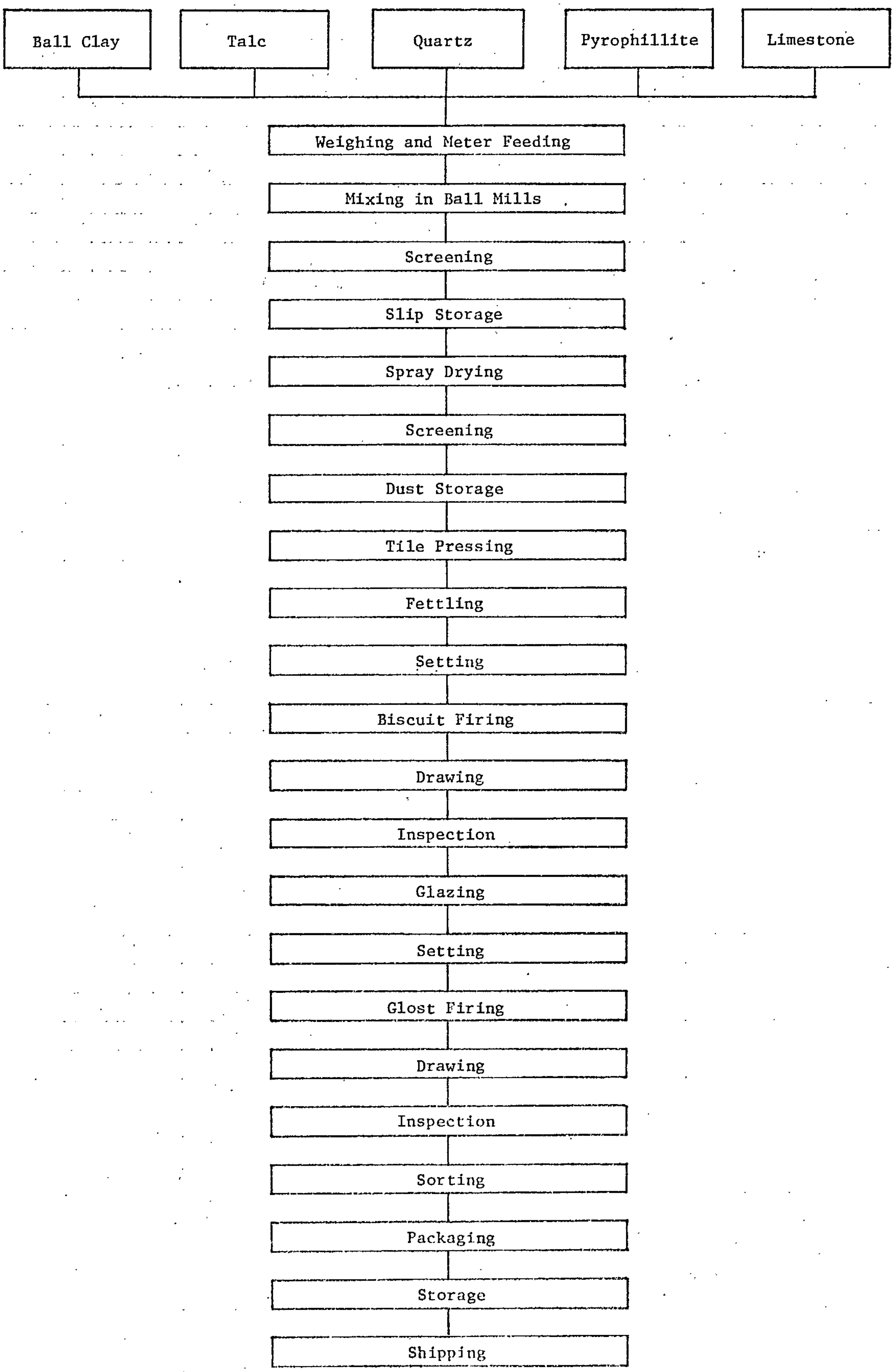
This method owes its origin to the observation that stains of different thicknesses gave different colour shades, the idea being then applied to glazes. A discussion upon this method is given in Appendix E.

FIGURE 2

FLOW CHART

PRODUCTION OF CERAMIC TILES

TWICE FIRING



Roll-Mark System

In the last four years, an American firm has developed a system of decorating tiles which will apply multi-colour decals to ceramic surfaces. See Appendix F for description of the process.

The techniques used for glazing of un-fired ware (that is, ware that undergoes only a single firing) are basically the same as those for fired ware, except that articles which are dried but unfired need more careful handling. Unfired bodies are more porous, and usually of a finer texture than fired ones. However, the fluid properties of the glaze need to be somewhat different.

PROCESS DESCRIPTION

Process

Tiles can be made by either the wet process or the dry process. The former is able to use low-cost raw materials, while the latter simplifies the body making.

Raw Materials

These come to the plant in box or covered gondola cars to be unloaded into bins or silos. For wet-process bodies, the clays are in lump form, but for dry-process bodies, they are air-floated and may come in bulk shipments or in paper sacks. The tale and other minerals are ground to specification and shipped in bulk or sacks.

Body Preparation

Body preparation may be divided into two methods, slip mixing and dry mixing. The traditional method for slip mixing is that the clays are either blunged or cylinder ground and the mill material such as quartz feldspar, prepared by cylinder grinding. The most intimate method of mixing is the continental practice of mixing clays with milled quartz and feldspar and mixing together in ball-mills. Proportions of slip are measured by dipstick and pint weight method or weight cum volume apparatus which, as the name implies, will measure large volumes of slip by weight and volume at the same time. The clay slip is then put through banks of sifters up 130's mesh, and over electromagnets, to get rid of iron contamination. The slip is then pumped to the mill room for de-watering. De-watering is done by filter pressing or spray drying. In the traditional method the slip is filter pressed and the pressed cakes are loaded on to toast rack type of trucks and dried down from approximately 25 per cent moisture content. Grinding of the clay to tile dust is done in grinding pans which have perforated grids through which the clay is forced into dust size. This ground material is then passed over a vibratory sifter and then conveyed to the tile making section.

Spray Drying

Although it has been used in other industries for many years, spray drying is comparatively new to the tile industry. The principle of spray drying consists of forcing slip through nozzles or disc atomizers which produce droplets of slip which are passed through a heated chamber which dries the droplets to granular form. The granule produced is spherical and of almost equal diameter. The advantages of the spray dryer are that it is a more efficient method of production, eliminating the process of filter pressing, drying and grinding. It is also claimed that the physical properties of the finished product, especially the grain size and moisture content of the dust, can, to a large extent, be controlled to suit particular press requirements and be kept constant during continuous working.

Dry Mixing

Finely ground air-floated materials are necessary for the dry mixing process, and these must be mixed intimately in some form of rotating pan or mixer. The water is usually added at this stage and then lumpy material is passed through a disintegrator or pan for grinding into dust size.

Tile Making

In principle, all tile presses are the same. A steel box surrounds a metal die, and the die is covered with dust to the level of the top of the box. An upper steel die then descends, sealing the box. The dust is pressed between the steel dies. The bottom die rises, ejecting the clay tile which has sufficient strength and rigidity to enable it to be dealt with by hand or conveyor belt.

There has been a trend over the years towards bigger presses and higher pressures in tile making. High pressure up to a point is beneficial, it gives higher clay and fired strength, lower firing contraction, water absorption and glaze bowing. It also gives greater latitude in the drying and firing of tiles with less tendency towards split in these processes. Automatic tile presses come in all shapes and sizes but in general they can be divided into three types.

The first type is the screw press and this gives the hardest pressure for the least mechanical effort. The actual pressing comes from the top die and much heavier hydraulic presses are required to give the same pressure. The second type of press is the cam press, which is really the reverse action of the screw press with the bump coming from the bottom die. The bumps are given by the rotating fly-wheel. With this press, programming of the filling bumping action is controlled by modification of the cams. The third type is the hydraulic press.

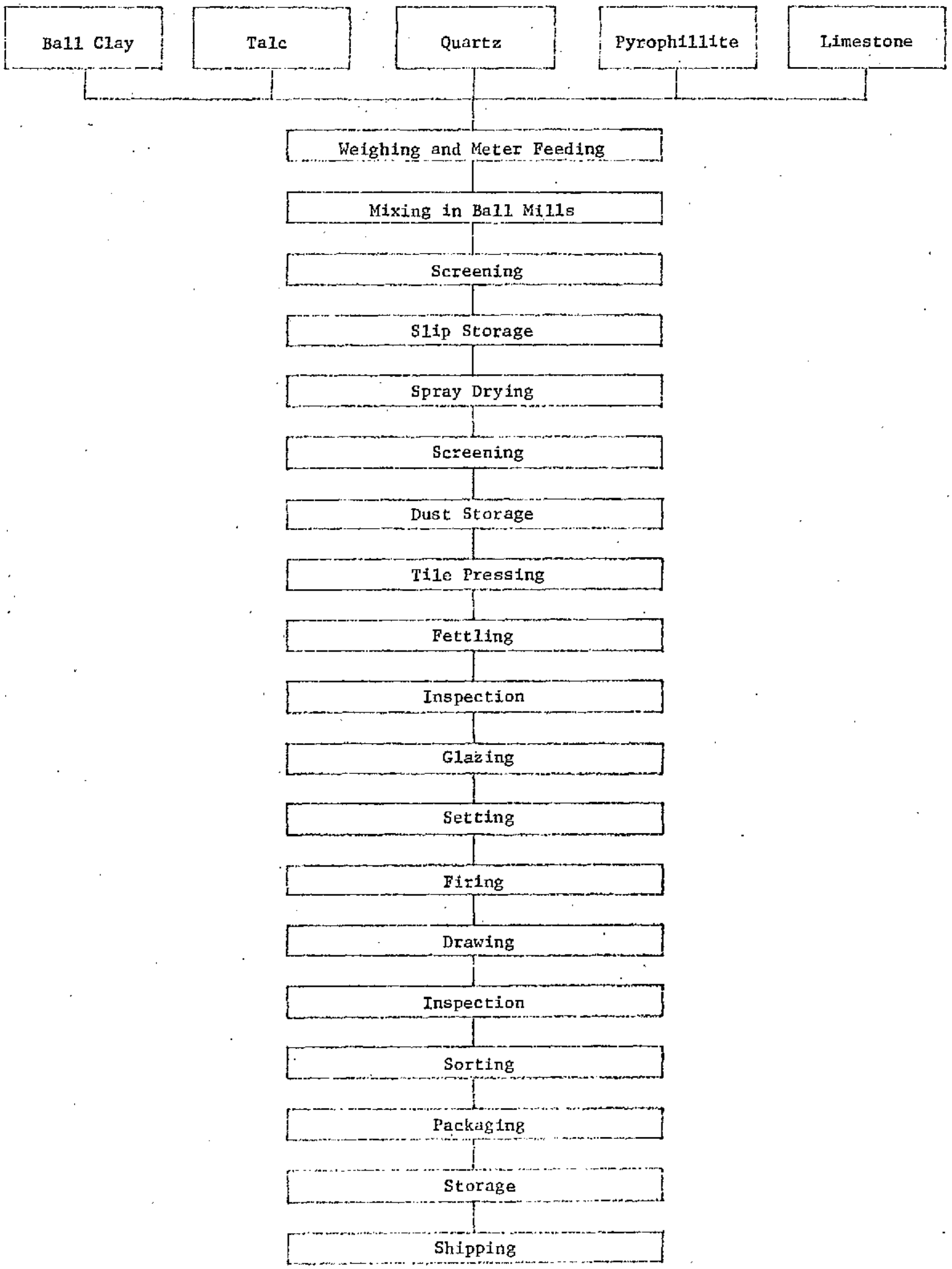
With all these presses, the action in the die box is the same. The tile is given two bumps, the first one being a consolidating squeeze in which the bulk of the air is expelled, while the second should be sufficient to give adequate hardness and strength to the pressed tile. The most important factor in tile making, after getting rid of the air, is to make certain that the pressure on the tile is maintained all the time that the tile is in the die box. If this is not maintained, the tile will expand and become distorted before ejection. It is essential for good tile making that adequate control is maintained over the moisture content and grain size of the dust. An excess of moisture in the dust will give laminated or wind-blown tiles, that is, the air has been trapped in the tile, and excess moisture can also give wedging and warping. For good measure, a wet tile will have a tendency to stick to the die, and production will fall alarmingly. If there is insufficient

FIGURE 3

FLOW CHART

PRODUCTION OF CERAMIC TILES

ONCE FIRING



moisture in the dust, once again lamination can result, and the clay strength of the tile is drastically reduced.

Too large a grain size will give reduced strength and bad surface, and too fine a grain size will produce lamination and decreased strength. Uneven die filling will result in a number of faults, including splitting and wedging. Dies are usually heated and cleaned with very light oils and/or silicones in order that the clay tile can easily be released from the steel dies after pressing.

Fettling

When the tile is removed from the die, fins are left along the edges. The fins were formerly removed by hand, but now there are many types of automatic fettling machines in use. As the tile moves along on a belt or belts, two edges rub along a strip of abrasive -- a metal screen or tungsten carbide scrapers. The tile is then turned through 90^{o} and the operation repeated. It is desirable, in some cases, to fettle both the top and bottom edges.

After the tiles have been fettled, they move along the same belts to loading stations where they are loaded either into refractory setters by automatic machines, onto kiln cars for the tunnel kiln, or onto rollers to feed into a roller hearth kiln.

In the case of "once-firing", the tiles will pass through the glazing process in their green state before being fed into the kiln for firing. See Figure 3 , opposite. This process of "once-firing" can be used only where the body materials of the tile have a nearly straight lined coefficient of thermal expansion. Consequently, there are no sharp volume changes in the crystalline structure. The proportion of materials in the body of a tile which develop gases during firing is very small.

Biscuit Tile Firing

From 150 degrees . to 500 degrees C., heating is fairly rapid. At temperatures just above 500 degrees C., clay gives off approximately 13 per cent of its weight in steam, and heating in this range has to be carefully controlled because of the danger of splitting. To add to the difficulties, silica undergoes rapid expansion at 575 degrees C., imposing a strain on the tiles when they are in a very weak state because the clay molecules have lost their combined water. Heating can then be quite rapid from 650 degrees C. to 950 degrees C., when fluxing and vitrification of the component material begins to take place.

Heating up to the maximum temperature, which is between 11 and 12 hundred degrees C., must be fairly steady to ensure that physical and chemical changes in the tiles take place uniformly. The overall cooling rate is greater than the heating rate, but care must be taken around 575 degrees C. and 225 degrees C. because of the rapid contractions due to the quartz changes at these temperatures. Once the biscuit firing and inspection have been completed, the tiles are ready for glazing.

Glazing Methods

There are several methods of applying glaze to the body tile, the main ones being waterfall dipping, spraying and silk screen printing. A waterfall dipping machine consists of a glaze container terminating at its base in a long narrow slot which is termed a flame nox, and this is mounted over a horizontal travelling wire belt. The container is filled with glaze and as the tiles are continuously fed along the wire belt they have to pass through a waterfall or descending flame of glaze. As the biscuit tile is porous, the slot glaze is absorbed almost instantly and the tile complete with its coating of glaze can be quite safely handled.

Control of pint weight and viscosity of glaze and drying rate must be adequate or faults such as pinholes, crawls and lines on the surface of the tile occur. These faults do not always disappear in the glost fire. The amount of glaze on each tile is controlled by the width of the flame box slot, and measurement of the amount of glaze is made by either weighing the tile before and after dipping or by the quicker method of measuring the actual glaze thickness on the body of the tile. Waterfall dipping is not suitable for applying glazes to clay tiles in the "once fired process."

Glaze application by means of spraying is used for glazing clay tiles, but can also be used for application to the biscuit tile in the twice fired process. The sprayers consist of a bank of spray guns contained in a tunnel, two sides of the tile being pointed at an oblique angle. The number of sprays depends on the size and speed of the tiles which are fed continuously on a wire belt, but there would normally be three or four on each side. Spraying is essential for the once fired process and is claimed to overcome porosity variation on the face of the biscuit tile. However, it is found that there is far more glaze waste using this method.

From the spraying, dipping and printing machines, the tile is placed in kiln furniture which ranges from the solid type crank, which has an area as large as the tile itself, to a skeleton type of kiln furniture. These cranks are then built up onto kiln cars ready for the glost fire.

After firing through a cycle time of approximately 20 to 25 hours, the kiln cars are drawn and the tiles are inspected and graded. From here they are packed into cardboard cartons, which are placed on pallets. These pallets are later shrink wrapped and then move by forklift trucks to the warehouse to await shipment.

Technology

The last ten to fifteen years have seen some major technological developments in the manufacturing process of ceramic tiles. These developments have brought about improvements to the consistency of the raw material body of ceramic tiles, accelerated production capabilities, and additional mechanization to various processes of tile body preparation and the charging and discharging of kilns which are usually performed by manual labour. These developments are;

- Spray Drying
- Fast Firing Roller Hearth Kilns
- Mechanical Handling Systems
- Silk Screen Printing
- Kervit Process of Manufacturing of Ceramic Tiles

Each is briefly described below.

Spray Drying

The method consists of pumping the slip into a stream of hot air. The spray droplets become dried to an extent that is easily controlled, and the material in granular form is collected at the bottom of the vessel. The hot air enters from the tap and follows a spiral flow pattern. Atomisation can be by two methods. The first is by a nozzle in the lower part of the drying chamber, pointing vertically upwards. The second is by centrifugal atomisation, using a rotary vaned disc which projects the spray radially.

The advantages of spray drying are:-

(a) It can be used for batch or continuous production.

(b) Drying and granulation are achieved simultaneously.

(c) Spherical, free-pouring granules of very small size and narrow size range are obtained.

(d) Control of final moisture content and of granule size as well as of bulk density of the granulated material is simple.

(e) Substantial saving in labour costs is possible owing to the elimination of filter-pressing, etc.

(f) Saving of floor space is considerable.

See Appendix G for a more detailed description of the process.

Fast Firing Roller Hearth Kilns

In attempts to reduce production time in the firing of tiles, and consequently reduce costs, fast firing roller hearth kilns have been successfully developed.

The need to be able to produce ceramic materials through fast firing, and possibly through one firing, has been felt first in the U.S. In that country, technicians and industrialists in the ceramic field have made the first steps in this sector, not only for sanitaryware, but also for tiles in general. The first experiments have shown at once that one firing could be considered a valid method, since the available raw materials (clays, talc, and wollastonite) easily allowed excellent results. Above all, however, such validity was subsequently proven with the concept of fast firing.

These concepts and these requirements immediately rebounded from America to Europe, where several producers started studying with enthusiasm the remarkable problems which could be solved by applying what was to become the new ceramic technology. The most difficult problem to be solved was doubtless the discovery of a process which could allow the fast firing of ceramic materials.

From this point of view, up to 15 years ago nothing, or almost nothing, had been realized and continuous kilns used all over the world were for the most part car tunnels kilns. The tunnel kiln, however, cannot allow a really fast firing: the large mass of cars represents an unsolvable problem when it must be heated and then cooled in a short time. The supports and refractory part of the cars themselves would not bear the thermal shocks to which they should be subjected. Moreover, the tunnel kiln does not allow, owing to its loading system of the materials on the cars, a full automation of operations which are carried out outside the kiln. Therefore, for fast firing of ceramic material in general, completely new kilns were necessary, in which the materials to be fired could be introduced piece by piece, and in which most of the dead weight constituted by the cars could be eliminated.

Let us briefly illustrate the kilns in which the materials to be fired, previously placed on proper refractory setter slabs, are conveyed by being placed on rollers which rotate by means of a suitable system of motor-reducers, gears and chains, etc. The rollers can be of high temperature resisting steel or of refractory materials. The kiln mounting is carried out by the manufacturer. Therefore, it is a pre-built kiln, which is assembled at the customer's premises with the help of his staff. Moreover, the various elements composing the kiln are equipped with wheels, making the kiln particularly "movable". This moveability is a useful advantage of the system in case of displacements, enlargements or other organization changes. All roller kilns distributed in the market up to three years ago were electric operated and counter-current working.

However, today, after many years of tests and huge investments, it is possible to build gas-fired roller kilns (town gas, methane, propane), and both counter-current and one-way current operation.

Pre-mixture combustion is extremely simple and is obtained by sending air and gas in suitable ratios and pressures to proper mixers and subsequently conveying this mixture to the burners unit. The burner terminal part is formed by simple refractory tubes entering the refractory slabs forming the hearth and vault of the various channels. The combustion products enter the channels through suitable holes made in the setters themselves and then come into contact with the material to be fired.

The roller kiln has been perfected in all details, tending to realize a fully automatic manufacturing plant. This technology has been further pushed forward in order to obtain fully automated lines.

Below, we summarize the advantages of this new technology in comparison with the traditional one:

a) Reduction in space needed for production

b) Drastic reduction in the time needed for producing tiles

c) Labour saving

d) Better qualities and performance

Mechanical Handling Systems

Automated handling equipment has been developed to deal with the transfer of tiles in production from one process to another where manual labour is normally used. These areas are:

- The receipt of the green tiles from the press, setting on kiln cars and loading into the kiln
- The discharge of kiln cars from the first firing
- The loading of the glazing lines
- The receipt of the tiles from the glazing lines, setting on kiln cars and loading into the kiln
- The discharge of kiln cars from the second firing.

Silk Screen Printing

Silk screen printing is discussed in the previous sections on ceramic glazes and the glazing process. In addition, Appendix D contains a detailed explanation.

Kervit Process of Manufacturing Ceramic Tiles

This process, discussed earlier, is very different from the conventional dust-pressed one in raw material approach, complete costing method, the use of ceramic moulds which carry the product through the kiln, and the rapid single firing technique. A full description of this process of manufacture is given in Appendix H.

TABLE 10

TYPICAL CERAMIC TILE PLANT

		Turnover 15-20 million sq. ft. per annum	Turnover 8-10 million sq. ft. per annum
		(A)	(B)
1.	Product	Ceramic Wall and Floor Tiles	Ceramic Wall and Floor Tiles
2.	No. of employees per shift (Excluding Administratives etc.)	36	24
3.	No. of shifts	Two x 8 hrs. per five day week	Two x 8 hrs. per five day week
4.	Equipment		
	. Hoppers - Raw Material	*	*
	. Conveyor Systems - Raw Material	*	*
	. Ball Mills	14	8
	. Spray Dryer	1	1
	. Hoppers - Powdered Material	*	*
	. Tile Presses	5	3
	. Kilns (Biscuit Firing)	2	1
	. Glazing Lines	5	3
	. Kilns (Glost Firing)	2	1
	. Inspection/Packing Lines	5	3

Peat, Marwick
and Partners

TYPICAL CERAMIC TILE PLANT

We now describe the requirements of a typical ceramic manufacturing tile plant using equipment incorporating the latest technical developments. Two sizes of plant have been examined in a preliminary fashion. One has a turnover of 15-20 million sq.ft. per annum, and the other produces a turnover of 8-10 million sq.ft. per annum. The products to be made are ceramic tiles for use on both interior and exterior walls and floors of buildings. In the example illustrated in Table 10, opposite, it has been assumed that the double firing process will be in operation. In cases in which, because of the availability of suitable raw materials, a single firing process would be involved, there would be no biscuit firing. In that case, the equipment requirement would be reduced by the kilns for biscuit firing. The number of employees would also be reduced by two for each biscuit kiln. In calculating the number of employees, no account has been taken for administrative staff because this figure is dependent upon many circumstances, and can be calculated only for each individual situation. The plant may be a subsidiary of a parent company who could supply all or part of the administrative services. On the other hand, the plant could be totally independent and require all these services.

Similarly, the description of the processing plant begins at the receipt of the raw materials in the plant and follows through to the packing lines. The manufacturer may decide to buy directly from the mine head instead of mining himself. This was discussed in section III, pages 11 and 12, where a variety of variable factors was listed.

Certain equipment has been marked with an asterisk and no indication has been given of the physical number required. The number of raw material hoppers would depend on such factors as:

- The reliability of the supply of raw materials, and
- The reserve stock which the company could afford to finance.

The type of conveyor systems and the number required would depend on the exact layout of the plant which can vary for each individual situation.

PRODUCTION TECHNIQUES

Canadian Approach

To retain a positive understanding of the Canadian Manufacturers approach, a study of the ownership of the firms comprising the tile industry must be made.

There are approximately five firms (excluding facing brick manufacturers) producing tiles in Canada. These are:

- Maple Leaf Ceramics Industries 1967 Ltd. — Montreal
- Ceratec Inc. (St. Lawrence Ceramics) — Quebec
- D.A. White & Co. Ltd. — Kingston
- Sovereign Potters Ltd. — Hamilton
- International Brick & Tile Ltd — Edmonton

Sovereign Potters Ltd. is an associated company of H.R. Johnson Ltd. D.A. White, President of the company, also manages the firm of D.A. White & Co. Ltd. There is obviously a close working relationship between these firms and H.R. Johnson Ltd. in relation to their business policy for Canada. Villeroy & Boch, the German ceramic manufacturers, have an interest in Ceratec Inc. (St. Lawrence Ceramics Ltd). The only two firms that appear to be truly Canadian-owned are:

- Maple Leaf Ceramics Industries (1967) Ltd.
- International Brick & Tile Ltd.

"There is really no true Canadian Industry as such", is the opinion of the overseas manufacturers. Their associated companies in Canada are only part of the overall policy approach to the Canadian market. Most of these companies manufacture only the more "convenient" products of the company's range for the Canadian market. The balance of the product range is supplied from overseas where cheap ocean transportation does not make the selling price prohibitive for the Canadian market. This state of affairs has set the stage for the establishment of other major management decisions in the business policies or strategies of these companies which have detracted from the building of an independent Canadian Industry. Research and development is a major part of any company's expenditures in this industry. Consequently, these firms must have a high rate of production to keep the cost rates per unit of production low. In the case of the foreign subsidiaries of these overseas companies, it has meant that they could not afford their own research and development. All this activity has taken place at the parent company corporate headquarters, from which any new technological developments have been dispatched to the subsidiary companies. Similarly, in the fields of marketing and sales promotion, the administrative and organizational procedures of new policies are first tested by the parent company in its home market, before being used overseas in the subsidiary company's markets.

Most of these large foreign parent companies have their own engineering subsidiary companies which have developed distinctive machinery to manage special situations in the manufacture of tiles. These engineering subsidiaries have also been used to adapt old equipment which has been acquired from bankrupt companies. These adapted plants have been used to produce the more regular and simple lines which are sold on the Canadian market, the remainder of the product being supplied from the modern overseas plants.

Domestic/Foreign Comparison

Although the basic processes involved in the manufacture of ceramic tiles in Canada are the same as those used by the overseas producers, there are different approaches that have been taken by Canadian manufacturers which have had some impact. These are in the following areas:

Raw Material Preparation

Most overseas manufacturers mine and prepare their own raw materials prior to the tile pressing stage. In Canada, most manufacturers have not attempted to prospect and exploit any local raw materials. They have for a variety of reasons (see Canadian Approach) found it expedient to buy their raw materials already prepared to be used in pressing of tiles. Most of these supplies come from the United tates. Consequently, in this country, there is no evidence of firms exploiting new technologies in tile body preparation, such as spray drying.

Glazing Materials and Processing

Because most of the Canadian plants are either foreign-owned or working in close co-operation with overseas firms, their capacity has been restricted to supplying particular segments of the home market. The impact of this has been two-fold:

- Most manufacturers bring in all their raw materials for the glazing process instead of preparing them in their own factories.

- Many of the manufacturers have not entered the highly decorative tile market, requiring the use of sophisticated silk screen printing processes which overseas manufacturers use on their glazing lines.

Single Firing

One of the most significant differences between Canadian and overseas manufacturers in the manufacture of tiles is that the latter generally twice fire their product (Biscuit Firing and Glost Firing) whereas in Canada (including the U.S.) the product is only once fired. The circumstance which enables North American manufacturers to once fire is the availability of two materials in economic quantities, namely talc and wollastonite. These materials allow the body to expand and contract with a nearly straight lined coefficient of thermal expansion. Consequently, there are no sharp volume changes in the crystalline structure. Other materials traditionally used in the tile manufacturing process do not possess these characteristics to the same degree and, dependent upon the application of the tile, have normally to be double fired.

Special Production Responses

In the final stages of production after the finished tile has been inspected and graded, various innovations and new techniques have been introduced by the manufacturers, basically to assist the consumer in reducing the installation time and costs.

Some of the more important of these innovations are discussed below.

Prefabricated Sections/ Sheets of Tiles

There is a steady growing demand for these products more from the industrial sector than the domestic side. For use indoors, either for walls or floors, we saw two examples of these prefabricated sections. The tiles are bonded together in numbers ranging from eight to twenty in a section. In the first example, we discovered the tiles were supplied in sheet form (5 x 3 in number), joined together with spots of insoluble plastic. The joints are equal and exact, and the plastic spots are rot-proof. In the second example, the series of tiles (4 x 5 in number) were also supplied in sheet form, bound together with a self adhesive polyurethane foam backing.

In both cases, these sheets can be laid either manually or by new machines which are now available on the market. The use of preformed units is a definite advantage for ease of laying. It is claimed by the manufacturers that the additional cost of the sheet form preparation per square meter is more than compensated by the speedier method of laying and the saving of time and, ultimately, laying costs.

Outdoor applications are to be found in the use of tile as a cladding or facing material for buildings. In these circumstances the tiles are assembled into metal frames which provide the shell of the prefabricated unit and are secured together with a polyester resin adhesive bath, between the joints of the tiles and the backing of the resultant panel. These panels are suspended from metal horizontal rails built into the outside of the wall of the building, on metal hooks which have been attached to the rear of the panel during the assembly stage.

Shrinkwrap Packaging

This form of packaging assists both the manufacturer and the various agents responsible in the distribution cycle to store efficiently, handle, and transport the tiles.

After the tiles have been packed in small cardboard cartons, they are stacked upon wooden pallets. A plastic shroud is dropped over the pallet holding the cartons of tiles. The pallet is loaded by forklift truck onto a conveyor belt which projects it towards the "shrink tunnel". As the pallet passes through the tunnel, warm air up to 500°F is blown over the plastic, causing it to shrink to a tough wrapping that is moisture proof, air tight, and transparent.

Self-Adhesive Tiles

These are tiles which are sold by the manufacturer to the consumer with the adhesive already applied to the back of the tile. They are backed with wax paper which has to be peeled off before use. The tiles are then placed on the surface of application, and grout inserted between the tiles to obtain the completed finish.

The application of the adhesive to the backing of the tile occurs in the latter stages of the manufacturer's production process. After the tiles have been inspected and graded, they are placed upon a conveyor belt which passes the tiles over the rims of four vertical revolving wheels. These wheels, which are suspended into a tank containing the adhesive liquid, revolve as the tile passes over the rims. A coating of the adhesive is smeared on the backing of the

TABLE 11

ECONOMICS OF VARIOUS PRODUCTION METHODS

IN CANADA AND ABROAD

	Manufacture Using Traditional Materials					
	Canada %	U.K. %	Germany %	Italy %	* Quebec Canada %	Kervit Process %
1. Raw Materials	50	24	20	41	35	15
2. Labour	27	40	46	30	32	25
3. Fuel	4	8	8	10	8	5
4. Overheads	19	28	26	19	25	55
5. Total Cost	100	100	100	100	100	100

* Proposed plant under construction

Source: Company interviews during survey

Peat, Marwick
and Partners

tile which is automatically covered with wax paper as it flows off the wheel rims. The tiles are then conveyed mechanically to be packed in cardboard cartons.

PRODUCTION ECONOMICS

During the course of our study, we interviewed various manufacturers in the countries indicated, on the subject of the cost to produce and sell ceramic tiles. Naturally, many of these firms were reluctant to release their figures, but they were prepared to discuss the relationship of the main basic cost elements to the total cost. From this we have prepared Table 11, opposite, showing a comparison of Canadian conditions with those of the principal European manufacturers. Figures are also provided for a proposed plant under construction in Quebec Province and a European firm manufacturing tiles by the Kervit process.

Our comments upon these figures tend to confirm opinions expressed in earlier sections upon the state of the Canadian industry and its position in relation to overseas manufacturers.

Raw Materials

In Canada, this element of cost is far higher than most overseas manufacturers, and in the table of comparison this difference amounts to nearly 100% on average. This can be accounted for by the following circumstances.

- The majority of Canadian manufacturers import most of their basic raw materials from the United States.
- Because of this factor, the transportation cost inflates the raw material price and accounts for nearly half of the total price of this cost element.

Most overseas manufacturers have a readily available source of raw materials nearby their production plants. This occurence is reflected in their figures.

Labour

The definition of labour included not only the basic rates of pay but also all fringe benefits accruing to the employees, such as life insurance, medical schemes, company car, pension schemes, etc. German labour costs are currently one of the highest in Europe, and have already overtaken North American rates. However, the difference may not be as large as the table percentages suggest, because most of the European firms interviewed have a larger percentage of indirect factory labour because of such service activities as research and development. This is further confirmed by the figures for the Kervit Process in which the company involved is a subsidiary of the Reed Paper Group in the U.K. which supplies it with all the technical services it requires.

Energy

The cost of fuel is a relatively small portion of total costs in the manufacture of tiles. Most Canadian firms employ the "single firing process", probably accounting for the cost difference with the European manufacturers who generally fire their tiles twice in the manufacturing process. The Kervit Process is a single firing operation, and the results compare with Canadian experience.

Overheads

Canadian firms have the lowest percentage overhead rates, because many of them are either subsidiaries or associated companies of a parent European firm and therefore do not have to support the high overheads of service departments (e.g. administration, research and technical development).

In addition, the amortization costs included in the overhead percentage cost is small because Canadian manufacturers are using old equipment, probably in some cases fully depreciated. In contrast, their European counterparts have more modern up-to-date equipment which by comparison will have much higher amortization rates.

1V - CONCLUSIONS AND RECOMMENDATIONS

Previously we have discussed in detail the Canadian ceramic tile market, the current status of the industry, and the various technologies and economics associated with manufacturing. Herein we present our conclusions and recommendations.

CONCLUSIONS

Three significant considerations in the assessment of additional domestic production capacity are the market prospects, sources of raw materials, and the various manufacturing configurations. We conclude the following:

Marketing

For 1974 the total Canadian market is estimated to reach 85 million sq.ft. of ceramic tiles, of which about 66 million sq.ft. will be imported.

- three quarters of the tiles sold are used in flooring application. Only one third of the current Canadian production is allocated to floor tile manufacturing.
- 64% of the market is concentrated in Quebec and Ontario.
- there are five domestic manufacturers: two in the Province of Quebec, two in Ontario, one in Alberta.
- the tile manufacturers, except for one, distribute imported ceramic tiles and sometimes other surface covering products which complement their lines.

- ceramic tiles come in two categories, wall tiles and floor tiles and two sub-categories, mosaic and quarry tiles. Wall tiles and mosaic tiles are the thinnest (1/8"), floor and quarry tiles are thicker ($\frac{1}{4}$" and more).

- non-white bisque is gradually replacing white bisque because of its lower cost and extra durability.

- imports as of September 1974, were 18 million sq.ft. of tiles under $2\frac{1}{2}$" and 34 million sq.ft. of tiles over $2\frac{1}{2}$" for a total value of $15.8 million.

- major exporters to Canada are Japan, Italy, United Kingdom, Spain, Germany, South Korea.

- in the under $2\frac{1}{2}$" importation, Japan is steadily loosing ground, while Italy is increasing its share (2.6% in 1970, 12.3% in September 1974). In the over $2\frac{1}{2}$" importation, Italy replaced the United Kingdom as the largest exporter to Canada as of September 1974.

- increased imports displaced other synthetic floor and wall coverings and did not compete directly with domestic producers.

- domestic tile makers did not respond through increased capacity to the increasing market demands for quantity and diverse decorative designs over the past several years.

- tariffs into Canada are 20% except for the U.K. at 15% and several preferential tariff countries such as Korea and Brazil where 13% applies.

- duty into the United States is $24\frac{1}{2}$% for non-communist countries.

- imports of ceramic tiles by the United States was 170 million sq.ft. in 1973.

- the largest Canadian importer, located in Montreal, achieves an annual sales level of $3 million.

- trends are towards greater use of ceramic tiles in kitchens, halls, patios and recreation rooms. Greater appeal is being made to the do-it-yourself market.

- major competitive surface covering materials include vinyl asbestos, linoleum, carpets, and hardboard sheets. Ceramic tiles have a high initial cost and low maintenance costs and therefore represent good value over the long-term.

- main competitive advantages of ceramic tiles include sanitation, fire-proofing, ease of maintenance, colour and decorative possibilities.

- per capita consumption has gone from 1.6 sq.ft. in 1963 to 3.1 in 1973.

- largest potential for ceramic tile is in the large decorative floor tile, over 4" x 4" and the exterior use of quarry tiles for institutional and commercial constructions.

- most likely total market size for 1979 has been estimated to be between 119 and 125 million sq.ft.

Raw Material Sources

There are suitable raw materials available in Canada for the manufacture of ceramic tiles, in areas which have reasonable access to the major consuming markets. These areas include the provinces of Quebec, Alberta and Ontario. We understand that one Italian firm has already prospected suitable and usable reserves of clay in the Province of Quebec.

- the majority of Canadian manufacturers are not using local raw materials, but are importing the majority of their requirements from the United States. While in the short term this conservative strategy appears beneficial, further efforts are required to determine the location of appropriate raw material sources.

- one known attempt has already been made by a Canadian manufacturer to recycle local waste material by using it as a component material with local clays to successfully manufacture ceramic tiles. However, we have no knowledge of the existence of the Kervit Process System using scrap glass, whiteware and sanitary ware.

Manufacturing

Except in the case of International Brick and Tile Co., there is very little modern technology being used in the manufacture of ceramic tiles in Canada. The few producers remaining in business (five in number) are still producing tiles from old equipment with little or no modern technology, thus limiting the product range, and the producers' ability to meet the changing demands of the market, (e.g. the advent of the decorative tile).

- the majority of Canadian manufacturers have not developed the more sophisticated glazing techniques which are necessary to produce the decorative style of tiles. This is partly due to the fact that they have not catered to this segment of the market. Consequently, we saw no evidence of the use of silk screen printing, stamp roller printing, or the roller mark system.
- the price of fuel is approximately 5% of the total cost to produce tiles, and consequently is not a major cost influence.
- there is very little research and development performed by the Canadian manufacturers.
- the major overseas manufacturers influence the Canadian manufacturing scene through their associated relationships with these companies. Any benefits from research and development are passed to the associated companies only if it suits the overall business policy of the overseas manufacturers.

- where convenient local supplies of raw materials may be used, Canadian manufacturers could reduce substantially the cost of raw material transportation to the plant, with the ultimate benefit of a more competitive priced tile on the Canadian market against foreign imports.

- Canadian manufacturers are generally taking advantage of the use of raw materials like talc and wollastonite. Therefore, they can and do use the single firing system. This assists in a faster total production time with the inherent benefits of greater unit output, and better flexibility to meet delivery dates.

- although we have seen evidence of the use of shrink wrapping, there has been no response by Canadian producers to market demands to develop new techniques such as:

    - prefabricated sections/sheets of tiles

    - self-adhesive tiles.

RECOMMENDATIONS

For Canada to profit from the ever-increasing factory costs by exporting countries and what appears to be a definite change in the domestic market place in which consumer tastes are progressively turning to ceramic tiles, additional manufacturing capacity would be needed to start what could become a strong Canadian ceramic tile position in north eastern North American markets. The prospective ceramic tile producer requires a high sensitivity to, and thorough experience with the different varieties of raw materials, technologies and merchandizing techniques of these tiles. We recommend the following:

- the location of additional manufacturing facilities should be near Montreal because of the proximity of both raw material deposits and access to North America's northeastern markets.

- the minimum capacity, subject to detailed feasibility studies, should be 8 to 10 million sq.ft., for a single product line and 15 to 20 million sq.ft. for more diverse product lines.

- the total domestic production capacity should not exceed 70 to 80% of domestic consumption for at least five years at which time the export marketing programs will have been established.

- in the near future, Western Canada may be investigated as a logical site to serve the North American Pacific Coast. (requires ascertainment of suitable clay deposits).

- new plants should be preferred over modifying existing plants because of the basic differences in raw material usage and technology.

- the new plants should be able to produce all ceramic tiles (quarry, wall, floor, glazed, unglazed, fancy and decorative)

- the new plants should be equipped with the most automated, and the most reliable machinery available, (including electronic quality control equipment).

- the equipment and technology should come from European Countries having the largest proven ceramic manufacturing output and the most diverse product items (such as Italy, Germany, and the United Kingdom).

- continuous access to technological improvements should be maintained as a condition for competitive survival.

- because of the high original investment required, new plant owners should have access to readily available funds and be prepared to see little return from their capital during the first stages of production.

- the organization sponsoring the new plants should have an established record of success in ceramic technology, manufacturing and marketing.

- the administration of such new manufacturing facilities should devote a large portion of its marketing strategies and efforts towards effective export marketing. It should preferably be associated with a distribution network, successfully marketing ceramic tiles in North America, or have very specific quantitative and qualitative plans and programmes towards the establishment of an effective distribution system.

- the organization should have, from the beginning, strong, up-to-date and aggressive marketing strategies, objectives and commitments (i.e. a marketing department, promotion budgets and proven marketing competence in North America)

- while government encouragement for additional manufacturing capacity should be extended to the existing domestic manufacturers such encouragement should not be restricted to this group.

- no further reduction of tariffs, should take place for several years as a short term stimulus for additional manufacturing capacity.

- the possibilities of utilizing Canadian raw materials for the manufacturing of other ceramic products, (i.e. sanitary ware, electronics and industrial components and decorative pieces), should be further analysed.

- along with the further development of manufacturing capabilities within various regions of Canada, government should encourage further marketing and feasibility studies for the ceramic tile industry. Joint promotional programmes for marketing ceramic tile products in Canada and the United States should be developed.

THE CERAMIC TILE INDUSTRY

IN CANADA

AND

THE PRACTICALITY OF ADDITIONAL

MANUFACTURING FACILITIES

APPENDIX A

TERMS OF REFERENCE

APPENDIX A

TERMS OF REFERENCE

1. The aim of the study shall be to assess the manufacturing possibilities in Canada in the light of changing circumstances in the traditional producing countries brought about by commodity price rises, increased fuel costs, etc.

2. The study shall embrace wall tiles, floor tiles, mosaic tiles, quarry tiles and any other form of ceramic tiles.

3. A statistical table shall be presented showing the trends over the last 10 years of imports, exports and domestic production.

4. The principal foreign and domestic producers shall be identified and their product lines described in general terms.

5. A short description shall be given of the different types of tiles and their method of manufacture.

6. Cost figures shall be developed as far as possible showing the principal cost elements of the foreign producers with special attention to raw materials, energy, freight and labour. Comparisons should be made for Canadian conditions.

7. For the purpose of (6), a designated region of the Province of Quebec shall be assumed to be the plant location.

8. Indications shall be given of the trend of technological change in the industries.

9. A picture of the Canadian market shall be given by questioning major consumers in the construction industry and future projection made.

10. Up to 2 trips to major exporting countries to gather local data may be authorized by the steering committee.

11. The advantages and disadvantages of complete or partial manufacture in Canada shall be analysed, with particular attention to the economics of glazing.

12. Brief reference shall be made of the domestic raw material situation with particular attention to suitability and availability.

13. A summary assessment shall be made of the present situation in Canada concerning the viability of Canadian manufacturing vis-à-vis imports.

14. The tariff situation in Canada and the major producing countries shall be presented.

15. Methods of installation and packaging shall be studied with particular attention to the more modern practices in European countries such as "modular" bathrooms and kitchens designed around standard pre-fabricated panels of floor and wall tiles.

16. Where possible cooperative marketing arrangements such as exist between some tile-makers and sanitary-ware manufacturers shall be examined.

17. After all the data have been gathered and analysed, the consultant's own conclusions and recommendations shall be presented at the end of the report.

18. The report shall be adequately summarized for quick reference.

19. The report shall be presented in 25 copies at the end of the time span.

20. In the interim, the consultant shall discuss progress with the steering committee at least once a month, and more frequently if requested.

THE CERAMIC TILE INDUSTRY

IN CANADA

AND

THE PRACTICALITY OF ADDITIONAL

MANUFACTURING FACILITIES

APPENDIX B

SUPPLEMENTARY CERAMIC TILE TARIFF DATA

TABLE B-1

TARIFF STRUCTURE - TILES

	TARIFF ITEMS COMMONLY APPLIED		
Tile, Ceramic Floor & Wall			
under 2 1/2 x 2 1/2	2850001	2841501	3261501
2 1/2 x 2 1/2 & over	2850001	2820501	2841501
over 2 1/2 x 2 1/2 in NES	2840501	2841501	2850001
Tile, Quarry, earthenware	2850001		
Tiles, Earthenware, over 2 1/2 in sq Unfinished	2841501		

		BRITISH PREF TARIFF	MOST FAV. NATIONAL	GENERAL TARIFF	GENERAL PREF. TARIFF
28415-1	Earthenware tiles, n.o.p.	12 1/2%	20%	35%	
*	GPT (1/7/74 - 30/6/84)				12 1/2%
28500-1	Tiles or blocks of earthenware or of stone prepared for mosaic flooring	15%		30%	
	GATT		20%		
	GPT (1/7/74 - 30/6/84)				13%
28205-1 *	Manufacturer of clay or cement n.o.p.	12 1/2%	12 1/2%	22 1/2%	
	GPT (1/7/74 - 30/6/84)				8%
35615-1	Manufacturer of glass n.o.p.	10%	20%	22 1/2%	
	GATT		17 1/2%		
	GPT (1/7/74 - 30/6/84)				10%

*
GATT IS SAME AS EXISTING TARIFFS

Source:

PEAT MARWICK AND PARTNERS

TABLE B-2

TARIFF STRUCTURE - RAW MATERIALS

		British Pref Tariff	Most Fav. Nation	General Tariff	General Pref Tariff
29500-1	Clays, including china clay, fire clay & pipe clay not further manufactured than ground	Free	Free	Free	
	GPT (1/7/74 - 30/6/84)				Free
29505-1	Woolastonite	Free	Free	Free	
	GPT (1/7/74 - 30/6/84)				Free
29525-1	China clay	Free	Free	25%	
	GPT (1/7/74 - 30/6/84)				Free
29645-1	Talc for use in the manufacture of ceramic tile (expires Feb. 28/1977)	Free	Free	25%	
	GPT (1/7/74 - 30/6/84)				Free

Source: Statistics Canada

TABLE B-3

LIST OF COUNTRIES FOR TARIFF CATEGORY

1973 Tile exporting countries entitled to:

A) British Preferred Tariff Treatment

- United Kingdom
- Australia
- South Africa

B) Most Favoured Nation Tariff Treatment

- Austria
- Belguim-Luxembourg
- Denmark
- France
- Germany West
- Greece
- Italy
- Netherlands
- Portugal
- Spain
- Sweden
- Switzerland
- Czechoslovakia
- Japan
- United States
- Taiwan

C) General Preferential Tariff Treatment

- Israel
- Hong Kong
- Singapore
- Korea, South
- Philippines
- Brazil
- Columbia
- Mexico

THE CERAMIC TILE INDUSTRY
IN CANADA
AND
THE PRACTICALITY OF ADDITIONAL
MANUFACTURING FACILITIES

APPENDIX C

SOURCES OF AVAILABLE MATERIALS
IN CANADA AND THE UNITED STATES

APPENDIX C

SOURCES OF AVAILABLE MATERIALS IN CANADA AND THE UNITED STATES

CANADA

Kaolin

Saskatchewan has the largest known occurence of kaolinized material of the four Western Canadian provinces. The extensive deposits of kaolinized sands in the Whitemud Formation have been the object of many studies by the University of Saskatchewan, the Saskatchewan Government, private industry, and the Government of Canada. However, it has proven difficult to locate suitably large deposits from which the kaolin could be extracted economically. The kaolins recovered from the sands toward the eastern part of the formation, in the Wood Mountain, Fir Mountain and Flintoft areas particularly, are of greater interest because of more favourable properties and higher recoveries than those from the westerly sands in the Eastend-Knollys area. It is believed that the clays recovered from the sands in the Whitemud Formation of the Alberta Cypress Hills would be somewhat the same as from the Eastend deposits.

Several kaolin occurences have been reported in northern Manitoba, one of which is located above Precambrian rocks on Punk Island. Indications are that the clay is refractory and suitable for whitewares, but the quantity of material is small. A nearby silica sand deposit operated by the Winnipeg Supply and Fuel Company, Limited on Black Island contains a small proportion of a white kaolin type mineral. These islands are in Lake Winnipeg about 90 miles by water from Selkirk.

The refractory clays of British Columbia that contain a kaolin-type mineral are generally fireclays or stoneware clays. A deposit of the Tertiary age is to be found at Giscome Rapids, on the Fraser River, about nineteen miles northeast of Prince George. The refractory clays are generally plastic, although some seams are very sandy. The material is usually iron-stained, and washed samples are difficult to bleach and are gritty. The clays have been found to be suitable for some whitewares and for refractories and have been used for facing materials.

Very promising sedimentary and heavily glaciated deposits of sands of Cretaceous age, containing kaolin; plastic, white, kaolinitic clays; fireclays, and stoneware clays occur in the James Bay watershed of northern Ontario along the Missinaibi and Mattagami rivers. Clay washed from the sands of the various occurrences is generally very refractory, has good colour, and fires white. It contains very fine quartz.

Development of the northern Ontario sands and clays has been very slow. Lack of transportation facilities, heavy overdurden, and a severe climate during the winter have hindered exploration. Improvement and development of roads, railways and methods of exploration have resulted in more activity in this area in recent years. Distance to markets, however, remains great and this may cause problems in future development.

A large deposit of kaolin and quartzite at St-Rémi-d'Amherst, Papineau County, 93 miles northwest of Montréal has been known since about 1894. In 1911 the St-Rémi Kaolin Company produced china clay for paper making from the white kaolinized beds.

A deposit at Chateau-Richer, near Québec City, Montmorency County, containing about 20% kaolin and 80% feldspar, has been under investigation and development for the past ten years by Quebec Clay Mining Ltd., Québec City.

To date no suitable deposits of kaolin have been found in the four Atlantic Canadian provinces, although deposits of refractory clay are known to occur at Shubenacadie and in the Musquodobit valley, Nova Scotia.

Ball Clays

Canadian ball clay differs from the white-coloured kaolin-type clays or sands in such ways as raw colour, fired colour, texture and plasticity. The very refractory ones have compositions similar to the kaolinized samples that have a high clay content, while the less refractory fireclays and stoneware clays have a higher proportion of fluxing minerals.

The Whitemud Formation of Saskatchewan contains many good-quality ball clays.

In the Willows, Readly, Big Muddy Valley, Blue Hills, Willow Bunch, Flintoft and other areas of southern Saskatchewan there are some very plastic ball clays. Some of them have extremely high green strength and are being successfully used at Medicine Hat and elsewhere as a pottery or whiteware ingredient. They are also being used in Vancouver for the manufacture of insulating firebrick and pottery, and for facing brick production in Saskatchewan. The Saskatchewan Whitemud Formation contains the only known ball clays in Canada. In general, the most promising deposits that can be economically developed have limited tonnages.

Common Clays and Shales

Common clays and shales are the principal raw materials available in Canada for the manufacture of clay products. They can be used for the manufacture of structural tile, partition tile, and quarry tiles.

Because of their content of iron, Canadian common clays and shales frequently fire salmon or red. Their fusion points are low - usually well below cone 15, which is considered to be the lower limit of the softening point for fireclays. Ordinarily, they are a heterogeneous mixture, including clay minerals and various other minerals such as quartz, feldspar, mica, geothite, siderite, pyrite, carbonaceous material, gypsum, calcite, dolomite and hornblende.

The Atlantic Provinces generally have excellent firing raw materials in this category. Clays from most of these areas are easy to dry, have suitably long firing ranges and are low in calcite or dolomite. The shales in this area are probably the most useful, but many clays are also satisfactory for ceramics. Tiles and pottery are the principal ceramic products made from these materials.

The ceramic clays and shales of Quebec are common, heterogeneous, mainly red-firing materials. As a rule the shales from Quebec are more suitable than the clays for making dense facing brick, because they usually have longer firing ranges. The Quebec Group shales are more refractory and have more plasticity than the Utica, Lorraine, Rockcliffe and Queenston shales of the St. Lawrence Lowlands. Because of their availability at Montreal, Utica and Lorraine shales are those most widely used in Quebec.

We understand that a firm of Italian manufacturers of tiles has done geological surveys in Quebec Province and found suitable raw material deposits in sufficient quantity and suitable location to justify the production of tiles.

These samples have already been proven under normal production condition in Italy and marketable tiles produced. As a result of their findings the firm is establishing production facilities near Bécancour in Quebec Province.

Silica

Silica, an important ceramic raw material, is used as sand in glass, glass fibre, silicon carbide and silica brick manufacture and, as flour, in enamel frits and in whitewares.

Silica occurs as the mineral quartz in sand, sandstone quartzite, and vein quartz deposits. Deposits are widespread in Canada, however, only those with a high silica content are of interest for ceramic applications. These latter deposits include sands in the Atlantic Provinces, those along the shores of the Great Lakes and Lake Winnipeg, and those occurring at numerous inland locations throughout Canada; loosely consolidated sandstone deposits such as the Sylvania sandstone of the Windsor-Amherstburg area of Ontario, the Red Deer River and Wapawekka Lake deposits or northern Saskatchewan and the Peace River deposits in west-central Alberta; firmly cemented sandstones such as the Postdam sandstone of eastern Ontario and southern Quebec, and those of the Canal Flats area of southeastern British Columbia; and Quartzite such as those at St. Donat, Quebec, and in the Golden area of southern British Columbia.

Nepheline Syenite

Nepheline-bearing rocks are not uncommon and are known to occur in Ontario, Quebec, and British Columbia. Only the Blue Mountain nepheline syenite deposit, northeast of Peterborough, Ontario, however, has thus far proved to have the relatively consistent mineralogical composition that permit the production of consistently high-quality products. The rocks consist approximately 50% soda feldspar, 20 to 25% of both nepheline and potash feldspar and small quantities of the iron-bearing minerals occur as discrete grains, nearly all of which can be liberated and removed to produce the principle product glass-grade nepheline syenite.

Limestone and Lime

Limestone and Lime are produced in Canada in sufficient quantity and of adequate quality to supply any industrial requirements. Only two provinces, Prince Edward Island and Saskatchewan, lack workable deposits of limestone. The uses for limestone have become so numerous and so diversified that deposits must be recognised not merely as limestone but as limestone of "high-calcium" or "dolomotic" designations, relative to the chemical analysis of the material. Canada's limestones are well distributed, and although all are not catalogued according to quality, there are ample resources.

Feldspar

Canada has a long history of providing feldspar to ceramic manufacturers. The common occurence of very corse-grained granitic pegmatites in several accessible parts of southeastern Ontario and southwestern Quebec provided a ready supply of various grades of both potash and soda feldspar over a period of 60 to 70 years.

Talc

Two talc mines operated in the southwestern part of the province of Quebec by Baker Talc Limited at South Bolton and by Broughton Soapstone & Quarry Company Limited at Broughton Station. The ground products from these operations are normally off-white in colour, but benefication processes are employed to up-grade the material.

At Madoc, Ontario, Canada Talc Industries Limited mines a near-white talc, containing some dolomite and remolite. Ground products are white and low in iron but contain varying amounts of dolomite. At one time Madoc talc was used for the manufacture of a wall tile, but proper quality control was not maintained.

Talc deposits are known in British Columbia, Ontario and Quebec. It is also reported that minor occurences of talc or soapstone are located in Nova Scotia, New Brunswick, Manitoba, Saskatchewan and Northwest Territories.

Pyrophyllite

Pyrophyllite of relatively high quality is mined at Long Pond, near Manuels, Newfoundland, by Newfoundland Minerals Limited. The entire output is shipped to American Olean Tile Company, Inc. at Landsdale, Pennsylvania, where it is used in the manufacture of ceramic wall tile.

Occurences of pyrophyllite in Brisith Columbia were investigated and although some were considered "very refractory" and others were considered suitable for whiteware bodies and refractories such as saggers, no continued production was initiated. A deposit of pyrophyllite was located at Senneterre, Quebec, by Domtar Construction Materials Ltd. for use in refractories.

UNITED STATES

Reference is also made to the availability of raw materials in the manufacture of ceramic tiles in the United States. Many of the

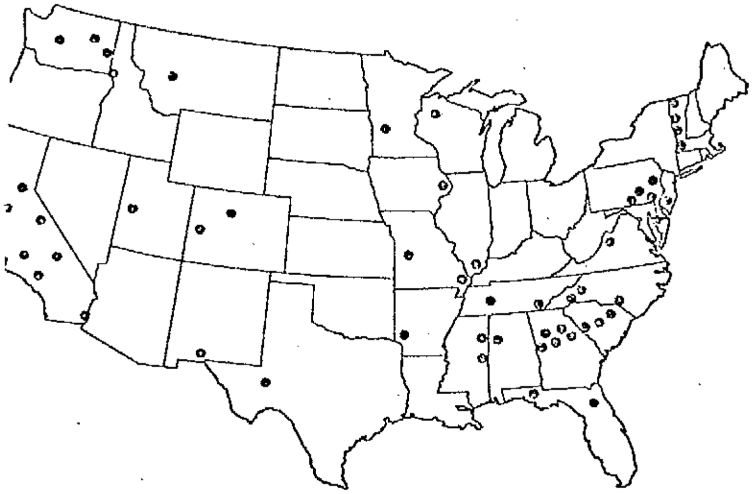


Fig. 1 - Location of principal kaolin deposits in the United States.

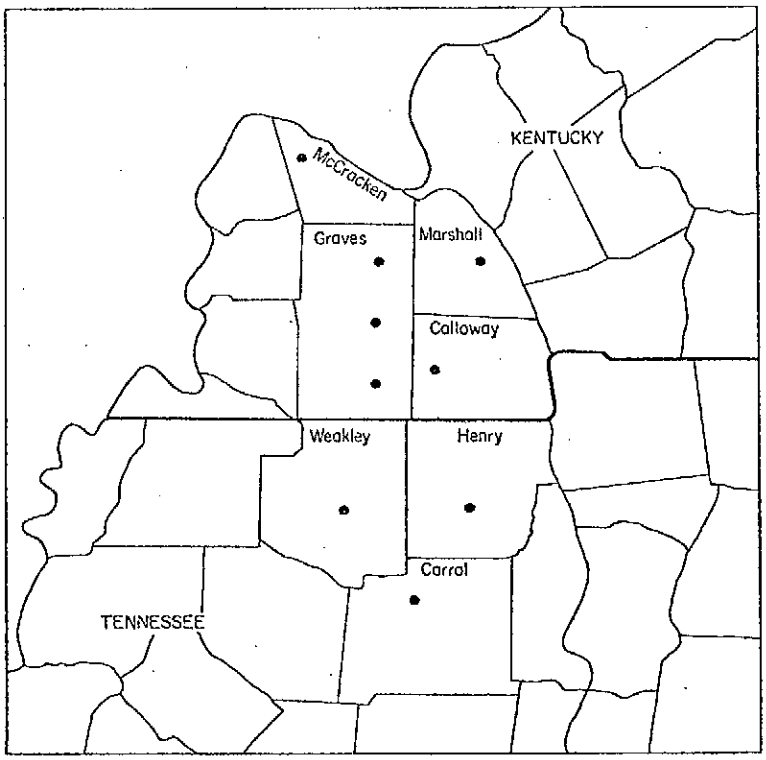


Fig. 2 Principal ball-clay deposits in the United States.

Canadian Manufacturers import some of these materials from the U.S. for a variety of reasons, mainly regularity and consistency of supply.

Briefly, the principal areas of these deposits for each type of material are described as follows:

Kaolin

The more important Kaolin deposits are to be found in Georgia, South Carolina, Florida and North Carolina, and California, and these areas are known to supply manufacturers in Canada. See Figure 1.

Ball Clays

The commercially important deposits run through Western Kentucky and in the Grenada Formation of Tennesse. Figure 2 shows the location of the better known ball-clay deposits, with discoveries having been reported in several other states, such as Alabama, Arkansas, Kansas, Texas, Missouri, Maryland and Delaware.

Talc

In the United States there are several producing areas for talc. There are two important areas in the New York State of the Northwest Slope of the Adirondacks; one near Gouverneur, St. Lawrence County, produces a fibrous tremolite talc, while the other near Natural Bridge in Lewis County produces a more massive product. Two areas in the Green Mountains of Vermont mine talc. These are in Johnson and Waterbury Counties. Important talc deposits occur in Eastern California in a long belt extending into Western Nevada. At this Northern end,

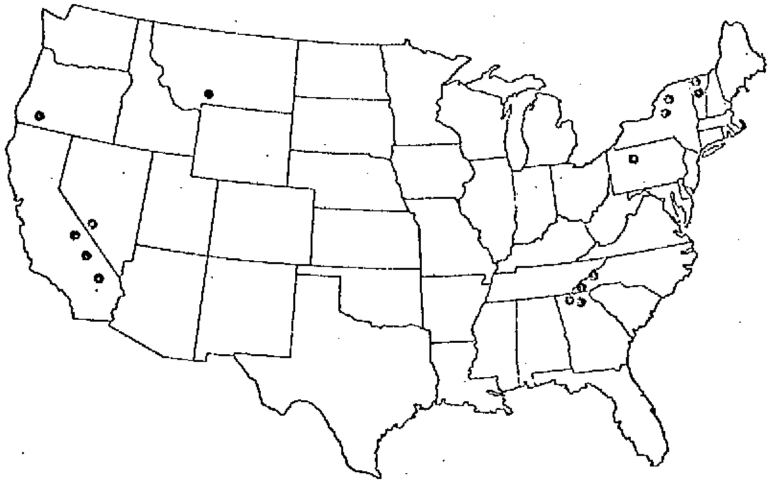


Fig. 3 United States talc deposits.

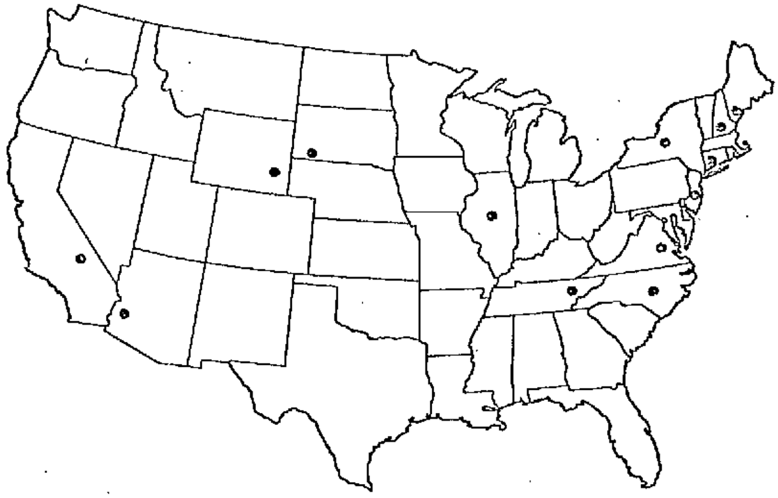


Fig. 4 Feldspar deposits in the United States.

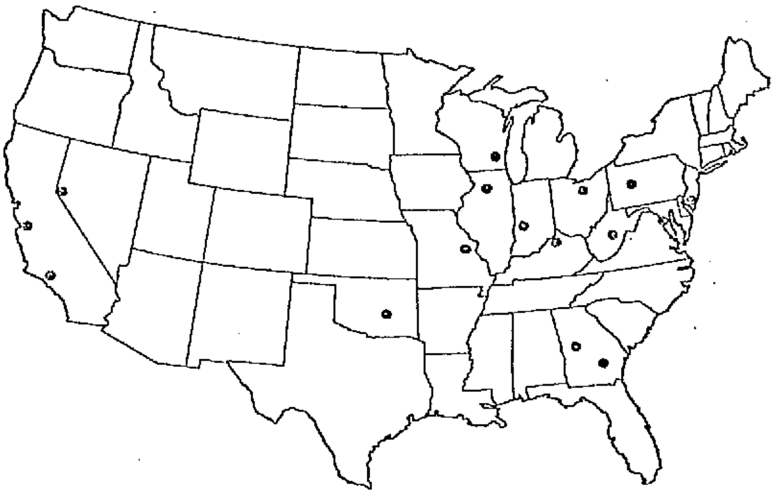


Fig. 5 Glass sand deposits in the United States.

Source: Norton, F.H., <u>Fine Ceramics</u>, New York: McGraw-Hill Inc., 1970.

deposits are worked at Silver Lake in San Bernardino County. Excellent talc is now being mined in Oregon and Montana. Figure 3 shows the location of the deposits in the States.

Pyrophyllite

Several deposits of this mineral are being worked in the United States particularly in North Carolina.

Wallastonite

The only deposit of sufficient purity for commercial use is that located at Willsboro, New York.

Feldspar

Figure 4 shows the principal Feldspar deposit reported in the United States. In the early parts of the century, the New England states were the large producers of feldspar; but at present North Carolina has taken the lead.

Quartz

There are many deposits of quantity in the United States of sufficient purity for ceramics. While many deposits of rock quartz are known, the cost of mining and pulverizing has made it more economical to use the friable sandstone from which glass sand is taken. The map in Figure 5 shows the chief deposits that have been opened up. Much of the quartz for whitewares comes from the sands in West Virginia and Illinois, not only because of their purity but because they are near the point of consumption.

THE CERAMIC TILE INDUSTRY

IN CANADA

AND

THE PRACTICALITY OF ADDITIONAL

MANUFACTURING FACILITIES

APPENDIX D

SERIOGRAPHIC DECORATION

(SILK SCREEN PRINTING)

ON CERAMIC TILES

APPENDIX D

SERIOGRAPHIC DECORATION (SILK SCREEN PRINTING) ON CERAMIC TILES

From its origin in the textile industry at the beginning of the 20th century, as the only decoration system that could provide a sufficient local amount of colour for printing fabrics with decorative designs, to its present use in electronics for manufacturing sub-miniaturized printed circuits to be used in space vehicles, seriography has covered a long distance, both rapidly and successfully, and has left remarkable traces in every field of technology.

If we are to analyze the reasons for this rapid success, we should go back to the characteristics that make seriography a quite different system and make it conspicuous among the other printing systems which in some cases it has superseded: while in other instances it has proved to be the only efficient system.

The chief characteristic of seriography is undoubtedly the thickness of the printing and hence the covering power of the printed colour. This has already been stressed in connection with the textile industry; however, this feature is one that has contributed to the success of the system in numerous other fields, such as the decoration of transparent wares, printing of fluorescent colours, printing of electronic printed circuits for further chemical etching, printing of ceramic glazes, etc.

Seriography has other important features which should be noted in view of its use in ceramics:

a) the low cost of the block and the easy way in which it can be processed, in comparison with other ordinary printing methods;

b) its very simple technique, which can be adapted to manual application in small factories and does not require highly skilled operators;

c) the flexibility of the matrix, allowing printing on a vast range of materials and surfaces, not necessarily plane. This is particularly important when printing on glass or plastic containers and ceramic ware of distinct shapes, including tiles which are of more direct interest in our case and the flatness of which is to some extent only theoretical.

d) the possiblity of utilizing the most varied types of glazes, consisting of either organic or inorganic pigments mixed in vehicles of different compositions, from water to oils of any kind and even waxes in the case of thermofluid glazes which, being solid at room temperature, are kept warm and hence fluid on the block and dry up as soon as they are printed, so allowing several different colours to be applied immediately in succession. The versatility of this technique has allowed it to gain wide application in all the above-mentioned fields, and this has led to the development of those materials which are required for the industrial use of the process.

At first seriography depended on many different supply sources. Nowadays special materials and equipment have been created to facilitate its use: from silk to nylon and metal fabrics; photosensitive gelatines permitting seriographic blocks to be made which show clear, minute details are capable of standing hundreds of thousands of printings; equipment suitable to manufacture these blocks; printing inks specially made and easily available; and finally, seriographic printing machines some of them highly automated and meeting the whole range of requirements in this field.

From the primitive manual blocks for pattern printing on tables for the textile industry, to the modern seriographic rotary machines for multicolour printing now in use, is a long way. For paper or plastic material printing, and in transfer production, automatic units can now reach an output of some 2500 copies per hour, which is very near the amount obtainable by such long established processes as lithography and typography.

Seriography with reference to the tile manufacturing industry

Seriography as far as the ceramic industry is concerned has established itself in recent times. It has however gained general acceptance, owing to the fact that its characteristics perfectly fit the techniques usually applied to ceramic ware.

Some ten years ago, a few factories tentatively started to decorate wall tiles with manual seriographic blocks and made way for what might be called the "decorated tile boom". In such a way, a battle was won which proved to be harder to fight in the commercial than in the technical field, and a stable market was gained for this product.

After the first resistance on the part of the consumer to accept and value the decorated ware was overcome, the entire ceramic industry showed an immediate interest in the new technique which, as a result, spread to a great number of factories, especially as the inherent technical difficulties have been quickly smoothed away.

Tile decoration has a wide range of possibilities and the pertinent printing process can be introduced at different points in the tile production cycle; on the biscuit-ware before glazing, in the case of whiteware; soon after glazing in many other cases; on the base itself, either on the raw or on the fired glaze; and so on through cycles ending with one, two or three firings.

No serious difficulty was met by the specialized chemical industries in providing colours and vehicles for the printing process and the mechanical industry immediately started designing the first equipment that would displace operatory labour. In this way began the mechanization of the manufacturing process and at the same time, of course, the race started towards cost reduction and quality improvement.

The Italian industry has designed and patented machines which combine and emphasize most features that make possible both a high-quality production and low costs. They are already in use in numerous factories and can be employed for decorating either green or biscuit ware, or otherwise raw and fired glazed material, and stoneware in relief.

All commercial size tiles can be decorated with these machines, which can operate either as a part of a glazing cycle or as independent equipment, when connected to a suitable feeder. In addition, several machines can work in conjunction, to print in succession as many colours as desired during one process only.

The equipment is fully automatic and hence the operator has nothing else to do but supervise the printing process, clean up the screen and feed in the colour. Any other operation is carried out by the machine itself which, by means of suitable safety devices, immediately stops in case of any difficulty arising.

The main steps of the working cycle can be described as follows: from either a feeder or from the glazing line, the tiles coming in, independently of their mutual distance, are stopped, brought together and transferred to the printing table. This assembly lifts up the tiles from the belts and delivers them in a "strictly constant" printing position. This is equally true of the distance between the seriographic cloth and the tile surface, as well as of the tile position with reference to the drawing on the block. To this effect, a suitable control device draws the tiles near to each other and squeezes them up against a stationary guide and a datum plane at 90° to the guide. In this way the tiles are perfectly adjusted with reference to two sides at a right angle. This control device possesses great accuracy, and it is interesting to remark that the same tiles, when passing through the machine for the second time and in the same position, do not show any sign of re-printing at all, except for a slight thickening of the drawing which is to be ascribed to the double colour deposit.

When in the printing position, the tiles are therefore stopped by the control device. They are lifted up from the belts and all of them brought at exactly the same distance from the lower surface of the seriographic block. This exact positioning results, of course, in a great uniformity of the drawing and colour deposit. In this way, one of the chief difficulties of the system, namely a difference of shade between individual tiles, is completely removed.

In fact, these machines, working at a high-quality level, can reach an output of 7000 tiles per hour, which is exceptional for this new branch of technology.

The economic effects of such an efficient tool in the operating schedule are easily inferred. The great increase in the demand for decorated ware undoubtedly depends on the reduced cost of the decoration process, which brings the prices of the decorated and plain glazed wares very near to each other.

The seriographic decoration process has facilitated this result and the new advances in mechanical design have permitted the above described machine to be manufactured, in order to attain such a result.

THE CERAMIC TILE INDUSTRY

IN CANADA

AND

THE PRACTICALITY OF ADDITIONAL

MANUFACTURING FACILITIES

APPENDIX E

STAMP PRINTING METHOD OF

DECORATING ON CERAMIC

WALL TILES

APPENDIX E

STAMP PRINTING METHOD OF DECORATING CERAMIC WALL TILES

This method called the stamp roller method, owes its origin to the observation that stains of different thicknesses give different colour shades, the idea being then applied to glazes.

The tiles to be decorated are first coated with a thin layer of a uniform coloured glaze. Then while the glaze is still fresh, the desired motif is applied by rolling a stamp roller over it. The ingenious idea is that the stamp roller scrapes off a certain small amount of the glaze at certain discrete points, thus allowing the uncoloured body underneath to shine through. This opens a wide range of possibilities of producing contrast effects, which may vary from the merest hint of a colour tint to the most intense or violent contrast, while in reality a single colour has been used.

It is an absolute requirement with this method that a clean stamp roller is used, whose surface is not wetted by the glaze. It is found in practice that the pattern producing roller transfers its colour or glaze to the blank roller moving just above it. If the roller above is, in addition, provided with a light metal scraper, the pattern-producing will be cleaned automatically and will continue to function, i.e. to remove glaze from the actual stamp. The removed colour or glaze is subsequently reclaimed so that only very small losses are incurred.

A wide range of shading on the stamp patterns make it possible to obtain a great variety of effects. Moreover, by selecting the porosity of the foamed material of which the stamp roller is made, the range of variations is still further increased.

For faultless results there are, however, the following prerequisites:

1. The chemical composition of the foamed-substance rollers must suit the composition of the coloured glazes used. This problem has given rise to a great deal of experimentation over the years and even today it is necessary to take care if expansion or distortion of the synthetic rollers is to be avoided.

2. The spindles to which the endless rollers, consisting of a special foamed material, are attached must be very accurate.

3. The decoration envisaged must be suitable for the coloured glazes that will be employed; for example, there must be no extremely narrow parts in patterns on thick glaze layers, etc.

4. The stamp roller to be used must be capable of producing deep and clean patterns.

The ever-increasing use of the stamp roller method of decoration may be taken as a proof of the fact that this technique not only affords a wide range of decoration possibilities and variations but also leads to both rational and economical production.

THE CERAMIC TILE INDUSTRY

IN CANADA

AND

THE PRACTICALITY OF ADDITIONAL

MANUFACTURING FACILITIES

APPENDIX F

THE ROLL-MARK SYSTEM

APPENDIX F

THE ROLL-MARK SYSTEM

The Meyercord Co. has developed a unique production method of applying multi-colour decals to glass, ceramics, and porcelain enameled surfaces at twice the present machine rate with no wastage, perfect colour register, and at less cost than conventional systems.

It is claimed that this equipment would virtually automate decorated tile production lines, allowing manufacturers to apply unlimited colours and designs at machine speeds yielding 53 tiles per minute in conventional sizes.

The new Roll-Mark system applies the decals up to six colours at one time from a 1,500 foot roll and automatically prevents any imperfect designs from printing. A single machine running three shifts can produce 73,000 perfect tiles a day.

The simple, compact application equipment weighs 360 pounds and measures 3 feet wide, two feet deep and three feet high above table level. It accommodates a wide range of product sizes and shapes and can apply decals up to 18 square inches. Larger sizes are to come. The equipment uses 120 volt, 60 cycle, 7 amp electrical service and 100 psi air pressure.

In ceramic tile manufacture the equipment can be loaded with rolls holding as many as 2,500 decorations. The machine reportedly will operate unattended for nearly an hour, until a new roll is required. Re-load time is about 35 seconds and consists of inserting a loaded roll on a spindle and threading the paper around four rollers and on to a take-up reel, much like a home movie projector.

Engineering and product development for the new roll-type decals required the invention of a continuous web press which prints the wide-web Roll-Mark decals on a specially formulated paper coated with chemicals that press the decal to be released at temperatures from 73° to 300°F. The press itself is a secret development.

The decals were engineered for permanent fusing to the product surface so that the design becomes an integral part of the product and never chips, cracks, peels or spawls.

THE CERAMIC TILE INDUSTRY

IN CANADA

AND

THE PRACTICALITY OF ADDITIONAL

MANUFACTURING FACILITIES

APPENDIX G

SPRAY DRYING

APPENDIX G

SPRAY DRYING

Materials Handled

Among the ceramic materials currently processed in spray drying equipment are alumina, hard and soft ferrites, barium titanate, forsterite, beryllia, steatite, lead zirconate, lead titanate, glass, refractory compositions, porcelain clay, wall and floor tile clay, and a number of the more exotic materials.

In handling the majority of these materials an organic binder and other additives are added to the feed slip, and the slip is processed to controlled particle size and controlled low final moisture, typical, less than 0.5%

Exceptions to this technique are wall and floor tile bodies which normally must be handled without organic binder to a controlled final moisture of 6% approximately. In this case the product moisture functions as the binder.

In some porcelain clay applications, the body is dried down to a controlled final moisture and the dry powder is re-wetted, again under closely controlled conditions, to a level ranging from 15% to 20% for subsequent pugging.

Equipment

There are three basic types of spray drying equipment, each designed on the basis of the atomization equipment used. These inclu-de the two-fluid or pneumatic nozzle, the centrifugal or rotating disc atomizer, and the single fluid or pressure nozzle. All three types a-re employed in the handling of ceramic materials and the choice depends on the capacity and the nature of the material being processed.

The two-fluid nozzle is employed for most ceramic materials dried with an organic binder system in capacities ranging up to 500 lbs, per hour of pressing grade powder. The nozzle in this type of unit is located in the bottom of the drying chamber, firing upward into a downward moving heated air stream. The narrow atomizing angle which can be achieved with this type of nozzle makes it possible to operate with a drying chamber of relatively small diameter. Here the cyclin-drical height of the chamber is the more critical dimension required to provide sufficient path to dry the large particles. The material fountains up through the chamber and back down to the collection point at the bottom of the chamber.

With the two-fluid nozzle, relatively low feed pressures are required. These nozzles are of the external mixing type; the feed slip flows through the nozzle at low pressure and low velocity. The high velocity atomizing work is done by the compressed air employed as the atomizing medium, outside of the nozzle itself. This ope-rating arrangement results in a minimum of abrasive wear in the feed system so that maintenance is kept to an absolute minimum.

The narrowest particle size distribution possible with these three types of atomization is obtained from the pressure nozzle, or single fluid nozzle. The use of this type of atomization, due to its many disadvantages, is limited to production of materials such as wall and floor tile clay. For these the residual moisture in the dried particles is used as a binder and this is normally required at 6% approximately. In order to achieve this close control of final moisture, a particle size distribution as narrow as possible is imperative so that the required moisture can be maintained in the larger particles without overdrying the smaller particles. This is only possible in extremely large equipment where a long retention time is available in which to bring the dried product to equilibrium conditions.

This requirement for closely controlled final moisture overrides the disadvantages of a high pressure feed pump and its maintenance cost, variations in product quality due to abrasive wear in the nozzle orifice, maintenance cost of the nozzles, and the fact that with a pressure nozzle a number of the operating variables are closely linked together. The first three of the above factors are relatively self explanatory, however the last item merits further explanation.

With the use of a pressure nozzle atomizer, particle size from a given orifice is governed by the pressure maintained on the feed. Feed rate for given orifice size is also dependant on the pressystem so that maintenance is kept to an absolute minimum.

The narrowest particle size distribution possible with these three types of atomization is obtained from the pressure nozzle, or single fluid nozzle. The use of this type of atomization, due to its many disadvantages, is limited to production of materials such as wall and floor tile clay. For these the residual moisture in the dried particles is used as a binder and this is normally required at 6% approximately. In order to achieve this close control of final moisture, a particle size distribution as narrow as possible is imperative so that the required moisture can be maintained in the larger particles without overdrying the smaller particles. This is only possible in extremely large equipment where a long retention time is available in which to bring the dried product to equilibrium conditions.

This requirement for closely controlled final moisture overrides the disadvantages of a high pressure feed pump and its maintenance cost, variations in product quality due to abrasive wear in the nozzle orifice, maintenance cost of the nozzles, and the fact that with a pressure nozzle a number of the operating variables are closely linked together. The first three of the above factors are relatively self explanatory, however the last item merits further explanation.

With the use of a pressure nozzle atomizer, particle size from a given orifice is governed by the pressure maintained on the feed. Feed rate for given orifice size is also dependant on the pressure of the feed. The outlet temperature of a spray dryer, at a given inlet temperature, is dependent on feed rate which, again, is dependant on feed pressure. With these various interdependencies it is obvious that a change in any single condition will immediately result in a change in all of the other conditions.

The third and most common type is the centrifugal atomizer. This type of atomizing equipment is for high capacities and the geometry of the dryer is such that diameter becomes the critical dimension. The flow from a rotating disc is essentially horizontal. Thus sufficient distance must be allowed between the atomizer and the chamber wall to permit the drying of the large particles.

The minimum diameter permissible to dry this type of product is 16ft. To control air patterns in the chamber, sufficient air must be provided to give a minimum drying capacity of approximately 600 lbs. per hour when handling a feed slip containing 65% solids. The largest size dryer produced to date for the production of pressing grade ceramics is 32ft. in diameter producing 3,000 lbs. per hour at the chamber bottom collection point.

Atomization is achieved through the use of abrasion resisting materials; the most common is tungsten carbide. The feed material is atomized through orifices in the rotating atomizer turning at speeds ranging from 7,000 to 13,000 RPM. Correct operating conditions are determined by capacity, atomizer diameter, and particle size required.

Particle size distribution form a centrigugal atomizer ranges between the two types of nozzles with a narrow distribution closer to that obtainable from the pressure type nozzle.

Maintenance costs with this type of unit also range between the two types of nozzle units since abrasion can certainly be expected by a rotating atomizer operating at the speeds required. Since the feed pump with this type of unit is required to be a non-pulsing controlled metering pump, no high pressures are required. Thus feed pump maintenance costs compare with two-fluid nozzles.

The other components that make up a complete spray drying system include direct gas fired air heater for the heating of the drying air, cyclone collector for the collection of the fine fraction dried and a wet scrubber for the final clean-up of the drying air before discharge to atmosphere.

Natural gas in direct fired air heaters is widely used in the United States. The highly efficient heaters of this type that are available and the lack of any truly objectionable products of combustion make this choice the most logical and inexpensive course to follow. However, under special conditions electric heaters and indirect gas heaters have been used.

Binders in the feed system make even the material which is air classified out of the drying chamber agglomerate to a particle size which makes cyclone collection extremely efficient. The very small fraction that escapes the cyclone collector is readily collected in a wet scrubber. Consequently, the use of cloth filter collection equipment is unnecessary when handling pressing grade ceramic powders.

The feed systems employed for this type of operation were varied during the early developmental years. Present practive has reduced this to one basic system which has become almost universal. This feed system consists of an over-sized Moyno pump, usually equipped with a rubber stator and a chrome-plated tool steel rotor. The pump is driven by a variable speed drive which, in turn, is controlled by a pneumatic operator taking its signal from the temperature recorder controller on the outlet of the dryer. The common practice is to size the Moyno pump to operate at design conditions at between 100 and 150 rpm with the variable speed drive having a ten to one speed ratio ranging from 36 to 360 rpm.

Operating an over-size pump at these low speeds makes it possible to handle these abrasive feed materials over extended periods because maintenance costs on the feed pump are reduced to acceptable minimums.

Feed Requirements

Once satisfactory operating conditions have been established in the spray drying portion of the system, it becomes a relatively simple matter to reproduce and maintain these conditions if a uniform and consistent feed supply flows to the dryer.

To maintain optimum reproducibility in day to day and week to week operation, it is imperative that the physical condition and the composition of the feed be maintained as constant as possible.

The greatest single source of variations in the feed preparation and the problems that these variations subsequently produce, is in the milling or mixing of the feed slip. The lack of control on the water used for rinsing ball mills or mixing tanks, which ultimately ends up in the feed tank, can result in fairly wide variations in the solids concentration of the slip to be fed to the dryer. This can cause variations in the particle size, capacity, bluk density, and flow close control of the feed preparation step is important. Unfortunately, experience has shown that this is the one area where control is lacking in many plants.

During the developmental years an extremely wide variety of additives was tried. Experience and the exchange of information in the industry, has slowly reduced this choice to a relatively few materials which have consistently produced superior results. A typical additive formulation consists of polyvinyl alcohol as the binder, a glycol lubricant and an ammonia-based deflocculent. Mircro-crystalline waxes are still being used as binders in a number of cases, but they are slowly but surely being supplanted by polyvinyl alcohol.

The variations in formulation are dictated by any number of factors including the type of pressing to be employed, the size of the piece being produced, and quite often, the intricacy of the piece itself.

Product Characteristics

The principal product characteristics to be controlled include bulk density, particle size, particle size distribution, and final moisture.

The major factor controlling the density of a dry pressing grade powder is the solids concentration in the feed slip; temperatures at which the material is dried contribute a lesser effect.

The normal requirement for any given body is a bulk as high as is possible. This is achieved by use of the proper deflocculent additive that will give a feed slip of maximum percent solids that can still be pumped while achieving a spherical particle in the dry state. It is possible to go too far in this direction to the point where the slip can be pumped and atomized, but with solids concentration so high that as soon as atomization has been achieved, the droplets dry to a firm consistency before forming the spheres. The particles, on visual examination, will appear in shapes such as rods, dumbbells, and teardrops. When this condition is encountered a reduction of 1 or 2% in the solids concentration will quite often provide sufficient fluidity to achieve the spherical particle desired.

The second and minor factor affecting bulk density is the operating temperatures of which the material is dried. The higher the operating temperature range, the greater is the tendency towards thermal expansion. Some improvement in particle density can be achieved by reducing the drying temperatures. The change in density is relatively small and care must be taken when using this approach since the capacity of the unit is dictated by the drying air temperature difference. Also the final moisture of the product is dictated primarily by the outlet temperature.

Particle size is strictly a function of the amount of work imparted to the feed slip in atomization. In a two-fluid nozzle this is controlled by varying the atomizing air pressure. An increase in air pressure results in more work on the feed slip and consequently, a finer particle size. Conversely, a reduction in air pressure produces less work on the feed slip and a larger particle size. The minimum air pressure possible is dictated by the largest particle which can be dried in a given drying chamber before that particle comes in contact with the chamber wall, resulting in chamber wall build-up.

In a centrifugal unit which a given feed slip and a given atomizer diameter, the particle size is governed by the speed at which the atomizer is rotated. In this case, higher speed gives greater centrifugal force and consequently, finer particles. The minimum speed at which satisfactory product can be achieved is again dictated by the largest particle which can be satisfactorily handled in a given drying chamber.

A second factor affecting particle size in a centrifugal unit is the diameter of the atomizer being used. However, under most conditions, the minimum size acceptable and maximum size possible falls within the range of a single wheel diameter and the rotational speed variations possible with a single spray machine. At larger wheel diameters lower rotational speeds achieve comparable particle size characteristics.

With a pressure nozzle atomization system particle size is governed by a combination of orifice size and feed pressure. Unfortunately, with a given orifice size, changes in feed pressure also change the feed rate and operating temperature, which limits the flexibility of this type of unit. With either a two fluid nozzle atomizer or centrifugal atomizer, changes in particle size are independent of the other operating variables and this greatly increases the versatility of this type of equipment.

Particle size distribution is somewhat dependent on the type of atomization used. If a bell shaped particle distribution curve is generated with a particular type of atomization, the average particle size does not appreciably affect the shape of the distribution curve.

The final major variable to be controlled is the moisture in the dried product. The normal requirement is for less than 0.5% retained moisture with occasional specifications going down to less than 0.3%. Moisture retained is primarily a function of the outlet temperature of the drying air. To achieve these relatively low final moistures outlet temperatures in the 300°F range are required; the minimum would be approximately 250°F. However, operating with an outlet temperature this low dictates a reduction in the inlet temperature reducing the total moisture in the system. This results in a lower saturation level at outlet conditions and a higher driving force to get the low moisture required.

Temperatures in excess of 300°F at the outlet can have adverse effects on the organic binder system so that minimum acceptable moisture in the final product must be balanced against the product quality.

Experience has shown that plants producing dry pressed products can reduce their rejection rate, reduce the labor requirement, and increase their product quality through the use of spray drying equipment. Plants currently employing spray drying equipment can generally improve their operation by a thorough review of the various operating variables and close control over their operating conditions.

THE CERAMIC TILE INDUSTRY

IN CANADA

AND

THE PRACTICALITY OF ADDITIONAL

MANUFACTURING FACILITIES

APPENDIX H

THE KERVIT CASTING PROCESS

APPENDIX H

THE KERVIT CASTING PROCESS

In 1960 tiles were almost invariably fixed by professionals and mainly by bedding them into sand and cement render. Adhesive fixing was in its infancy in the UK and only the most adventurous DIY* person would consider doing his own tiling. Polycell, then a relatively young company, but one which had established itself in the minds of the home decorator by its strong marketing approach, was looking for new areas into which to extend such activities. With foresight and determination the decision was made to create a DIY market for tiling.

Thin-bed adhesive fixing was an essential part of this development, and the natural partner to this was the use of a thin tile. Such a tile would have to be strong and flat, and after consideration of various methods of manufacture an Italian system of casting and rapid firing was chosen as the one which met Polycell's requirements.

Italian Know-how

A factory was built at Penketh near Warrington in the U.K. There followed almost two years of intense building and development, translating Italian experience into the use of the raw materials available in the UK, and to the production of a product which would satisfy the quality requirements of the British market. The Polycell tile was launched nationally in the 10.8 cm (4¼in) x 10.8 cm (4¼in) x 4mm (5/32in) format in eight colours without spacer lugs early in 1962.

* DIY:- Do it yourself

The market was created by promotional techniques which rapidly justified the forecasts which had been made. Within a very short time 20,000 yd^2 of product were being sold each week and from that time onwards the DIY market has continued to grow.

The process is very different from the conventional dust-pressed one in its raw material approach, its complete casting method, the use of ceramic moulds which carry the product through the kiln and the rapid singlefire technique.

Setter Manufacture

Since the moulds used in this process perform a dual function and act also as carriers of the product during firing, they are generally referred to according to this latter function as setters. It is essential that they have a high porosity (approximately 40% by volume), the correct pore size, since this controls the rate of suction during casting, adequate strength and good resistance to thermal shock, since it is essential that they can be handled and passed through the rapid fire kiln for as many cycles as possible. Their average life is found to be about 75 trips through the process.

When the process was introduced a programme of technical work was necessary to devise a formulation which would have the required properties, since the early products based on the Italian "know-how" changed their suction performance after about 20 journeys through the kilns. This was resolved before the production commenced at full scale.

The setters are flat, square ceramic pieces 12mm (½in) thick and are produced by the dust-pressing process. The raw materials are all fine powders of ball clay, china clay, limestone and zircon. These are mixed dry in a Simpson mixer, water added to 9.5% and mixing continued to produce a semi-dry dust. The setters are pressed from this on Sheepbridge automatic presses, some semi-automatics being used for the special shapes needed for the manufacture of RE and REX tiles. The green ware is stacked in cranks on kiln cars holding $40yd^2$. These go first into a drying chamber and subsequently into one of a bank of eight electric intermittent kilns where they are fired by automatic programme controllers to the correct schedule to a top temperature of 1140°C. After visual selection the setters are ready for use in the manufacture of tiles.

Glaze Frit Melting

Very soon after the DIY market was established the company decided to produce its own glaze frit, which had so far been bought from specialist producers. A frit melter was designed to operate on a continuous basis. The principles used in this design were based on those employed in both the glass melting and glaze melting fields. The batch is mixed from the various raw materials in a Cumflow mixer which empties the mix into a conical hopper. The hopper is elevated into position near the melter and discharges into a watercooled screw feeder which controls the rate of feed into the melting chamber through the back-wall. The unit is fired by an oil burner situated in the front wall, the flame passing down the melter and over the batch pile; the exhaust gases passing out through two side flues near the back-wall. These flues join above the furnace and the waste gases pass up through a metallic recuperator, which heats the secondary air supply, and out of the chimney stack. The batch is melted and flows towards the front end where the molten material overflows through a spout and falls between water-cooled mild steel rollers. These press the glaze material into a flat sheet approximately 3mm (¼in.) thick cooling it sufficiently for counter rotating hammers to break it up beneath them. The resulting frit falls into a rectangular metal bin which serves as a storage unit prior to its use in the glaze slip. The melting bath is built with 9 in. thick blocks of Kaolith, the super structure is built in silica, and the uptakes are constructed with high alumina bricks. Two such units are operating, each capable of melting 25 to 30 tons of frit per week, and they have a life of approximately two years between major rebuilds.

Raw Materials

In most ceramic processes clay plays a vital role, and the clay used must be capable of providing good porosity characteristics, high green strength, low drying, and firing shrinkages, and the desired final porosity. A great deal of research has been and is being done to reduce this dependence, and the Kervit process goes a long way towards achieving this.

The body of the tile is composed of a high proportion, approximately 90%, of materials which have already been through a firing process and are therefore substantially transformed into their final state. These comprise sanitary-ware and electrical porcelain scrap, glass cullet, and various fired scrap resulting from the process itself. The purchased scrap and cullet come from manufacturers of ceramic ware and glass, and care is taken in their purchase to ensure consistency of overall composition. The remaining 10% of the body is china clay used for the purpose of ensuring suspension in the slip state.

The scrap materials are stored in large bays and each is separately crushed through a large eccentric cone crusher, followed by a granulator. The material then passes through a vibrating sieve and over a magnet to extract iron, the pieces which are not greater than 6mm being transferred to a storage hopper, and the oversize being returned into the circuit. This plant is capable of handling about 200 tons per week of scrap materials. The various scrap materials are separately dealt with in this way and the crushed materials contained in a series of storage hoppers each capable of holding up to 15 tons.

Processing of Body Slip

The mix for the body is weighed out on a travelling weighbridge moving along the line of hoppers, and the china clay is added together with small quantities of chemicals such as flocculents and deflocculents which are required to give the slip the necessary viscosity and water release characteristics. The total mix is transferred by overhead crane into one of a bank of 6ft ball mills. A measured quantity of water is added and milling takes place in the Silex lined mills, containing French flint pebbles as the grinding media, for a predetermined period of about 10 hrs. At the end of this period the degree of grinding is checked by a member of the technical process control team located within the factory, this routine check being a determination of the proportion of the slip retained on a 350 mesh B.S. sieve. If this value is satisfactory the slip is discharged by compressed air into one of a long line of large storage arks which are sunken into the floor. Whilst in this ark the slip is continuously agitated by wooden paddles to ensure suspension, and its viscosity and water release characteristics are checked and adjusted by the control team.

Engobe and Glaze Slips

A similar slip is prepared for the engobe layer. Defluorinated Cornish stone replaces the glazed porcelains used in the body slip to ensure freedom from specks which might affect the overlying glaze during firing. The slip characteristics are adjusted to the appropriate viscosity and water release values which differ from those of the body slip.

Glaze slips are also prepared, these being typical fully fritted formulations using the frits melted as described above and containing the usual small quantities of clays and additives. These base glaze frits are made either from all opaque frit, all transparent frit, or a mixture of the two depending upon the colour for which they are to be used. Some of them are ball-milled in similar mills of those used for the body and engobe and others in porcelain or steatite-lined mills using the corresponding types of grinding media.

The colorants which are refractory oxide stains are added to a small quantity of base glaze and processed in small ball mills before adding to the bulk base glaze in rapidly agitated mixing arks.

As with most ceramic processes control of glaze colour is a vital part of quality control, and this is done at the Kervit factory by the technical team responsible for process control. As each new batch of glaze is prepared hand dips are made, fired, and checked against standard shade boards. Due to the rapid fire process employed all these firings can be done in the production kilns, thus eliminating any problem of translating findings from experimental to production firing conditions.

Colour Control

Initial assessments are carried out visually, but measurements on the Colormaster instrument assist decisions on corrective additions to bring the shade on to the standard required. When the technical team has completed its work, a small quantity of tiles is made under production conditions and firings done in each of the production kilns to be used for this colour. Unless these results are deemed satisfactory the batch of glaze does not go into production.

Tile Manufacture

The three prepared and tested slips are pumped across into small supply tanks adjacent to the tile making machine. This consists of a long straight sequence of conveyor belts, having a total length of 200 ft. down which the moulds pass. The three layers forming the tiles are cast on to the belt during this passage which takes about five minutes.

The machines were designed on the basis of the Italian machines, but every section was developed during the initial experience of production. This resulted in many improved features and several completely new engineering solutions to ensure a minimum of damage to the final product. The engineering development was done almost entirely by the group engineering staff and the machines were manufactured by local engineering firms.

The setters (or moulds) are fed on to one end of this machine. Since they have in general already completed several cycles through the process, the first section is devoted to a number of scraping and brushing operations to ensure that the face of the setter is clean. It then passes through a waterfall dip which applies a dilute suspension of a refractory powder, thus providing a layer which will prevent the tile sticking to the setter during the firing process.

Special Body Dip

Three successive waterfalls apply the body, engobe and glaze layers, the body dip being of a special design to ensure an even deposit of material across the setter. As each slip is applied the suction of the setter draws the water down into it, and the controls applied to setter manufacture and slip adjustment ensure that all visual signs of water have disappeared from the surface of the cast within about 30 sec.

At this stage the next layer can be applied. After application of the glaze layer a further drying period of about 35 sec. is allowed before the setters pass through buffing stations to remove material from their sides. This enables them to be located and pass through the cutting stations where the tiles are cut to size by trimming off about 3/16 in. of material around the four edges. This excess material is subsequently used up in the production of body slip. At the end of the machine the green tiles on their setters are semi-automatically transferred on to trays and stacked ready for placing on the kiln cars.

Firing the Product

The fast-firing kilns employed are 180 ft. long and are constructed as a muffle kilns. The burners are situated on the roof firing downwards into a combustion chamber above the muffle blocks which form the roof of the tunnel through which the ware passes. An arrangement of flues gives control over the preheat section which is heated by the exhaust gases, and over the cooling section into which cold air is introduced both above and below the muffle blocks. Initial firing was with town gas, but as soon as initial production problems were solved attention was given to kiln development. This resulted in a changeover to firing by gas oil with automatic temperature control of the combustion temperatures, to improved kiln design and the incorporation of a drying section utilizing hot air from cooling area. These latter two improvements enabled the through-put to be increased by 25%. The total time through the kiln from cold to cold is now 1½ hr.

Single-layer Loading

The ware is loaded in a single layer on to small cars with tops approximately 29 in. x 29 in. in size. Each car holds 36-4¼ in. tiles and a car enters the kiln every seventy seconds, the timing of the push being automatically controlled. The early kilns were constructed with two individual units in one structure arranged in counterflow. This simplified the flow of cars and eliminated the need for a return track. Subsequent kilns were still built in pairs, but with the flow in the same direction. Although a return track was needed this enabled a higher degree of automatic handling to be introduced. By this time Polycell was owned by Reed Paper, now Reed International, and group engineering facilities were employed in the design and construction of this handling equipment.

Grinding and Selection

On emerging from the kilns the tiles are automatically lifted off the setters and stacked ready for the next process. The setters return to the making machines.

While the first tiles used for the development of the DIY market did not have spacer lugs, development work soon started to enable this to be done. The process which resulted and through which every tile now passes, including RE and REX tiles, is a grinding one carried out on the fired tile. This process ensures that every tile is ground to size, and the grinding wheels are profiled to leave spacer lugs of the recommended BCRA shape on the tile edges. Continuing technical development of this grinding unit had led to simpler machine operation with improvements in performance and final product quality.

After grinding, the tiles pass through a visual inspection process to remove all rejects and seconds prior to the packing into cartons.