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APPLIED SCIENTIFIC RESEARCH CORPORATION OF THAILAND

APPRAISAL REPORT NO. 7
FEASIBILITY OF SODIUM SILICATE MANUFACTURE IN THAILAND

PART I: MARKET SUPPLY AND DEMAND FOR SODIUM SILICATE

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PART II: TECHNICAL AND COMMERCIAL FEASIBILITY OF MANUFACTURE
OF SODIUM SILICATE

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FOREWORD

During the examination of the statistics of imports of a number of chemicals into Thailand, it became clear that sodium silicate appeared to offer good prospects for local manufacture.

In consequence, this brief examination of the market and of the technical-commercial aspects of manufacture was undertaken. It shows that sodium silicate has a substantial, rising, and presumably stable market in Thailand and that its local manufacture, properly undertaken, may well prove a profitable venture.

It is hoped that this report will help those contemplating manufacture and will also lead to some rationalization so that the market is not fragmented among too many producers.

Officers of ASRCT will be pleased to discuss with those interested, further aspects of the data presented here and will be especially glad to assist with technical problems which may arise in the establishment of manufacture.

FEASIBILITY OF SODIUM SILICATE MANUFACTURE IN THAILAND

PART I: MARKET SUPPLY AND DEMAND FOR SODIUM SILICATE

By Norman L. Wake* and Rachnekorn Wanotayarote*

SUMMARY

Import statistics for Thailand show that for the year 1966, some 2085 metric tons of sodium silicate were imported, with a value of 2,467,884 baht. A demand projection indicates a usage of some 4,700 tons by 1972.

However, these quantities include both solid and liquid forms of sodium silicate, as well as comprising alkaline and neutral types. Approaches to major users of sodium silicate showed that about 10 per cent of the demand is for the alkaline type.

Usage is almost wholly in detergent powders and soap with small usages in metal moulding, carton closing and furnace construction. A potential, possibly large, market exists in water treatment.

No demand for sodium metasilicate has been found.

Supplies of sodium silicate are at present derived wholly from imports although some material has been produced locally, and several companies are contemplating manufacture. Major users in Bangkok would welcome a local supply of sodium silicate, (provided price and quality are competitive) as it would reduce stock-holding and the nuisance of drum handling.

The main problem appears to be not so much one of encouraging local manufacture, but of trying to rationalize the several plans for manufacture so as to avoid over-fragmentation of the market.

MARKET SURVEY IN DETAIL - DEMAND

Import statistics give an incomplete picture of the demand situation for sodium silicate in Thailand, firstly because there has been an intermittent production locally by Thai Acids Industry Company Ltd., and secondly, because the import comprises both solid sodium silicate and sodium silicate in solution. As only one major user imports solid sodium silicate, the quantity imported in

* Economic Evaluation Group, ASRCT, Bangkok.

either form cannot be published since that would constitute disclosure of a single company's business.

It can be said, however, that the import statistics certainly give an indication of trend of demand and also give an idea of total demand sufficiently close for planning the scale of equipment (see Part II).

Table 1 and Figure 1 show imports of sodium silicate into Thailand over the past seven years. A Gompertz projection of these data (see Table 2 and Figure 2) indicates that imports should reach some 4,700 tons by 1972. Here, again, it is stressed that the projection refers to a mixture of liquid and solid material.

TABLE 1
IMPORTS OF SODIUM SILICATE INTO THAILAND, 1960-1966

Year	Quantity, kg	Value, CIF, baht
1960	444,755	720,118
1961	412,486	576,376
1962	844,700	1,107,772
1963	993,550	1,315,932
1964	1,499,404	1,905,138
1965	1,519,529	2,018,774
1966	2,084,799	2,467,884

Source: Department of Customs, Bangkok.

TABLE 2
GOMPERTZ PROJECTION OF IMPORTS (TABLE 1) OF SODIUM SILICATE INTO THAILAND*

Year	Projected demand (metric tons)
1967	2,423
1968	2,846
1969	3,292
1970	3,766
1971	4,232
1972	4,715

* Projection by Mr. J. Mayne, Electrical Engineering Unit, ASRCT.

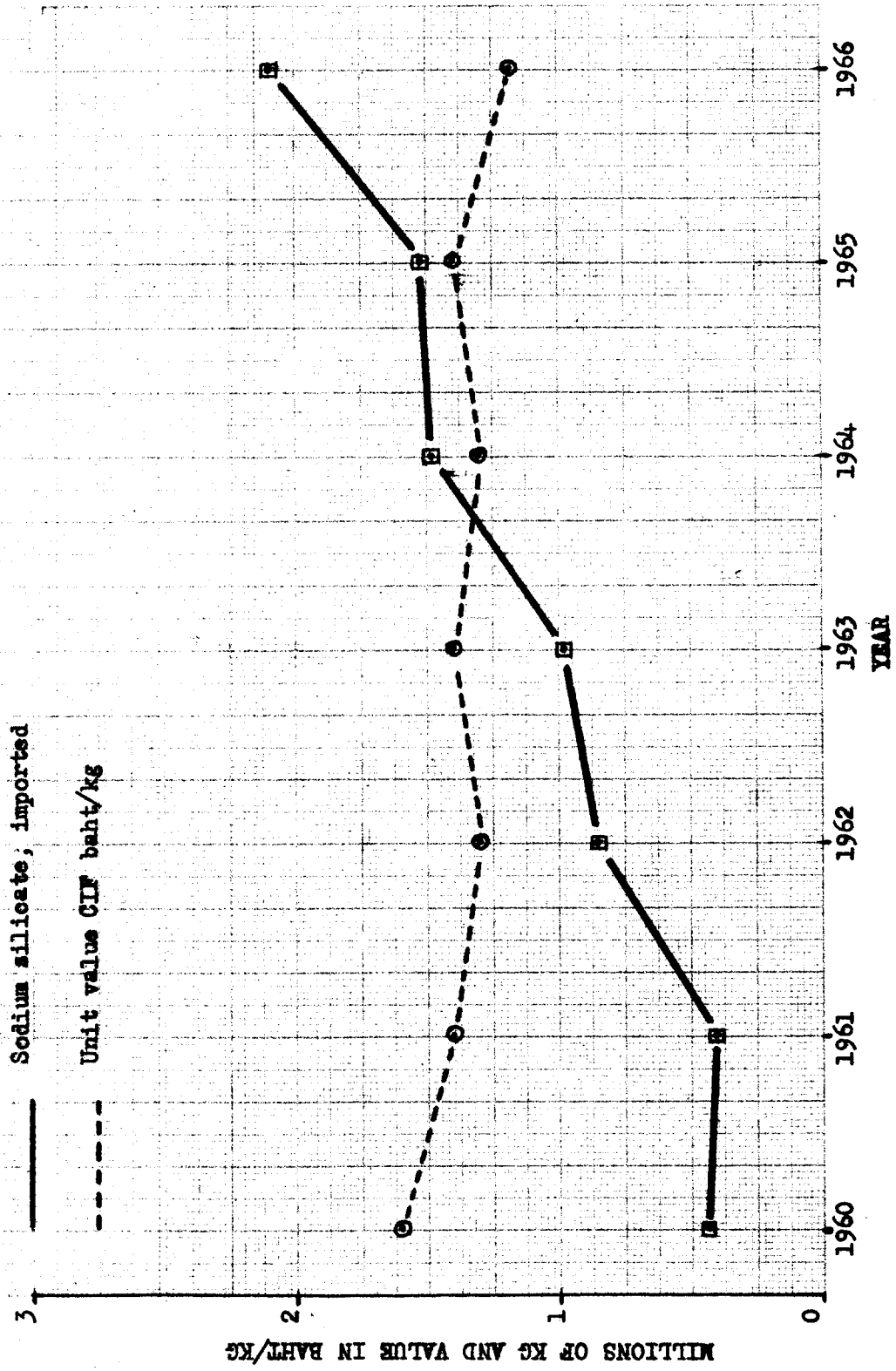
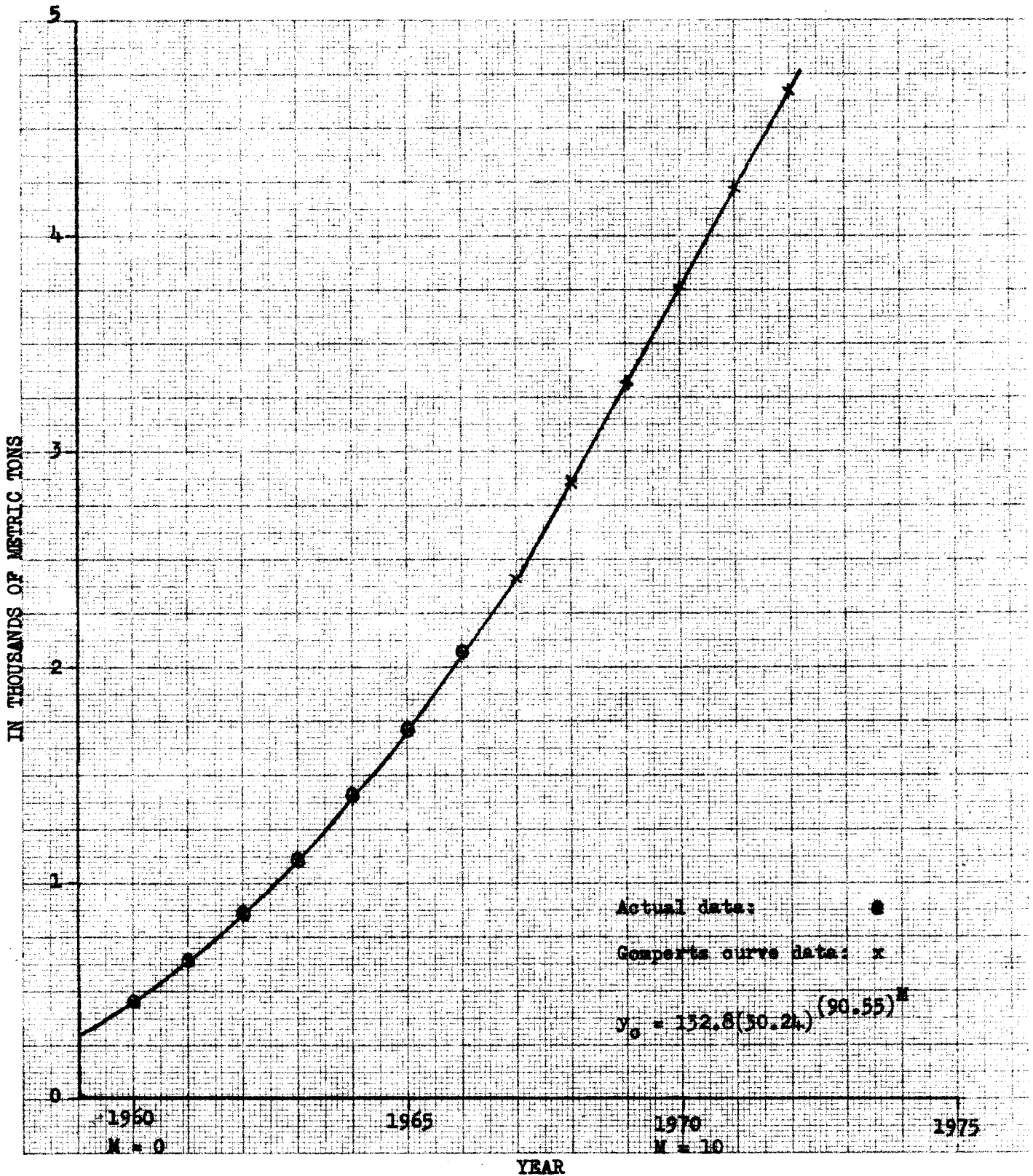


Figure 1. Imports of sodium silicate into Thailand, 1960-1966



Source: Tables 1 and 2

Figure 2. Gompertz projection of sodium silicate imports into Thailand

USAGE BY INDUSTRIES

Table 3 summarizes the results of approaches to users of sodium silicate in Bangkok, and shows that by far the major usage is in soaps and detergents. About 10 per cent of this material is of "alkaline" type (i.e. two or less molecules of SiO_2 to one molecule of Na_2O), the remainder being "neutral" sodium silicate. Some of the material is in lump form as mentioned above. It is probable that there are other, rather minor, uses of sodium silicate not located in our market enquiries. No usage of sodium metasilicate could be found.

TABLE 3

CONSUMPTION OF SODIUM SILICATE BY MAJOR USING INDUSTRIES IN THAILAND 1967

User Industry	Current annual usage (calculated as solid sodium silicate)
Soaps and detergents	1300 tons
Foundry moulding	$6\frac{1}{2}$ tons
Carton closing	"a few tons"
Fire-proof mortars	"a few tons"

There is a potential market in Bangkok for sodium silicate in water treatment and this market may be large. The treatment normally given to water by the Bangkok Water Works is to use alum and lime as flocculants, but it has been established that in the wet-season sodium silicate would be a useful additional treatment as it gives a quicker and coarser floc. So far, however, the use of sodium silicate has been ruled out on the score of expense.

PRICE

The price of solid alkaline sodium silicate delivered in Bangkok (from Hong Kong) was quoted at 1600 baht per long ton in September, 1967. The unit price shown in Figure 1 has a distinct falling tendency but this may be due to an increase in the proportion of sodium silicate in liquid form.

The tariff on solid sodium silicate imported into Thailand is 15 per cent ad valorem.

SUPPLY

The Thai market for sodium silicate has been supplied by imports except for some local manufacture by the Thai Acids Industry Company Ltd. Table 4 sets out the countries from which sodium silicate was imported in 1966.

Our enquiries indicated that there are at least four companies interested in the manufacture of sodium silicate in Thailand and since, if all four were to proceed to the stage of production, the market would be over fragmented, we sought, and obtained, permission from the four companies for their names to be disclosed so that some mutual rationalization of plans could be achieved. The four companies are:-

- (1) Thai Acids Industry Company Ltd.,
417 - 9 Rama IV Rd., Bangkok.
(rebuilding its present plant)
- (2) Thai Glass Manufacturers,
15 Amphoe Rat Burana
Bangkok.
- (3) Hong Kong Sodium Silicate Manufacturing Ltd.,
303 Yu To Sang Building,
Queen's Rd., (c),
Hong Kong
- (4) Nightingale Chemicals (NSW) Pty. Ltd.,
Allen Street, Waterloo, NSW, Australia.

TABLE 4

IMPORTS OF SODIUM SILICATE IN THAILAND BY COUNTRIES, 1966

Countries	Quantity, kg	Value, CIF, baht
Hong Kong	751,296	920,485
Singapore	56,376	61,415
Japan	1,146,980	1,288,984
Taiwan	30,000	42,518
Federal Republic of Germany	10,020	21,112
United Kingdom	90,127	133,360
Total	2,084,799	2,467,884

Source: Department of Customs, Bangkok.

FEASIBILITY OF SODIUM SILICATE MANUFACTURE IN THAILAND

PART II: THE TECHNICAL AND COMMERCIAL FEASIBILITY OF MANUFACTURE OF SODIUM SILICATE

By Wilhelmus C.J. Hermans*

SUMMARY

Sodium silicate solutions are produced by fusing sodium carbonate and sand at a temperature of 1350°C. The resulting melt is dissolved in water and/or steam. Based on the sodium silicate consumption pattern in Thailand as described in Part I, a production unit with a capacity of 5000 tons of sodium silicate solutions, located in the surroundings of Bangkok is proposed.

The required investment capital for this unit should be 1,700,000 baht. Total cost-price (before taxes) of one ton sodium silicate solution (50 % solids, Na₂O/SiO₂ ratio 1 to 2.0) is estimated at 785 baht ex-factory and at 810 baht delivered in Bangkok. This is well below (by about 200 baht) the present minimum import price.

INTRODUCTION

As described in Part I, the current demand for sodium silicates, Na₂O.nSiO₂, in Thailand is met by imports. This second part of the report presents the result of a brief study to determine the economic and technical feasibility of manufacturing of sodium silicate (solutions) locally.

Concerning the technical feasibility it can be stated that the sodium silicate manufacturing process, which resembles the process for glass production, is relative simple and is certainly feasible in Thailand. One of the raw materials, sodium carbonate, will have to be imported. The required pure sand is available from Songkhla.

To determine the economic feasibility the succeeding sections give the results and findings of this study in respect to:

Required capital investment, with supporting data and recommendations for process type, plant location and production capacity.

* Technological Research Institute, ASRCT, Bangkok.

Manufacturing cost, with a framework of reference regarding requirements and cost of labour, raw materials, utilities and working capital.

In those instances where conclusive information could not be obtained directly, the figures used were selected in such a way as to maintain reasonably conservative engineering perspectives.

Economic feasibility is regarded as being realized when the difference between the cost-price of sodium silicates manufactured in Thailand and the import price of this commodity is adequate to assure that local production will be profitable.

SODIUM SILICATES REVIEW

General

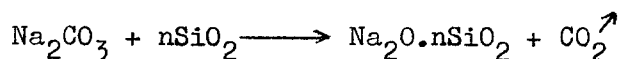
A wide variety of soluble sodium-silicates are commercially manufactured. Products vary from those containing 1 mole Na_2O and 4 moles SiO_2 (waterglass) to those containing 2 moles Na_2O and 1 mole SiO_2 . Sodium silicates with a composition of $\text{Na}_2\text{O} \cdot 2\text{SiO}_2$ or less siliceous are sometimes called "alkaline" whereas the more siliceous silicates are described as "neutral".

The possible applications for sodium silicate (solutions) are numerous. Large scale outlets for this product are in the formulation of detergents and in the production of silica gels. The use as an adhesive in paper packaging is also well recognized and consumes a large proportion of the sodium silicates produced. These three uses account for about half of the sodium silicate consumption, the remainder being uses in cements, coatings, textile bleaching, abrasives, water treatment, soil treatment, etc.

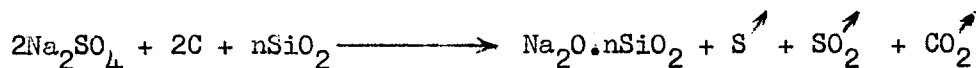
The general price level of sodium silicate does not fluctuate very much except with major economic shifts which boost all costs for labour, raw materials (especially soda-ash), and overhead faster than the usual rate of improvement in manufacturing techniques can cope with these costs.

Manufacturing process

Sodium silicates are normally made by fusing sodium-carbonate (soda-ash) and silica (sand) in a furnace resembling that for the manufacture of glass. The reaction takes place at about $1300-1450^\circ\text{C}$ as follows:



In special situations when the price of sodium sulphate is exceptionally low, this chemical can be used as the alkali source:



In the soda-ash process (see Figure 3), sand and the sodium carbonate in selected proportions, are charged into the furnace. Fuel gas or oil is burned to maintain oven temperatures of 1300-1450°C in the hot zone. The melted materials gradually flow through the furnace evolving carbon dioxide. There is a normal shrinkage - approximately 10 per cent - in the weight of the charge, due to the loss of gases and volatilization of alkali oxides. The fused melt is drawn from the furnace continuously or periodically as a thin stream.

The melt may be dissolved directly in a (rotary) dissolver with hot water and steam at atmospheric pressures. The required quantity of steam depends on the ratio of SiO_2 to Na_2O . Products with a higher ratio are more difficult to dissolve and more steam will have to be used.

The resulting solution is usually turbid from fine unmelted sand particles and the impurities in the sand and water. Most of these settle out rapidly in a tank.

If solid sodium silicates are to be manufactured, the melt from the furnace is solidified by passage on to a moving chilled conveyer of steel molds, in which the melt cools to a semi-transparent, clear, light bluish-green glass. To dissolve this glass, steam at a pressure of 6-8 kg/cm² has to be applied.

Plants for producing sodium silicate and its solutions are quite simple. The characteristics of the product are determined by raw material ratios and furnace conditions. As with other furnace processes, continuous operation is required because of the premature failure of the refractory if the furnace is alternately heated and cooled.

Ordinary glass-melting type of furnaces are used, but special care in specification of construction materials is needed because, compared with ordinary glass, the temperature is higher and the melt more corrosive.

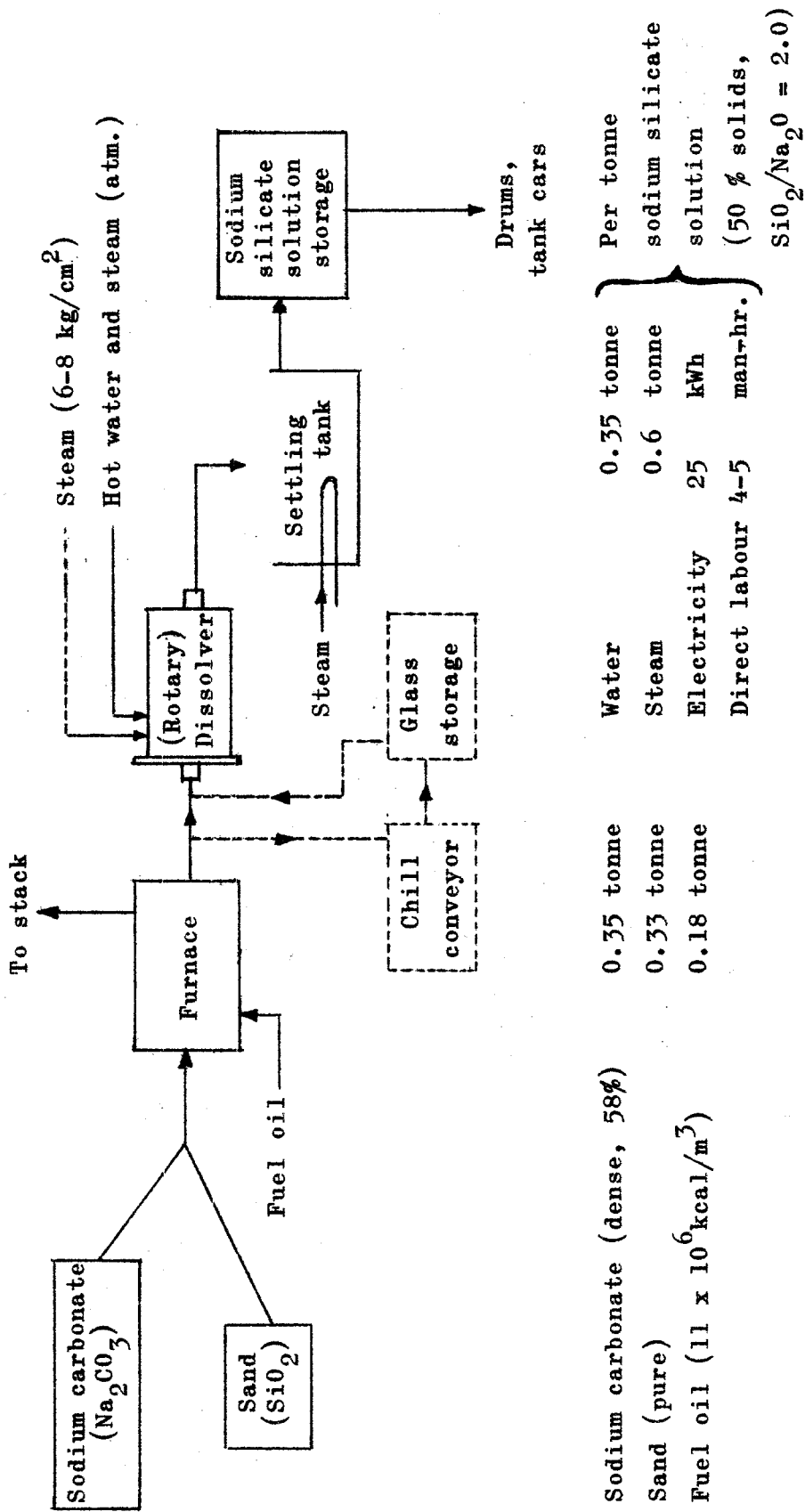


Figure 3. Flow chart for manufacture of sodium silicate.

MANUFACTURE OF SODIUM SILICATES IN THAILAND

Location

In considering the possible sites for a sodium silicate plant, it appears that a location in the neighbourhood of Bangkok would be advantageous in many respects:

Access to sources of raw materials. Soda ash is imported through the Port of Bangkok. The other raw material, sand, has to be obtained from Songkhla. A well organized transport system to serve the sand-consuming glass industry in Bangkok already exists.

Access to the product markets. All chief consumers of sodium silicate have their factories located in the environs of Bangkok.

Supply of utilities. The required utilities electricity, fuel-oil, and water are all available at a lower rate in Bangkok than in most other locations of Thailand.

Transportation. Bangkok and surroundings are served by adequate hard surfaced highways which makes possible delivery of the sodium silicate solutions in tank trucks.

The location of the sodium silicate plant in the neighbourhood of Bangkok has only one major drawback: industrial sites are not plentiful and the cost of land is high. However, in spite of this fact, it is recommended that serious consideration is given to locating the plant near Bangkok.

The sodium silicate plant required to serve existing demand will be relatively small. For this reason it might be possible to combine this unit with an existing factory, for example a glass factory or another chemical industry (which preferably is already using sodium carbonate or sodium silicate as a raw material). In this way a smaller piece of land will be required and initial investment for utilities, e.g. steamboiler, can be reduced.

Capacity

The local market development as shown in Table 2 and figure 2 of Part I of this report indicates that without speculation on export possibilities an installed furnace capacity of 2500 tons of solid sodium silicate per year would be justified. It is estimated that a factory with this capacity could

start to produce (beginning of 1969) at 75 per cent of its full capacity. With the anticipated growth of the local market the factory would have to run at full capacity in 1971 to meet the expected demand at that time.

Based on the plausible assumption that all consumers will want to buy their sodium silicate in solution, the capacity of the dissolving equipment is recommended to be approximately 20 per cent larger than the capacity required to dissolve the 2500 tons of sodium silicate in accordance with detergent specifications.

In this way the dissolving equipment will not be the bottle neck in the plant when other kinds of sodium silicate solutions have to be produced.

Process selection

In Thailand the price of sodium sulphate is not exceptionally low in comparison with the price of sodium carbonate. Both raw materials have to be imported. For this reason the soda ash process as described earlier is recommended for sodium silicate production in Thailand.

In order to be able to produce sodium silicate solutions with different specifications in respect to $\text{SiO}_2/\text{Na}_2\text{O}$ ratio and solids content, the installation of equipment for direct dissolving with hot water and steam at atmospheric pressures is recommended.

ESTIMATE OF THE LOCAL PRODUCTION COSTS OF SODIUM SILICATE

Before attempting to estimate the sodium silicate production cost, a framework of reference has to be assessed. The data for this framework are based on assumptions or are obtained from literature and existing practices. With the data here presented it will be possible to estimate the production costs of sodium silicates with different $\text{SiO}_2/\text{Na}_2\text{O}$ ratios either in solid form or in solution.

Reference framework

(1) Process type, capacity and location of the plant will be as recommended earlier in this report. For the calculations it will not be assumed that this plant is combined with another chemical factory or glass industry.

(2) Initial investment for process equipment, including construction and engineering fees: 1,500,000 baht (600 baht per ton of annual solid sodium

silicate capacity.)

(3) Required land will be 2 rai. In the vicinity of Bangkok, the price of this land, prepared for construction, is estimated at 100,000 baht per rai.

(4) Description and Bangkok prices of the required raw materials and utilities are as follows:

Imported sodium carbonate 58 / Na₂O. dense: Price delivered at factory 1300 baht per metric ton.

Pure sand from Songkhla: Price delivered at factory 115 baht per metric ton.

Fuel-oil with a heating value of approximately 11,000,000 kcal/m³:
Price delivered at factory including storage facilities 550 baht per cubic metre.

Water: Price at factory 1.0 baht per cubic metre.

Steam of 6-8 kg/cm²: Price 50 baht per metric ton.

Electricity: Price 0.25 baht per kWh.

(5) Labour and overhead: For the whole production unit, including the dissolving part, two labourers and one technician per shift are needed: Labourers at 25 baht per shift and the technician at 75 baht per shift. The cost of overhead is estimated to amount to 150,000 baht per year.

(6) Working capital is required to keep an inventory of the raw materials and products; sodium carbonate inventory sufficient for 60 production days, sand for 30 days and products for 30 days of supply (including receivable accounts).

Working capital is also required to prepay 15 days labour and sodium silicate selling costs.

Calculations

Based on the information described above in the reference framework, an estimate is made of the production costs of a sodium silicate solution containing 50 % solids and a SiO₂/Na₂O ratio of 2.0. At full capacity 2500 tons solid sodium silicate or 5000 tons solution can be produced per year of 300 production days.

Initial Investment Fixed Costs

Process equipment, transport, engineering and construction fees	1,500,000	baht
Land 2 rai at 100,000 baht per rai	<u>200,000</u>	baht
TOTAL INITIAL INVESTMENT	1,700,000	baht

With a complete depreciation in 6 years, this initial investment results in a fixed cost of 285,000 baht per year.

Manufacturing Costs, Variable Costs

Raw materials

Soda ash (58 % Na ₂ O, dense) 0.35 ton per ton of product (20 % excess) at 1300 baht per ton	$5000 \times 0.35 \times 1300 = 2,275,000$	baht
Sand 0.33 ton per ton of product at 115 baht per ton	$5000 \times 0.33 \times 115 =$	<u>192,000</u> baht
Total raw materials	2,467,000	baht per year
	or	493 baht per ton of product

Utilities

Burner fuel-oil 11,000,000 kcal/m ³ 2,000,000 kcal per ton of product at 550 baht per ton	$5000 \times \frac{2,000,000}{11,000,000} \times 550 = 500,000$	baht
Steam 0.6 ton per ton of product at 50 baht per ton	$5000 \times 0.6 \times 50 = 150,000$	baht
Electricity 25 kWh per ton of product at 0.25 baht per kWh	$5000 \times 25 \times 0.25 = 31,250$	baht
Water 0.35 m ³ per ton of product at 1.0 baht per m ³	$5000 \times 0.35 \times 1.0 =$	<u>1,750</u> baht
	683,000	baht per year
	or	1,365 baht per ton of product

Labour and overhead

2 helpers per shift

at 25 baht per shift $2 \times 350 \times 3 \times 25 = 52,500$ baht
(350 days per year ,
3 shifts per day)

1 technician per shift

at 75 baht per shift $350 \times 3 \times 75 = 78,750$ baht

Overhead at 150,000 baht
per year

150,000 baht

Total labour and overhead

281,250 baht per year

or 562 baht per ton
of product

Repairs and maintenance

85,000 baht per year

or 17 baht per ton
of product

Interest on working capital

60 days inventory of soda ash

455,000 baht

30 days inventory of sand

19,200 baht

30 days product storage and
accounts receivable

500,000 baht

(product at 1000 baht per ton

14 days labour prepay

11,800 baht

15 days selling expenses

6,000 baht

6 days fuel-oil

10,000 baht

Total working capital

1,001,000 baht

Interest on working capital

at 12 % per year

120,000 baht per year

or 24 baht per ton
of product

TOTAL VARIABLE COSTS

3,636,250 baht per year

or 727 baht per ton
of product

The above calculations show that for this sodium silicate production unit the fixed costs per year amount to 285,000 baht and that the variable costs are estimated at 727 baht per ton of sodium silicate solution (50 % solids, $\text{SiO}_2/\text{Na}_2\text{O} = 2$). With a full capacity production the total production cost would be:

$$727 + \frac{285,000}{5,000} = 784 \text{ baht per ton}$$

The fixed costs are constant and independent of the composition and quantity of product manufactured. However the variable costs are a linear function of the production output and vary also with the composition of the product.

The variable costs of a product different in composition from the product which has been used for the calculations can be estimated in the same way; for example,

- for a solution with 40 % solids and a $\text{SiO}_2/\text{Na}_2\text{O}$ ratio of 2.0, the variable costs will approximately amount to $\frac{40}{50} \times 727 = 580$ baht per ton
- for a solution with 50 % solids and a $\text{SiO}_2/\text{Na}_2\text{O}$ ratio of 3.0, only the costs of raw materials have to be recalculated, the other costs are nearly constant:

Raw materials

Soda ash (58 % Na_2O , dense)

0.275 ton per ton of product (20 % excess)

at 1300 baht per ton $5000 \times 0.275 \times 1300 = 1,787,500$ baht per year

Sand 0.375 ton per ton of product at 115 baht per ton

$5000 \times 0.375 \times 115 = \underline{215,625}$ baht per year

Total raw materials

(5000 tons of product per year)

2,003,125 baht per year

or

401 baht per ton

of product

With the other process costs constant this new raw material contribution results in a variable costs for this product of 635 baht per ton.

ESTIMATED SALES REVENUE AND GROSS PROFIT

As shown in Part I of this report, the price of imported sodium silicate solutions with 50 per cent or less of solids and a $\text{SiO}_2/\text{Na}_2\text{O}$ ratio of 2.0 is at present in the range of 1000-1100 baht per ton delivered at the factory. The production costs in Thailand for this material is estimated at 784 baht per ton. With an assumed transport and selling expense of 3 per cent, the price for this sodium silicate solution delivered at the factory would be 810 baht per ton. Compared with the lowest import price, a gross profit of 190 baht per ton would be obtained. For products with another composition it is assumed that this profit margin will be the same. Based on this assumption, the sales and gross profits for the first five years of operations are shown in Table 1.

TABLE 1
SALES REVENUE AND GROSS PROFIT FOR 5000 TONS
PER ANNUM FACTORY MANUFACTURING SODIUM SILICATE

Period	50% Solids $\text{SiO}_2/\text{Na}_2\text{O}=2$ solution production ton	Fixed costs baht	Variable costs baht	Total production costs baht	Selling and transport expenses baht	Total costs baht	Sales revenues baht	Gross profit baht
Construction and start up 6 months (end 1968)	-	-	-	-	-	-	-	90,000*
1st production year (1969)	3750 (75%)	285,000	2,730,000	3,015,000	95,000	3,110,000	3,750,000	640,000
2nd production year (1970)	4250 (85%)	285,000	3,100,000	3,385,000	115,000	3,500,000	4,250,000	750,000
3rd production year (1971)	5000 (100%)	285,000	3,640,000	3,925,000	125,000	4,080,000	5,000,000	950,000
4th production year (1972)	5000 (100%)	285,000	3,640,000	3,925,000	125,000	4,080,000	5,000,000	950,000
5th production year (1973)	5000 (100%)	285,000	3,640,000	3,925,000	125,000	4,080,000	5,000,000	950,000

* less of 12 per cent interest on invested capital

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