# PACKAGING RATIONALISATION

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A Dissertation Submitted to the Faculty of Engineering
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for the Degree of Master of Sciences.

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# D E C L A R A T I O N

I declare that this dissertation is my own, unaided work. It is being submitted for the degree of Master of Sciences in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

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IDO RIEGER

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# A B S T R A C T

In this Packaging Rationalisation project a wide spectrum of S.A.B. packaging lines related problems are discussed and analysed in order to obtain an overview of the packaging system as well as pointing out potential areas of development and improvement. Issues such as efficiencies, required capacity, line design, shift configuration, production location and others are discussed.

PLEASE NOTE: Numbers, and data, have been altered to protect information which is confidential and sensitive to S.A.B..

## ACKNOWLEDGEMENTS

I would like to express my thanks to the following individuals who reviewed this project at various stages:

| | | | |
|---|---|---|---|
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## ABBREVIATIONS AND TERMS

| | |
|---|---|
| S.A.B. | South African Breweries |
| 750's | A major S.A.B. pack - 750 mℓ Returnable Bottle (Q.D.C.) |
| b.p.h. | Bottles Per Hour |
| Br | Brewery |
| Br4 | A new brewery south of Johannesburg - i.e. Brewery 4 |
| Capacity | Production Capacity |
| c.p.h. | Cans Per Hour |
| Hℓ | Hectolitre = 100 litres |
| Hr | Hour (60 minutes) |
| L.P. | Linear Programming |
| N.P. | Northern Provinces |
| NRB | Non Returnable Bottle |
| N.T. | Normal Time |
| O.T. | Over Time |
| Ph | Phase |
| P.V. | Present Value |
| Q.C. | Quality Control |
| Q.D.C. | In S.A.B. a 750mℓ bottle - Quarts Deposit Container |
| R | Rands |
| RB | Returnable Bottle |
| S.A. | Southern Africa |

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# CHAPTER 1: PROBLEM SITUATION

The aim of the following section is to present S.A.B. (South African Breweries) and its environment. The reader who is familiar with S.A.B. should skip this chapter.

S.A.B. Beer Division is one of S.A.B. Group's divisions and is referred to throughout the study as S.A.B..

S.A.B. produce, pack, distribute and sell beer, currently 6 different brands of beer and 6 different packs. (A brand pack matrix is presented in appendix no. 1.5.)

S.A.B. is divided into 5 regions of which the Nortnern Provinces region is by far the biggest (sales volumewise) and is responsible for and sells about 73% of total division sales. This study concentrates on the Northern Provinces (N.P.) packaging environment but most of the results should be applicable to all regions. (The different regions and their sales percentages are presented in appendix no. 1.1.)

Within Northern Provinces, S.A.B. operates 6 breweries (production, packaging and manufacturing depot) and another 10 depots. This arrangement gives rise to a great deal of inter-depot operations. Changes in production capacities, products produced at each production centre and shift in demand location are hence inter-related and dynamically affect each other. (A schematic map of N.P. breweries and depots is presented in appendix no. 1.2.)

Sales demand is increasing at a rate of about 11% a year and it is estimated by S.A.B. forecasters that the S.A. market is far from saturation and the demand will continue to increase at a rate of about 11% at least for the next 10 - 15 years. This means that new production capacities have to be introduced almost every year. It also means that within the next 7 years, S.A.B. production capacity has to double. High and medium sales forecasts, by pack for N.P., are presented in appendix no. 1.3.

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S.A.B. has a monopoly of the beer market in South Africa. It has the advantage of relative freedom in the short term but the disadvantage of being constantly concerned with potential competition entering the beer market. S.A.B. does however regard the wine industry as its main competitor.

In broad terms, S.A.B. activities can be divided into 3 categories:

a. Production Of Beer

A process that takes about 3 - 4 weeks and is normally referred to as production (which in turn is divided into brewing and storage for maturation purposes).

b. Packaging

The process of filling bottles or cans with beer. With a bit of luck, the correct brand is inserted into the correct bottle with the correct labels, the right quality, age and timing. At the end of the 1983 financial year (F83) S.A.B. will be handling more than 2 500 million containers p.a..

c. Distribution

The packed beer (on pallets) is stored in the production warehouse for any period between 0 hours (peak time) to 3 days and distributed either to a customer or a depot. The goods from the depot are in turn distributed to the customers. Because of quality consideration, it is S.A.B.'s policy never to deliver, to a customer, beer that is more than 3 weeks old (after packaging).

This study is concerned with the packaging operations in S.A.B. and its main objective is to look for potential areas of improvement in the packaging system of S.A.B..

The following aspects were examined with a view to identifying potential areas for improving packaging:

a. Packaging Plant Utilisation (see Chapters 3 and 4);

b. Brewing/Packaging Capacity Relationship (see Chapter 5);

c. Cost of Capacity (see Chapters 6 and 7);

d. Determination of optimal Production Capacity (see Chapter 8);

e. The effect of different production Location (see Chapter 9);

f. Measurement of Efficiency (see Chapter 10);

g. Packaging Line Balancing (see Chapter 11);

h. Estimation of potential involved in a Single Pack Plant (see Chapter 12);

i. The possibilities of Shift Configuration changes (see Chapter 13);

j. A technique to approach yearly Production Planning (see Chapter 14).

Many of these aspects examined only identify areas of future study and general macro policy at S.A.B..

The S.A.B. Financial Year starts on 1 April of each year. The year starting at 1/4/82 and ending at the 31/3/83, for example is Financial Year 83 and is referred to as F83.

S.A.B. packs are divided into categories, of majors and minors. 750 mℓ bottles, sometimes referred to as Q.D.C. (Quarts Deposit Container), are returnable bottles and account for about 56% of total demand (by volume).

450 mℓ and 340 mℓ cans are the second largest sales packs - representing 22% and 10% of total sales respectively. It is normally convenient to regard the two can sizes as one pack - Cans.

340 mℓ Non Returnable Bottles (dumpies) are "responsible" for about 8% of total sales.

These 3 packs - 750 mℓ, cans and NRB's are normally referred to as major packs.

375 mℓ bottles (regularly referred to as pints) and 340 mℓ returnable bottles, used only for Amstel, and Draughts are grouped together and considered as minor packs (about 3-4% of total sales). An ABC Chart is presented in appendix no. 1.4. The study concentrates on the major packs only, specifically on quarts (750's) and cans. Some of the results and most of the methods are however also applicable to the minor packs. It should be borne in mind that although in this study the minor packs are virtually neglected, they can cause major problems due to a production and distribution nuisance. Furthermore, total yearly production of "minor" packs in S.A.B., in F83 will be about 335 000 Hℓ a year - a respectable European brewery.

# CHAPTER 2: INTRODUCTION

S.A.B.: Beer Division spends large amounts of money on its packaging system. Annually tens of millions of rands are invested in the most sophisticated machines available in the world and hundreds of millions for the actual packaging process.

The range of issues affecting the S.A.B. packaging system are enormous - the big capital outlays, industrial relations, capacity limits, risk considerations, quality demand, technological bounds, possible competition, control and management requirements, uncertainty regarding demand, the big lead time of constructing new breweries and many other typical industrial related problems.

Due to the above two factors, large amounts of capital involved and enormous complexity, S.A.B. management felt it necessary for a Packaging Rationalisation project to be undertaken. In S.A.B., a continuous effort is made to improve performance on an ongoing basis, often on a micro level. It is hoped that this study will prove enlightening to packaging related studies.

The main aim of this project is to present an overview of the packaging system of S.A.B., and to consider ways of improving performance, saving expenses, increasing utilisation, reducing capital investment and in general to look at ways of moving towards better performance. It has been attempted to find general relations, connectivity between different alternatives, new approaches to problems and new or different techniques to solve them. It has further been attempted to demonstrate a wide range of techniques, algorithms, and methods of thinking that can be used in any further studies. Although at the end of every chapter a set of conclusions and results are stated, they are not necessarily the most important output of the study. Of at least equal importance are the concepts and the approach used. One hopes that some of the results may be implemented but what is important is that this study will never end. The results and concepts presented are to be used as a base, framework and starting point to further investigation. This process should repeat itself continuously.

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In the following pages, the main chapters of the study are briefly discussed. This should serve as an overview of the project.

UTILISATION

Utilisation is defined to be the ratio between the actual usage of our resources and some theoretical maximum. The utilisation of S.A.B. packaging plants is shown to be very low, definitely below 50% and under some definitions less than 30%. This of course depends very much on the definition of utilisation, capacity efficiencies and other parameters. The fact that S.A.B. plant utilisation is so low indicates a potential area for improvement. (See Chapter 4)

GENERAL RELATIONSHIP OF PACKAGING TO BREWING CAPACITY

Currently S.A.B. believes that packaging capacity should be above brewing capacity. Practically in the field, some of the plants have higher brewing capacity than packaging. There are good reasons to justify S.A.B.'s current approach (for example pack share movement) but there are very valid arguments against it as well (mainly costs). (See Chapter 5)

COST OF PLANT

The actual cost S.A.B. experiences when installing new packaging plant, taking into account tax, opportunity cost and cash flows must be found. The present value of the expenses is calculated and found to be about R8 - R9 per Hℓ/year capacity (present value, after tax, only a 750 packaging line). (See Chapter 6)

COST OF CAPACITY

The cost of a certain capacity in present value terms, taking into account the plant cost (cost of plant) and labour annuities, must be calculated. This is very important as it should be used as a base cost comparison for different proposed enhancements and investments. (See Chapter 7)

## REQUIRED PACKAGING CAPACITY MODEL

The optimum relation between planned capacity and sales forecasts must be found. These decisions are taken regularly by S.A.B.: Beer Division Management. A formal method of approaching the matter is developed and presented. The concepts, it is believed, should be used in any capacity plan (total, regional, brewing, logistics) as well as for packaging capacity decisions. (See Chapter 8)

## LOCATION

This is mostly a logistic problem. By producing a certain pack at a certain place the distribution costs may be affected very significantly. This kind of decision is very involved and the distribution cost is unfortunately not the only parameter that has to be considered. By means of a linear programming model, some different scenarios are compared. (See Chapter 9)

## EFFICIENCY

Efficiency is a measure of performance which is currently measured relative to the filler manufacturer rating. It is argued that by so doing, by using the current efficiency definition, we are not measuring the correct quantities. Therefore, it is necessary to determine the most effective method of measuring efficiencies. (See Chapter 10)

## LINE PROFILE

The way packaging lines are designed is debatable. Currently the line profile follows a V shape in which machinery, up and downstream from the filler, is designed to have significantly higher rating than the filler. This is the way S.A.B. and other firms are designing their lines. It is also the approach presented in relevant journals. However, it is believed that it is not necessarily the optimum way and another approach is presented. (See Chapter 11)

SINGLE OR MULTI- PACK BREWERIES

There are certain advantages to a single pack plant. An effort is made to qualify them (it is almost impossible to quantify them). (See Chapter 12)

SHIFT CONFIGURATION EFFECTS

The effect of different shift configurations on S.A.B.'s capacity and cost should be determined. These calculations are very sensitive to the different parameters, such as opportunity cost, labour cost escalation and time span considered. Changes in shift configuration can result in significant changes in utilisation. (See Chapter 13)

PRODUCTION PROFILE THROUGHOUT THE YEAR

The problem of meeting peak demand by use of over time, or the build up of reserve stock or increased capacity is posed. Typical aggregate production planning is considered using graphic methods. (See Chapter 14)

# CHAPTER 3: CAPACITY DEFINITIONS

For the purpose of this study, and it is suggested that in S.A.B. generally, the following definitions are used:

1. Maximum theoretical capacity per unit time is the maximum amount of hl that can be produced during the relevant time period assuming full use of plant during that time, with no maintenance, stops or any other breakdown. Therefore maximum theoretical capacity per year is the plant rate (Hl/Hr) x 24 x 365. It is obvious that such capacity cannot be achieved in practice, nevertheless, the advantage is that the above number is easily calculated with no ambiguities to be used as a base of comparison to the actual or planned capacity.

2. Capacity - actual output achieved or planned and/or designed capacity, in hl per unit time.

3. Utilisation - the ratio between capacity and maximum theoretical capacity. The utilisation is affected by shift configuration, maintenance, efficiency, holidays, etc..

Utilisation is, therefore, the percentage of the maximum theoretical capacity that S.A.B. is utilising or planning to utilise.

## CHAPTER 4: UTILISATION

Utilisation is a measure of the extent to which plant is used i.e. the ratio of actual usage to maximum possible usage. Low utilisation is caused by many factors, some of which can be controlled to a certain degree, while others may be controlled only to a small degree and some cannot be controlled at all.

The main factors affecting utilisation are: shift configuration, efficiency, yearly maintenance, weekly maintenance and holidays.

On the following table, different shift configurations are presented with their relevant utilisation in percentage. In addition, a factor is calculated. This factor is the product of the utilisation and total number of hours (in a week or year). Multiplying this factor by the rated capacity of the line (Hℓ/Hr) (or lines) gives the total Hℓ that can be expected to be produced in the period (week or year). This is the capacity.

The current situation in Southern Transvaal is represented by case C while case D represents N.P..

The following table obviously oversimplifies the situation and its only purpose is to identify potential areas of improvement.

TABLE 4.1: UTILISATION CALCULATION FOR DIFFERENT SHIFT CONFIGURATIONS

| CASE | SHIFT CONFIGURATION HRS/WEEK | YEARLY MAINTENANCE FACTOR | WEEKLY MAINTENANCE FACTOR | HOLIDAY FACTOR | EFFICIENCY (FACTORY) | UTILISATION | WEEKLY FACTOR | YEARLY FACTOR |
|---|---|---|---|---|---|---|---|---|
| A | 45/168<br>1 x 9 | 0,91 | 0,89 | 358/365 | 0,7 | 14,89 | 25,08 | 1304 |
| B | 90/168<br>2 x 9 | 0,91 | 0,89 | 358/365 | 0,7 | 29,79 | 50,18 | 2609 |
| C | [39.90/168+13.120/168]/52<br>(= 0,58)<br>2 x 9 + PEAK O.T. | 0,91 | 0,89 | 358/365 | 0,7 | 32,27 | 54,36 | 2827 |
| D | 120/168<br>2 x12 | 0,91 | 0,89 | 358/365 | 0,7 | 39,72 | 66,91 | 3479 |
| E | 135/168<br>(3 x 8) | 0,91 | 0,89 | 358/365 | 0,7 | 44,08 | 75,27 | 3914 |
| F | 135/168 | 0,91 | 1 | 358/265 | 0,7 | 50,20 | 84,57 | 4397 |
| G | 168/168 | 0,91 | 0,89 | 358/365 | 0,7 | 55,60 | 93,66 | 4870 |
| H | 168/168 | 0,91 | 0,89 | 1 | 0,7 | 56,69 | 95,50 | 4966 |
| I | 168/168 | 0,91 | 0,89 | 1 | 0,8 | 64,79 | 109,14 | 5675 |

A - one shift

B - two 9 hour shifts

C - two 9 hour shifts, over time during peak

D - two shifts, 5 days over time throughout the year

E - 3 x 8 hour shift system (5 2/3 days)

F - 3 x 8 hour shift system, weekly maintenance by another crew

G - 4 x 8 hour shift system

H - 4 x 8 hour shift system, working also on holidays

I - INCREASE IN FACTORY EFFICIENCY

YEARLY MAINTENANCE - assumed to be about 9%.

WEEKLY MAINTENANCE - assumed to be about 11%.

## CONCLUSIONS

1) S.A.B.'s utilisation of plants (packaging) is very low. It is about 30 - 35% of the maximum theoretical possible usage.

2) While it is obvious that 100% utilisation will never be achieved - the above leads one to believe that much higher utilisation, than the current usage, can be achieved.

## CHAPTER 5: GENERAL RELATIONSHIP OF PACKAGING TO BREWING CAPACITY

Production of beer is a complicated and involved process. The process can be divided into about 8 - 9 components, each performing a unique operation. Each of these components are made up of a number of units which altogether have to be accurately tuned so as to fulfil the objective of supplying the best possible product at the least cost.

Unfortunately a plant whose components are failure free has not yet been built, nor can its performance be managed with absolute efficiency.

Therefore, after determining the required output of the plant, the relative capacities (taking into account utilisation) of the different components have to be determined, such that the aggregate performance will be the desired one.

This can and should be the subject of a full scale separate study. In this section, the general relationship and results, mostly qualitative, will be derived. Still more important, an effort will be made to name and understand, all factors affecting the optimum capacity relation.

### CURRENT TRENDS

As it stands now, S.A.B.'s policy is to provide about 20% excess packaging capacity over and above brewing capacity. (Reference 5.1) In practice, however, most of S.A.B.'s plants have excess brewing capacity. These figures depend very much on utilisation assumed for Brewery 4. In the Management Brief (Reference 5.1), shift configuration was assumed to be 3 x 8 hour shift. While for the current plants 2 x 9 hour shift is assumed. (See appendix no. 5.2 for the actual relationship between packaging and brewing capacity.)

<u>CAPITAL COST</u> (All cost numbers are in thousands)

The Base for the following information is taken from the "Capital Cost Analysis" prepared by The Cost Engineer (June 1981), using the numbers relevant to a 60 000 hℓ/week Plant, inflated at 10% per year to obtain "standard day" for the study of June 1982.

FIGURE 5.1: MAIN COMPONENTS (PLANTS) OF A BREWERY

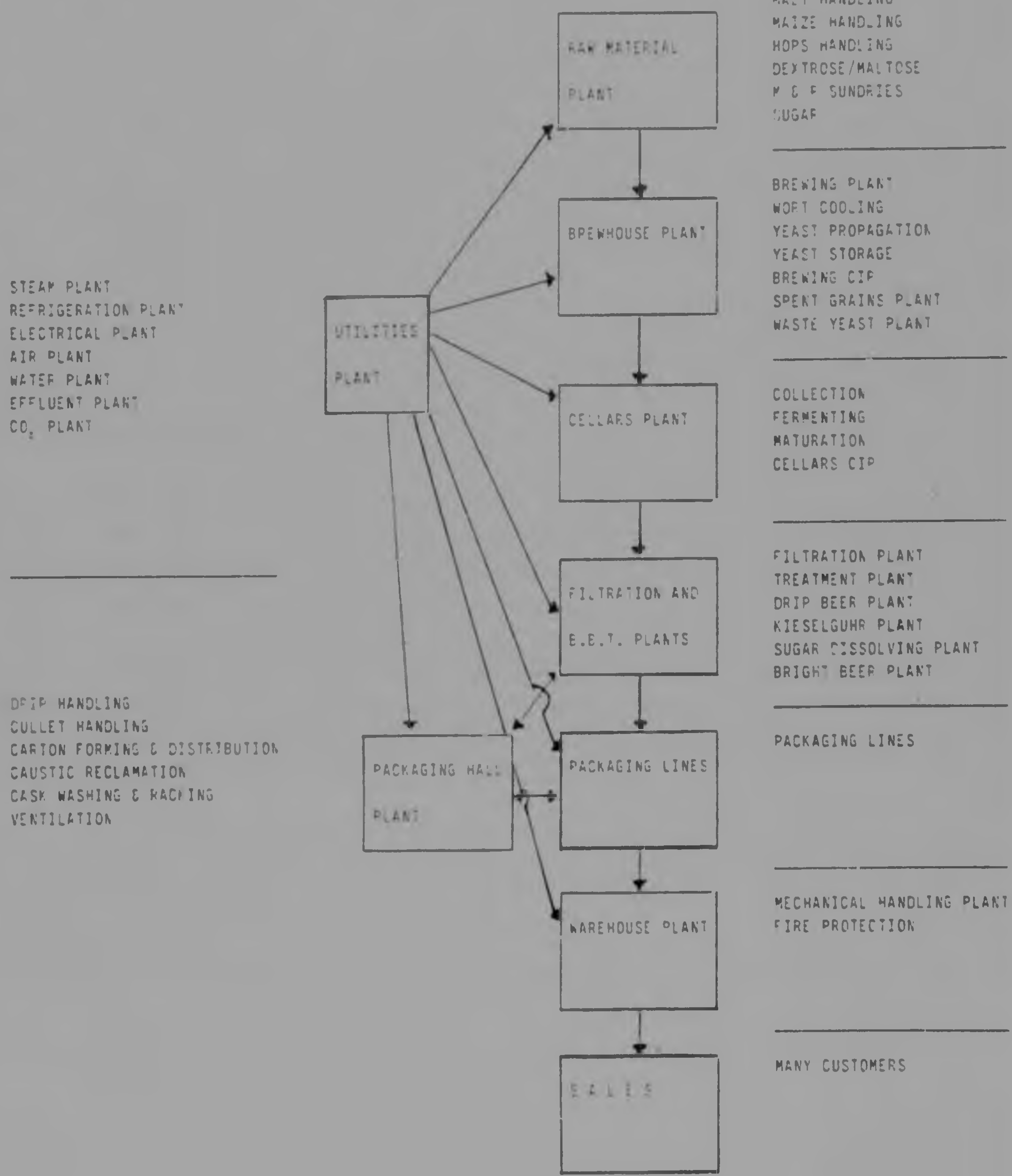


TABLE 5.1: COST OF THE MAIN COMPONENTS (PLANTS) OF A BREWERY (R'000)

| | PLANT | BUILDINGS | TOTAL |
|---|---|---|---|
| Raw Materials | 1 412,6 | 1 624,5 | 3 037,1 |
| Brewhouse | 5 404,1 | 1 336,7 | 6 740,8 |
| Cellars | 11 251,1 | 2 961,0 | 14 212,1 |
| Filtration | 3 748,5 | 874,8 | 4 623,3 |
| Packaging Lines | 34 005,4 | 727,3 | 34 732,7 |
| Packaging Hall | 1 242,7 | 2 679,6 | 3 922,3 |
| Warehouse | 3 269,8 | 3 519,6 | 6 789,4 |
| Utilities | 15 773,0 | 911,8 | 16 684,8 |
| Site Works Plant | 824,1 | 4 479,6 | 5 303,7 |
| Auxillary Buildings | 928,8 | 3 859,0 | 4 787,8 |

See appendix no. 5.1

From the above figures, Table 5.1, it is clear that the Packaging Plant is much more expensive than any other plant in a factory (furthermore, any reasonable combination of the different Blocks within a factory will have the same result).

When planning a factory and considering the capacity relation between the different plants, the packaging complex should be regarded as the principle producer of the goods and all other parts of the factory must serve the packaging lines.

This may not be the traditional way of looking at beer production and it is probably not the way S.A.B.'s image should be advertised, but costwise this is the situation.

Furthermore, analysing the production variable cost, the packaging cost is roughly twice as big as the Brewing cost. This means that S.A.B. should try to minimise, in the first place, as much as possible, its investment in packaging and reduce packaging variable costs.

SALES

As the future is difficult to predict and because S.A.B. is subjected to pack share movement, there is a tendency to have a higher capacity than required so that fluctuations in pack share can be handled simply by producing more or less in existing lines and not by building a new line to cater for unexpected occurrences. This reasoning tends to increase the relative packaging capacity. In N.P. there are about 20 Packaging lines and some of them are multi-purpose. This situation naturally will help in the future to handle pack share movements. Furthermore, it is believed that by means of advertising (or lack of advertising), and especially by means of cost differentiation, the sales pack share can, to a certain degree, be controlled. This, of course, costs money (expenses of advertising, loss of revenue due to reduction of costs to encourage sales of a certain pack) and appropriate balancing between cost of under capacity and the cost of preventing such a situation has to be found. (Refer to Chapter 8 - "Required Packaging Capacity Model".) It is, however, suggested that a study be initiated to determine what the limits of S.A.B. influences on pack share are and what the costs involved are.

STORAGE

The possibility of storing products between the various Blocks of the factory, influences the capacity required. The higher the storage capacity before and after the Block, the lower its capacity can be. The Packaging Plant has the warehouse as an almost ideal storage facility (definitely enough to meet sales fluctuation as is proved and presented in the long term storage study). (See Chapter 14 - "Production Profile Throughout The Year")

The cellars, before packaging, also provide a means of storage, enabling the Packaging Block to run on a relatively low, but constant, production rate.

UTILISATION

It seems that this will eventually prove to be the dominant factor in determining the capacity required. As S.A.B., at the moment, is utilising about 35% to 45% of its present (theoretical) capacity (see Chapter 3 - "Capacity Definitions"), there is probably a good chance of dramatically decreasing the required capacity (and therefore capital investment) by achieving higher utilisation.

CONCLUSIONS

1) S.A.B. is not running a brewing nor distribution business. It is largely running a packaging business, and it is packaging problems that are of primary concern.

2) When planning new capacity, the packaging should be built so as to meet sales and all other components should be built to serve packaging.

3) Assuming the cost of packaging is a monotonic increasing function of its capacity, then the packaging capacity should be decreased as much as possible.

4) It is felt that the systems involved are big enough to assume that a ratio of 1 : 1 between packaging and brewing is close to optimal. However, a scientific and quantitative method (possibly simulation or probability theory) should be developed and used for determining the optimal ratio.

## CHAPTER 6: CAPITAL COST SAVING POTENTIAL

By increasing the utilisation of their existing equipment, S.A.B. can delay the introduction of new capacity giving rise to capital cost saving. To estimate capital cost savings, many factors must be taken into account, some of which can be relatively accurately estimated, while others can not.

The cost of a plant is a function of the plant size. There are many methods to estimate such a cost saving. Probably the simplest way is to assume all functions to be continuous (in real life some of them are step functions); then to calculate the value of an additional production unit. Assuming a certain production per year for this line, one can find the capital cost investment per 1 Hℓ/year production capacity; any increase in utilisation that will cost S.A.B. less than the above calculated figure is worth consideration.

### ASSUMPTIONS

a. Continuous and linear behaviour of the system.

b. 750's packaging line, typical rate 315 Hℓ/hr.

c. Canning line, rate 60 000 cans per hour.

d. Yearly factor: 3 175 (explained in Chapter 4 - "Utilisation").

e. Cost of 750 packaging line: R12 million (see appendix no. 6.1). (Reference 6.1)

f. Cost of Canning line: R5,3 million (see appendix no. 6.2). (Reference 6.1)

g. Proportional cost of building and civil work: R2,7 million per packaging line. (Reference 6.1)

h. Tax: 46,2%.

i. 30% investment allowance for plant.

j. 25% initial allowance for plant.

k. 13% yearly allowance on straight line for 6 years.

l. 20% investment allowance for buildings.

m. 2½% per year straight line for 40 years Depreciation allowance.

n. Cost of capital (opportunity cost) - 16%.

o. All payments at the end of the year.

p. Scrap value - 0.

Present value factor is $\frac{1}{(1,16)^n}$

n - number of years.

(Reference 6.2 - nos. 8 - 14)

TABLE 6.1: CASH FLOW: 750 PACKAGING LINE - 42 000 BOTTLES PER HOUR

(R'000 000)

| END OF YEAR | EX-PENSE | BOOK VALUE | ALLOW-ANCE | INVEST-MENT ALLOW-ANCE | TAX-ABLE EARN-INGS | TAX | CASH FLOW | PV FACTOR | PRES-ENT VALUE |
|---|---|---|---|---|---|---|---|---|---|
| 0 | -12,0 | 12,0 | | | 0 | | -12,0 | 1 | -12 |
| 1 | | 7,44 | 4,56 | 3,6 | -8,16 | 3,77 | 3,77 | 0,862 | 3,25 |
| 2 | | 5,88 | 1,56 | | -1,56 | 0,72 | 0,72 | 0,743 | 0,535 |
| 3 | | 4,32 | 1,56 | | -1,56 | 0,72 | 0,72 | 0,641 | 0,462 |
| 4 | | 2,76 | 1,56 | | -1,56 | 0,72 | 0,72 | 0,552 | 0,397 |
| 5 | | 1,20 | 1,56 | | -1,56 | 0,72 | 0,72 | 0,476 | 0,343 |
| 6 | | 0 | 1,20 | | -1,20 | 0,55 | 0,55 | 0,410 | 0,230 |

TOTAL PRESENT VALUE: -6,783

TABLE 6.2: CASH FLOW: CANNING LINE - 60 000 CANS PER HOUR

(R'000 000)

| END OF YEAR | EX-PENSE | BOOK VALUE | ALLOW-ANCE | INVEST-MENT ALLOW-ANCE | TAX-ABLE EARN-INGS | TAX | CASH FLOW | PV FACTOR | PRES-ENT VALUE |
|---|---|---|---|---|---|---|---|---|---|
| 0 | -5,3 | 5,3 | | | 0 | | -5,3 | 1 | -5,3 |
| 1 | | 3,286 | 2,014 | 1,59 | -3,604 | 1,665 | 1,665 | 0,862 | 1,435 |
| 2 | | | 0,689 | | -0,689 | 0,3183 | 0,3183 | 0,74 | 0,236 |
| 3 | | | 0,689 | | -0,689 | 0,3183 | 0,3183 | 0,641 | 0,204 |
| 4 | | | 0,689 | | -0,689 | 0,3183 | 0,3183 | 0,552 | 0,176 |
| 5 | | | 0,689 | | -0,689 | 0,3183 | 0,3183 | 0,476 | 0,151 |
| 6 | | 0 | 0,530 | | -0,530 | 0,2449 | 0,2449 | 0,410 | 0,100 |

TOTAL PRESENT VALUE: -2,998

The above figures are very much dependent on the above assumptions and before any decisions are taken, the type of calculation demonstrated above should be undertaken using the appropriate assumptions, as close as possible to the actual situation.

TABLE 6.3: CASH FLOW: BUILDINGS

(R'000 000)

| END OF YEAR | EX-PENSE | BOOK VALUE | ALLOW-ANCE | INVEST-MENT ALLOW-ANCE | TAX-ABLE EARN-INGS | TAX | CASH FLOW | PV FACTOR | PRES-ENT VALUE |
|---|---|---|---|---|---|---|---|---|---|
| 0 | -2,70 | 2,70 | | | | | -2,70 | 1 | -2,70 |
| 1 | | 2,632 | 0,0675 | 0,54 | -0,6075 | 0,2807 | 0,2807 | 0,862 | 0,242 |
| 2 | | 2,565 | 0,0675 | | -0,0675 | 0,0312 | 0,0312 | 0,743 | 0,023 |
| 3 | | 2,497 | 0,0675 | | -0,0675 | 0,0312 | 0,0312 | 0,641 | 0,020 |
| . | | . | . | | . | . | . | . | . |
| . | | . | . | | . | . | . | . | . |
| 40 | | 0 | 0,0675 | | -0,0675 | 0,0312 | 0,0312 | 0,0026 | 0,000 |

2,31 million Rands is the real cost of the building and civil work per packaging line.

$$PV = -2,7 + 0,2807 \times 0,862 + 0,0312 \times \sum_{n=2}^{40} \frac{1}{1,16^n}$$

$$= -2,7 + 0,24 + 0,0312 \times \sum_{n=2}^{40} 0,862^n$$

$$= -2,7 + 0,24 + 0,0312 \times 5,37$$

$$= -2,29$$

Using the above results, the cost of the packaging line, after tax, can be estimated by adding the plant and building costs:

| | | |
|---|---|---|
| 750's line : | Plant cost after tax | R6,8 million |
| | Civil (buildings) cost after tax | R2,3 million |
| | Total Cost after tax | R9,1 million |
| Canning Line : | Plant cost after tax | R3,0 million |
| | Civil costs after tax | R2,3 million |
| | Total cost after tax | R5,3 million |

Using R9 million (instead of 9,1) for the 750's lines and R5,3 million for canning lines, the cost per Hℓ per year capacity may be calculated. Assuming yearly production capacity of about 1m Hℓ per year for a 750's line and 0,75m Hℓ per year for a canning line, the cost, after tax, per Hℓ per year capacity is 9:1 i.e. R9/Hℓ per year for the 750's line and 5,3:0,75 i.e. R7/Hℓ per year for the canning line. Therefore, any investment, enhancement or improvement that costs S.A.B. less than R9 for each Hℓ per year capacity or R7/Hℓ per year capacity (750's and cans respectively) should be considered very seriously.

Furthermore, it should be noted that the above numbers (R9 and R7) are after tax figures. This means that an investment of about R17, which really costs S.A.B. only R9 (very roughly), is the equivalent number (before tax). Therefore, any investment that is tax deductable (and all investments normally are), and is less than R17/Hℓ per year, should be considered.

## CONCLUSIONS

1) Low utilisation costs S.A.B. a huge amount through the need to increase capital: in the order of R9/Hℓ per year capacity (after tax) or R17/Hℓ per year capacity before tax.

2) These numbers should be used as a guide line for searching for ways to increase the plant's utilisation.

3) Every proposed investment should be separately studied.

4) The above savings can and should be applied for new plants that are constructed and/or being planned at this stage. This means - to reduce the capacity of the packaging lines (Rosslyn, Brewery 4 ...) as much as possible and increase utilisation (efficiency, shift configuration, line balancing and so on).

## CHAPTER 7: COST OF CAPACITY

Assuming all functions to be linear and continuous, the current cost of a capacity of 1 000 000 hℓ/year is calculated. The expected life is assumed to be 15 years, inflation 12%, cost of capital 16%, labour wages increases about 1% above inflation resulting in a discounting factor for wages of 3% (0,97).

The case is different for the Plant - the cost of plants generally in the long term do not exceed the inflation rate and therefore, should be discounted at a rate of about 16 - 10 = 6%. Allowing for technical innovations and development at a rate of another 5% per year, results in a discount factor of 11% (1/1,11 = 0,9). The present value of the investment on 750's line, after tax, using 16% as the opportunity cost, is (see Chapter 6 - "Capital Cost Saving Potential") 9,00m Rands (rating 315 hℓ/ha). Present value of capital investment on a canning line is assumed to be R5,3m Rands.

The calculations presented here are based on a time span of 15 years (roughly the life time of a plant). The same sort of calculation, but for an infinite time span, is performed in appendix no. 7.1.

FIGURE 7.1: CASH FLOW: 750 LINE WITH LABOUR

| | CAPITAL INVESTMENT (R) | LABOUR (R) |
|---|---|---|
| 0 | 9 000 000 | 147 881 |
| 1 | | 147 881 |
| 2 | | 147 881 |
| 3 | | 147 881 |
| 4 | | 147 881 |
| 5 | | 147 881 |
| 6 | | 147 881 |
| 7 | | 147 881 |
| 8 | | 147 881 |
| 9 | | 147 881 |
| 10 | | 147 881 |
| 11 | | 147 881 |
| 12 | | 147 881 |
| 13 | | 147 881 |
| 14 | | 147 881 |

The above are the costs associated with a 750 capacity of 927 360 Hℓ/year.

Labour real cost per year after tax - 274 872 x (1 - 0,462) = 147 881.

Labour - 15 years annuity of R147 881 per year discounted at 3%:

$$147\ 881 \times \frac{1 - 0{,}97^{15}}{1 - 0{,}97} = 1\ 807\ 841$$

Capital investment in new capacity, after tax, is R9 000 000 once every 15 years (see Chapter 6 - "Capital Cost Saving Potential").

This expense occurs only once in the 15 year segment that is considered here and is assumed to be paid at the beginning of those 15 years, therefore, the P.V. remains R9 000 000.

Adding the P.V. of labour and capital:

$$\begin{array}{r} 9\ 000\ 000 \\ +\ \underline{1\ 807\ 841} \\ 10\ 807\ 841 \end{array}$$

OR for 1 000 000 Hℓ:- $10\ 807\ 841 \times \frac{1\ 000\ 000}{927\ 360} = 11\ 654\ 418$

R11 654 418 per (1m Hℓ per year) Capacity

OR R11,654 per (1 Hℓ per year) Capacity.

Using infinite series results (see appendix no. 7.1):

R17 584 724 per (1m Hℓ per year) Capacity

OR R17,584 per (1 Hℓ per year) Capacity.

FIGURE 7.2: CASH FLOW: CANNING LINE WITH LABOUR

| | CAPITAL INVESTMENT (R) | LABOUR (R) |
|---|---|---|
| 0 | 5 300 000 | 59 952 |
| 1 | | 59 952 |
| 2 | | 59 952 |
| 3 | | 59 952 |
| 4 | | 59 952 |
| 5 | | 59 952 |
| 6 | | 59 952 |
| 7 | | 59 952 |
| 8 | | 59 952 |
| 9 | | 59 952 |
| 10 | | 59 952 |
| 11 | | 59 952 |
| 12 | | 59 952 |
| 13 | | 59 952 |
| 14 | | 59 952 |

The above are the costs associated with a canning capacity of 577 760 Hℓ/year.

Labour real cost per year after tax - 111 436 x (1 - 0,462) = 59 952.

Labour - 15 years annuity of R59 952 per year discounted at 3%:

$$59\ 952 \times \frac{1 - 0{,}97^{15}}{1 - 0{,}97} = 732\ 911$$

Capital investment in new capacity, after tax, is R5 300 000 once every 15 years (see Chapter 6 - "Capital Cost Saving Potential").

This expense occurs only once in the 15 year segment and is assumed to happen at the beginning of those 15 years, therefore, the P.V. is 5 300 000.

Adding the P.V. of labour and capital:

$$\begin{array}{r} 732\ 911 \\ +\ \underline{5\ 300\ 000} \\ 6\ 032\ 911 \end{array}$$

OR for 1 000 000 Hℓ:- $6\ 032\ 911 \times \frac{1\ 000\ 000}{577\ 760} = 10\ 441\ 898$

R10 441 898 per (1m Hℓ per year) Capacity

OR R10,442 per (Hℓ per year) Capacity.

Using infinite series results (see appendix no. 7.1):

R15 056 042 per (1m Hℓ per year) Capacity

OR R15,056 per (1 Hℓ per year) Capacity.

CONCLUSIONS

1) On average, a packaging capacity of 1 hℓ/year costs S.A.B. a large amount. The following costs include direct labour cost - for 750's production R11,654/(Hℓ per year capacity), and for Canning Lines - R10,442/(Hℓ per year capacity).

2) Any investment, which will result in increased capacity, with a present value after tax lower than the above figures, should be considered seriously.

3) It should be remembered that the same sort of calculation, using an infinite series yields a much higher number. The infinite assumption may be sometimes a more appropriate figure to be used. It should further be noted that all costs are after tax cost. Before tax, the numbers have to be multiplied by a factor of 2 (roughly).

4) The above numbers are limited in the sense that they are average numbers and it has been previously stated that a man with one leg in boiling water and the other in icy water, on average should feel comfortable.

## CHAPTER 8: REQUIRED PACKAGING CAPACITY MODEL

In trying to determine the required packaging capacity, one has to take into account many factors including:

a. demand to be met;
b. spare capacity for pack share fluctuation;
c. spare capacity to accommodate for industrial unrest;
d. reduction of expenses;
e. capital cost of introducing the required capacity.

Some of the above factors are very difficult to quantify. In the following pages a model will be developed and formulated. This model should help the decision maker in comparing different capacity plans on a divisional (whole of South Africa) or regional basis. By using the model, the user will become aware of the capital investments and the risk associated with each possible capacity plan. For example, the question of whether to introduce a new capacity module in 1986, when it will only be partially required if demand is high and will not be required at all if demand is low, or whether to introduce this capacity in 1987, is a question of comparing early capital layout with risk and can be analysed by means of the capacity model. The decisions involved are high level decisions and the parameters that should be fed to the "thinking algorithm" should be varied on the base of trial and error until satisfactory results are obtained.

### MODEL FORMULATION

As the future is unknown, the expected cost rather than the actual cost should be minimised (the actual cost is unknown but the expected cost can be calculated). Using as a base the sales forecast, there is a certain probability that the sales will be higher or lower. The same applies to capacity. Due to technical problems and industrial unrest, there is a chance of lower or higher capacity than actually planned. The following formulation, makes some assumption and derives an expression, which results in the expected cost as a function of the planned capacity being derived.

Let $S_i$ be total sales forecasted in period i.

Let $P_i$ be the pack share forecasted in period i.

Let $P(A)$ be the probability of an event A.

Let RL be the loss in Rands for every Hℓ under the demand.

Let $PCA_i$ be the planned production capacity in period i.

Let CC be the cost of capital investment in R/Hℓ per year.

Let n be number of periods considered.

Let r be cost of capital (opportunity cost).

Let $CA_i$ be Actual production capacity in period i.

Total Expected Cost = Capital Investment + Expected Loss due to Insufficient Capacity

$$\text{Capital Investment} = \sum_{i=1}^{n} CC \times (PCA_i - PCA_{i-1}) \times \frac{1}{(1+r)^n}$$

Difference between Sales and Capacity is: $S - C$

$$\text{Expected Difference in period i is: } \underbrace{\int_{S=-\infty}^{+\infty}}_{\text{DEMAND}} \underbrace{\int_{C=-\infty}^{+\infty}}_{\text{CAPACITY}} P(S_i=S)xP(CA_i=C)x(S-C)dCdS$$

Expected Loss (in Present Value terms) =

$$\sum_{i=1}^{n} \frac{1}{(1+r)^k} \times RL \times \left( \int_{S=-\infty}^{+\infty} \int_{C=-\infty}^{+\infty} x\, P(S_i=S)xP(CA_i=C)x(S-C)xH(S-C)dCdS \right)$$

where H(x) is called the Heaviside function and is defined to be:

$$H(X) = \begin{cases} 0 & \text{when } X < 0 \\ 1 & \text{when } X \geq 0 \end{cases}$$

TOTAL EXPECTED COST

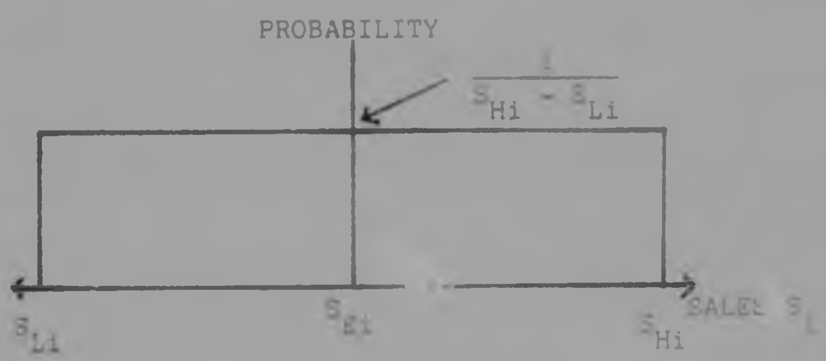
$$TEC = \sum_{k=1}^{n} \frac{1}{(1+r)^k} x[CC(PCA_i - PCA_{i-1}) + RL( \underbrace{\int_{S=-\infty}^{+\infty}}_{\text{SALES}} \underbrace{\int_{C=-\infty}^{+\infty}}_{\text{CAPACITY}} P(S_i=S)xP(CA_i=C)x(S-C)$$

$$xH(S-C)dCdS]$$

And the objective is to find decision variables $PCA_i$ for $i = 1,2,3....n$ such as to minimise TEC knowing the probability distribution of $S_i$ and $CA_i$ and the cost parameters CC, RL and r. The expression for TEC may be regarded as a general model of which a particular case will be developed in the following pages.

For simplicity, it is assumed the probabilities are uniform.

FIGURE 8.1: PROBABILITY DISTRIBUTION OF DEMAND



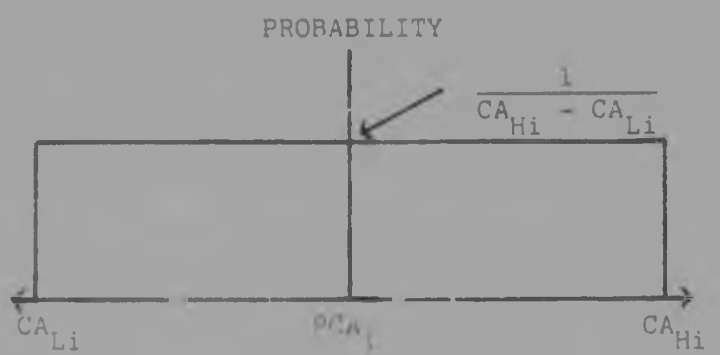

$S_{Ei}$ - Expected Sales in period i.
$S_{Li}$ - Lowest Expected Sales in period i.
$S_{Hi}$ - Highest Expected Sales in period i.

The above diagram represents the density distribution function:

$$P(S = K) = \frac{1}{S_{Hi} - S_{Li}}$$

The same applies to the capacity - due to industrial unrest, unexpected breakdowns - the actual capacity $CA_i$ will differ from the planned one $PCA_i$.

FIGURE 8.2: PROBABILITY DISTRIBUTION OF PRODUCTION CAPACITY



And as for the sales, $CA_{Hi}$ is the highest expected capacity in period i and $CA_{Li}$ the lowest.

It should be noted that in both cases, the middle expected value ($S_{Ei}$ or $PCA_i$) is not necessarily in the centre.

$$TEC = \sum_{k=1}^{n} \frac{1}{(1+r)^k} [CC(PCA_i - PCA_{i-1}) + RL \int_{S=-\infty}^{+\infty} \int_{C=-\infty}^{+\infty} \frac{1}{S_{Hi} - S_{Li}} \times \frac{1}{CA_{Hi} - CA_{Li}} \times (S - C) \times H(S - C)dCdS)]$$

where S is used for Sales and C for Capacity.

First the expected under capacity in period i must be found:

$$\int_{S=S_{Li}}^{S_{Hi}} \int_{C=CA_{Li}}^{CA_{Hi}} \frac{1}{S_{Hi} - S_{Li}} \times \frac{1}{CA_{Hi} - CA_{Li}} \times (S - C) \times H(S - C)dCdS$$

$$= \frac{1}{S_{Hi}-S_{Li}} \times \frac{1}{CA_{Hi}-CA_{Li}} \times \int_{S=S_{Li}}^{S_{Hi}} \int_{C=CA_{Li}}^{CA_{Hi}} (S - C) \times H(S - C)dCdS$$

$$= \frac{1}{\phantom{S}} \times \frac{1}{\phantom{S}} \times \int_{S=S_{Li}}^{S=S_{Hi}} [H(S-CA_{Li}) \times \frac{(S-CA_{Li})^2}{2} - H(S-CA_{Hi}) \times \frac{(S-CA_{Hi})^2}{2}]$$

$$= \frac{1}{S_{Hi}-S_{Li}} \times \frac{1}{CA_{Hi}-CA_{Li}} \times \int_{S=S_{Li}}^{S_{Hi}} \times (H(S-CA_{Li}) \times \frac{(S-CA_{Li})^2}{2} - H(S-CA_{Hi}) \times \frac{(S-CA_{Hi})^2}{2})dS$$

(See appendix no. 8.2)

$$= \frac{1}{(S_{Hi}-S_{Li})(CA_{Hi}-CA_{Li})} \times [H(S_{Hi}-CA_{Li}) \times \frac{(S_{Hi}-CA_{Li})^3}{6} - H(S_{Hi}-CA_{Hi}) \times \frac{(S_{Hi}-CA_{Hi})^3}{6}$$

$$-H(S_{Li}-CA_{Li}) \times \frac{(S_{Li}-CA_{Li})^3}{6} + H(S_{Li}-CA_{Hi}) \times \frac{(S_{Li}-CA_{Hi})^3}{6}]$$

The above expression is the Expected under capacity and will be referred to as $EUC_i$. The cost associated in period i is RL x $EUC_i$ and our objective is to minimise

$$TEC = \sum_{k=1}^{n} \frac{1}{(1 + r)^k} \times [CC \times (PCA_i - PCA_{i-1}) + RL \times EUC_i]$$

To find the optimum $PCA_i$ for all periods, and to minimise TEC one can differentiate the above function for each and every period separately and find optimum values for each and every $PCA_i$. To find optimal $PCA_i$ values, one has to express $S_{Li}$, $S_{Hi}$ and $CA_{Li}$, $CA_{Hi}$ in $EUC_i$ as a function of $PCA_i$ and $S_i$ respectively. This is not easily done analytically because the equations involved are of the fourth power for the above simplest case (uniform distribution).

Furthermore, the problem is not continuous and most probably only discreet amounts of capacities can be introduced at different periods.

Therefore, a computerised system, to be used in a trial and error mode, was developed.

The input to the model is cost of capital, costs of introducing capacity, of under capacity, the parameters for the probabilities and the current capacity, the sales forecast figures and the planned capacity.

The output is the cost associated with any capacity plans, separated to expected cost due to under supply and the investment cost in new capacity. In any one session, the model recalls the lowest cost achievement. For further details on the model refer to appendix no. 8.1.

PARAMETERS TO THE CAPACITY MODEL

The model can be used for estimating the best capacity required for total beer production. However, as this study is concerned about packaging, a certain pack capacity study is of interest as well.

In experimenting with the model one should pre-determine the parameters, and then find the best capacity plan. It depends on the degree of confidence the user has in the parameters, he should play around with the parameters he is not confident about to gain the feeling of the sensitivity of the result to those parameters.

The two most important parameters are the costs involved in introducing a new capacity and of being unable to supply the demand. In addition, cost of capital and the range of possible sales demand and actual capacity influence the results.

A. Cost of introducing a new capacity - the units are in Rands per capacity unit of 1 $H\ell$ per year capacity. Assuming a cost of R120 000 000 for a brewery producing 2 600 000 $h\ell$/year, the cost of introducing the capacity is about R46/($H\ell$ per year capacity) or about R26/($H\ell$ per year capacity) taking into account allowances and tax. This is a gross number representing the average cost per capacity unit of 1 $H\ell$ per year capacity. When considering a single line (see Chapter 6 - "Capital Cost Saving Potential"), the cost due to the introduction of only the line itself is only about R9/($H\ell$ per year capacity) after tax. When trying to determine optimum capacity for a certain pack, a number somewhere in between may be used.

   If it has already been decided to build a brewery of a certain capacity or alternatively, the gross capacity plan is already determined or exists and one is trying to trade off between various packs - a number closer to R9 should be used but the results then obtained are limited in their generality. It is believed that normally a number closer to 26 should be used.

   It has been pointed out that the same model can be used to determine the optimum method of introduction of new capacity within a region, in a situation where the region hasn't enough production capacity and has to import the beer from another region. In this case, the cost of under capacity can be accurately calculated to be the cost of transporting the beer from another region (which is not the case in a real under capacity situation).

B. Cost of inability to supply a certain pack or beer - Here one should differentiate between two basic cases - competitive environment and monopoly situation as is the current case.

In the competitive case any Hℓ's not sold by S.A.B. will most probably be sold by the competitor. This is a leaverage process and may result in further loss of sales of other packs. The marginal profit per Hℓ (changing slightly from brand to brand and pack to pack) is about R22,50/Hℓ (after tax - R12,50). A further loss due to loss of good will and loss in other packs and brands may be estimated in further 60% resulting in a total of R20 for every Hℓ under capacity.

In a non-competitive situation, as S.A.B. is experiencing now, two cases should be considered: out of the two cases, the better case is the one where a shortage of one pack exists but the customer is able to purchase another pack. This will probably result in some loss of total volume sales but certainly not a total loss, say about 40% - R12,50 x 0,4 = R5/Hℓ. In addition, a loss due to "the invitation of a competitor" is estimated to be a further R5 resulting in a total of R10 per Hℓ not supplied.

In the worst case, under capacity in one pack and no spare capacity in the other packs, a loss of R12,50 for sales and a further 50% loss of goodwill and competition risk, results in a loss of R19 per every Hℓ not sold.

C. Ranges for sales and capacity.

Sales: when considering total volumes, a range of the about 5-10% above or below the estimate is reasonable. When considering a certain pack the range should be increased because of the multiple effect of total volume fluctuation and pack share changes, resulting in say 10-15% for stable packs and 15-20% for non-stable packs.

Capacity: while large fluctuations in capacity are highly unlikely and may range up to 1-3%, a down trend due to technical problems and industrial unrest should be taken into account, resulting in a decrease in production capacity (relative to the planned one) of up to say 1-5%. If technical innovation is to be taken into account (such as possibly higher gravity (concentrated beer production), reduction in process time, etc.) the upward range should be increased accordingly.

The above numbers shouldn't be regarded as absolutely true. There are many hidden costs and losses associated with under capacity. There are a number of variables influencing the ranges of sales and capacity. Inflation will probably look different in one years time and many other parameters will change the outer and inner systems. The above numbers should be used as guidelines, and be re-examined every time a new study is undertaken.

MODIFICATION TO THE MODEL

In order to test the model, trial runs were made using actual data and real alternatives of the long term capacity strategy. While doing so, some shortfalls to the model were discovered and some new ways of interpreting it were developed.

The main problem was found to be the cost of introducing new capacity. As it stands in the formulation presented previously the cost is CC x ($PCA_i$ - $PCA_{i-1}$) - when i is the relevant period, PCA is the planned capacity and CC is the cost per every unit capacity. This was not always found to be realistic as the cost does differ from case to case due to economies of scale, tax consideration, etc.. Furthermore, by having a constant CC, the periods cannot be set as quarters (of a year). For example, if a capacity is to be introduced in the last quarter of the year, only 1/4 (roughly) of the yearly capacity has to be introduced in that year but the full expenses occur in that year.

A modification was introduced, such that the cost of the new capacity can be inserted directly, bypassing the original cost calculation.

In addition, the maximum number of periods were increased to 22 (previously 17) thus enabling more than 5 years in a quarterly model.

For computer model and log - see appendix no. 8.4.

USING THE MODEL ON ACTUAL FIGURES

As a test and an example of the use of the model, five runs were made on 5 different N.P. capacity options. The model was a quarterly model, with 22 such periods using PA2 - the option in which the user can insert cost figures separately to each capacity introduction.

The five alternatives are five different N.P. capacity plans that were at one stage or another, considered. In practice in this case a decision was taken without using the model.

Every financial year, starting at F86, was divided into four quarters of which the third is peak period. The five distinct capacity plans differed from each other in that the scheduling of the introduction of new capacities was different.

A financial year start at 1/4, introduction of new capacity is assumed always to occur at the beginning of a period - (month 4, 7, 10 or 1).

The following parameters were used for the experimental runs:

a. Cost of not supplying 1 Hℓ - R40 (quite high);

b. Sale tolerance - 7% up to 10% down on official High sales forecast;

c. Cost of Capital - 4% per quarter (about 16% per year);

d. Costs of new capacity were entered separately for every capacity introduction and can be seen in the computer printouts presented in the appendix no. 8.5.

TABLE 8.1: RESULTS OF 5 EXPERIMENTAL RUNS ON CAPACITY MODEL

The results are summarsied in the following table.
(BR stands for Brewery and PH for Phase. Capacity Units are in Hℓ/week.)

| RUN NO. | NEW CAPACITY INTRODUCTION PLAN | | EXPECTED COST |
|---|---|---|---|
| 1 | Rosslyn (+ 12 000 Hℓ/w)<br>BR 4 PH 1 (+ 77 000 Hℓ/w)<br>BR 4 PH 2 (+ 77 000 Hℓ/w)<br>BR 5 - Isando (+ 77 000 - 47 000) | 10/86<br>4/87<br>10/88<br>10/89 | R310 903 523 |
| 2 | Rosslyn + 12 000 Hℓ/w<br>BR 4 PH 1 + 77 000 Hℓ/w<br>B4 PH 2 + BR 5 - Isando (77 000 + 77 000 - 47 000) | 10/86<br>10/87<br>10/89 | R312 633 398 |
| 3 | Rosslyn + BR 4 PH 1 (12 000 + 77 000 Hℓ/w)<br>BR 4 PH 2 (+ 77 000 Hℓ/w)<br>BR 5 - Isando (+ 77 000 - 47 000 Hℓ/w) | 10/86<br>10/87<br>10/89 | R318 444 067 |
| 4 | Rosslyn (+ 12 000 Hℓ/w)<br>BR 4 PH 1 (+ 77 000 Hℓ/w)<br>BR 4 PH 2 (+ 77 000 Hℓ/w)<br>BR 5 - Isando (+ 77 000 - 47 000 Hℓ/w) | 10/86<br>7/87<br>10/88<br>10/89 | R307 115 799 |
| 5 | Rosslyn (+ 12 000 Hℓ/w)<br>BR 4 PH 1 (+ 77 000 Hℓ/w)<br>BR 4 PH 2 (+ 77 000 Hℓ/w)<br>BR 5 - Isando (+ 77 000 - 47 000 Hℓ/w) | 10/86<br>10/87<br>10/88<br>10/89 | R307 205 209 |

In reality option 4 was chosen for S.A.B.'s Capacity Plan. Although this decision was not based on the results of the model (the model did not exist at that time), the fact that the model indicates the same answer (Run no. 4) is encouraging.

CONCLUSIONS

1) Cost of not meeting demand is finite.

2) If it is finite, there is a point in balancing the cost of introducing new capacity to the cost involved in taking the risk of having under capacity.

3) The model developed, tested and experimented in this chapter can and should be used as an aid in the decision taking process.

4) If successful, the probability distribution function can be modified (the function PEUC is explained in appendix no. 8.3) to present a more realistic probability distribution.

## CHAPTER 9: LOCATION

The packed beer has to be distributed to the various depots according to the demand. One should try to minimise this cost. However this is complicated by the many factors involved, which interact between themselves. For example, one of the issues that has to be considered is the single pack brewery. It is believed that such a configuration will reduce production cost and might reduce required capital investment. On the other hand, transport costs will rise relative to an optimum situation. This is the purpose of the following study - to analyse and determine the optimum location of production under various situations.

To work out the different alternatives, a Linear Programming (L.P.) model was used. It was decided to use an L.P. model rather than a purely transportational one, because of the multi-pack situation (the normal transportation algorithm applies only to one product), because of the flexibility required to check different alternatives and mainly to the fact that the L.P. model already exists at S.A.B. (being used regularly for production planning).

Roughly, the L.P. model optimises (minimal cost) a production plan, taking into account brewing costs, packaging costs, beer transfer costs, transport costs, and handling and holding costs. For the purpose of this study, brewing and packaging costs were set to be zero. So in effect, reducing the L.P. model to transportation optimisation algorithm.

In the L.P. model, a theoretical super line, which can be regarded as the packaging hall, was set up at each factory and different production locations were tested by controlling the type of pack to be produced at each location.

The sales demand is Financial year 83 demand (F83) i.e. April 1982 - March 1983, and the transportation cost parameters are Financial year 82 (F82) costs, converted to F83 cost figures by multiplying all cost parameters by [illegible].

THEORETICAL OPTIMUM - LP RUN 1

In the first run, which should serve as a reference, all parameters were left free. This means: all packaging lines essentially were given unlimited capacity, in other words brewing was not restricted. All packaging lines were able to produce all packs. No pack restriction was imposed on the model. Finally all possible routes between factories and depots were allocated with the corresponding cost per Hℓ. This again is not an actual situation, as in actuality, transport from particular factories is restricted to particular rail depots.

The results of this run are important as they reflect the optimum production location taking into account distribution costs and disregarding all other factors. The year results are summarised in the following table in 1 000 Hℓ's.

TABLE 9.1: Production Plan in 1 000 Hℓ Per Plant Per Pack

| PLANT | ISANDO | ALRODE | CHAMDOR | ROSSLYN | UNITED BR | BLOEM-FONTEIN | TOTAL |
|---|---|---|---|---|---|---|---|
| PACK | | | | | | | |
| 750 | 1 621,4 | 862,5 | 798,1 | 472,1 | 578,1 | 297,4 | |
| 500 NRB | 36,0 | 16,3 | 10,5 | 13,3 | 1,2 | 0 | |
| 450 CAN | 529,6 | 236,4 | 340,2 | 250,7 | 53,5 | 282,4 | |
| 375 PINT | 118,6 | 58,9 | 57,0 | 54,6 | 2,8 | 22,8 | |
| 340 CAN | 457,9 | 131,6 | 44,2 | 98,0 | 20,8 | 80,3 | |
| 340 NRB | 294,8 | 158,4 | 76,5 | 120,6 | 2,6 | 70,9 | |
| 340 RBAMS | 25,6 | 12,0 | 2,8 | 4,5 | 7,5 | 1,5 | |
| 50L CASK | 21,8 | 0 | 0,7 | 2,5 | 0 | 0 | |
| TOTAL | 3 105,7 | 1 476,1 | 1 330,0 | 1 016,3 | 659,8 | 755,4 | 8 343,3 |
| PER CENT | 37,2% | 17,7% | 15,9% | 12,2% | 7,9% | 9,7% | 100,0% |

Total Cost for the Plan - R4 131 950 / year

RESTRICTED TRANSPORT - LP RUN 2

A second run was done with a restricted transport situation, i.e. no transport from Isando, Chamdor and United Breweries to Rail depots such as Bloemfontein, Welkom, Potchefstroom, Pietersburg and Nelspruit.

Again, brewing capacity and type of pack produced at each depot, was unrestricted. The optimal solution yielded an objective value of R4 420 600, increased by R288 650 a year. The production mix, suggested by the above circumstances, is similar to that previously discussed.

TABLE 9.2: Production Plan In 1 000 Hℓ Per Plant Per Pack

| PLANT | ISANDO | ALRODE | CHAMDOR | ROSSLYN | UNITED BR | BLOEM-FONTEIN | TOTAL |
|---|---|---|---|---|---|---|---|
| PACK | | | | | | | |
| 750 | 1 621,4 | 1 009,6 | 650,9 | 472,1 | 578,1 | 297,4 | |
| 500 NRB | 36,0 | 16,3 | 10,5 | 13,3 | 1,2 | 0 | |
| 450 CAN | 529,6 | 353,6 | 223,0 | 250,7 | 53,5 | 282,4 | |
| 375 PINT | 118,6 | 67,3 | 48,5 | 54,6 | 2,8 | 22,8 | |
| 340 CAN | 457,9 | 151,4 | 24,5 | 98,0 | 20,8 | 80,3 | |
| 340 NRB | 294,8 | 176,8 | 58,4 | 120,6 | 2,6 | 70,9 | |
| 340 RBAMS | 25,6 | 12,5 | 2,4 | 4,5 | 0,7 | 1,5 | |
| 50L CASK | 21,8 | 0 | 0,7 | 2,5 | 0 | 0 | |
| TOTAL | 3 105,7 | 1 787,4 | 1 018,8 | 1 016,3 | 659,8 | 755,4 | 8 343,3 |
| PER CENT | 37,2% | 21,4% | 12,2% | 12,2% | 7,9% | 9,1% | 100,0% |

Total Cost for the Plan - R4 420 600 / year

While at all other centres, production remained the same, 3,7% of Chamdor production moved to Alrode. Thus rail depots that were supplied by Chamdor are now being supplied from Alrode instead, at an increased cost of R288 650 a year.

The actual brewing percentage, for each plant, capacity-wise is:

| PLANT | ISANDO | ALRODE | CHAMDOR | ROSSLYN | UNITED BR | BLOEMFONTEIN |
|---|---|---|---|---|---|---|
| PER CENT | 27,5% | 29,1% | 17,6% | 17,5% | 5,7% | 2,7% |

Comparing these numbers with the optimum results in Table 9.2, it is clear that Isando, Alrode, United Breweries and Bloemfontein are in a condition of under capacity, percentage-wise, relative to the optimal solution.

RESTRICTING TOTAL PLANT CAPACITY - LP RUN 3

Running the same model, this time restricting the total capacity at each plant to the current brewing capacity, resulted in the following optimal production plan:

TABLE 9.3A: Production In 1 000 Hℓ Per Plant Per Pack

| PLANT | ISANDO | ALRODE | CHAMDOR | ROSSLYN | UNITED BR | BLOEM-FONTEIN | TOTAL |
|---|---|---|---|---|---|---|---|
| PACK | | | | | | | |
| 750 | 1 582,1 | 1 053,9 | 690,3 | 516,1 | 534,2 | 253,1 | |
| 500 NRB | 30,1 | 16,3 | 16,4 | 14,0 | 0,5 | 0 | |
| 450 CAN | 419,8 | 658,2 | 304,8 | 281,5 | 28,4 | 0 | |
| 375 PINT | 118,9 | 67,3 | 48,5 | 54,6 | 2,8 | 22,8 | |
| 340 CAN | 369,4 | 245,4 | 69,5 | 138,4 | 10,2 | 0 | |
| 340 NRB | 193,8 | 348,4 | 58,4 | 120,6 | 2,6 | 0 | |
| 340 RBAMS | 25,6 | 12,5 | 2,4 | 6,0 | 0,7 | 0 | |
| 50L CASK | 21,8 | 0 | 0,6 | 2,5 | 0 | 0 | |
| TOTAL | 2 761,4 | 2 401,9 | 1 190,9 | 1 133,7 | 579,4 | 276,0 | 8 343,3 |
| PER CENT | 33,1% | 28,8% | 14,3% | 13,6% | 6,9% | 3,3% | 100,0% |

Total Cost for the Plan - R7 521 000 / year

The above production plan cost R7 521 000 per year, an increase of R3 100 400 per year! It also assumes a total production capacity of 10 488 000 Hℓ/year (including Rosslyn) which is 25%! more than required. This excess capacity enabled the allocation of more production to Isando (and United Breweries) than determined by the capacity ratios.

When restricting the total capacity to about 8 748 000 Hℓ/year, the cost rose to R9 697 950 - an increase of R2 179 250 per year.

VERY RESTRICTED PLANT CAPACITY - LP RUN 4

A further restriction of plant capacity, so that the total N.P. capacity was just enough to supply the demand, was examined in LP Run No. 4. The yearly cost increased dramatically to R9 697 950, an increase of about R2 200 000 from LP Run No. 3. More than R1 500 000 of it is due to stock holding costs - storage of beer at pre peak period because of the relatively low capacity, which prevents the plant from producing peak demand. Using the "very restricted capacity" and attempting to operate a single pack brewery led to infeasible solutions.

Because of the high cost of stock holding in the optimal solution and because of the feasibility problems involved in checking different runs, this level of capacity restriction will not be used to compare different alternatives. However, it should be noted that in actuality S.A.B. does experience capacity levels quite close to the demand. The effect of low capacity should be kept in mind. The lower the capacity relative to demand, the higher are the distribution, stock holding and other costs, (for example operating costs) which have not been considered here. The difference between alternatives will also increase respectively.

RESTRICTING PACK PRODUCTION - LP RUN 5

Until this point, only general relations between total capacity, transport and cost were considered. The next step is to vary the location of pack production - restricting some plants to the production of certain packs. The third run will be the reference case - with current brewing capacity, pack production unlimited in each factory, objective function of R7 521 000 per year. The Brewing capacity and transport parameters will not be changed and different production scenarios will be investigated.

BASE CASE: TOTAL N.P. BREWING CAPACITY 10 488 000 Hℓ/YEAR.
TRANSPORT ROUTES - Almost all possible routes allowed.
PACKAGING - All packs can be produced at all plants.
COST - R7 521 000 per year.

The yearly production by plant is summarised in Table 9.3A, the same information is presented in percentage figures within each plant, and as percentage out of total N.P. production Table 9.3C.

TABLE 9.3B: Pack Production Share as Per Cent of Plant Total

| PLANT | ISANDO | ALRODE | CHAMDOR | ROSSLYN | UNITED BR | BLOEM-FONTEIN | TOTAL |
|---|---|---|---|---|---|---|---|
| PACK | | | | | | | |
| 750 | 57,3 | 43,9 | 58,0 | 45,5 | 92,2 | 91,7 | |
| 500 NRB | 1,1 | 0,7 | 1,4 | 1,3 | 0,1 | 0 | |
| 450 CAN | 15,2 | 27,4 | 25,6 | 24,9 | 4.9 | 0 | |
| 375 PINT | 4,3 | 2,8 | 4,1 | 4,8 | 0,5 | 8,3 | |
| 340 CAN | 13,4 | 10,2 | 5,8 | 12,2 | 1,8 | 0 | |
| 340 NRB | 7,0 | 14,5 | 4,9 | 10,6 | 0,4 | 0 | |
| 340 RBAMS | 0,9 | 0,5 | 0,2 | 0,5 | 0,1 | 0 | |
| 50L CASK | 0,8 | 0 | 0 | 0,2 | 0 | 0 | |
| TOTAL | 100,0% | 100,0% | 100,0% | 100,0% | 100,0% | 100,0% | |

Total Cost for the Plan R7 521 000 / year

TABLE 9.3C: Pack Production Share as Per Cent of Total N.P. Production

| PLANT | ISANDO | ALRODE | CHAMDOR | ROSSLYN | UNITED BR | BLOEM-FONTEIN | TOTAL |
|---|---|---|---|---|---|---|---|
| PACK | | | | | | | |
| 750 | 19,0 | 12,6 | 8,3 | 6,2 | 6,4 | 3,0 | |
| 500 NRB | 0,4 | 0,2 | 0,2 | 0,2 | 0 | 0 | |
| 450 CAN | 5,0 | 7,9 | 3,7 | 3.4 | 0,4 | 0 | |
| 375 PINT | 1,4 | 0,8 | 0,6 | 0,7 | 0 | 0,3 | |
| 340 CAN | 4,4 | 3,0 | 0,8 | 1,6 | 0,1 | 0 | |
| 340 NRB | 2,3 | 4,2 | 0,7 | 1,4 | 0 | 0 | |
| 340 RBAMS | 0,3 | 0,1 | 0 | 0,1 | 0 | 0 | |
| 50L CASK | 0,3 | 0 | 0 | 0 | 0 | 0 | |
| TOTAL | 33,1% | 28,8% | 14,3% | 13,6% | 6,9% | 3.3% | 100,0% |

Total Cost for the Plan - R7 521 000 / year

The above is an optimal solution from the transportational point of view. Practically, the distribution of production throughout the different plants cannot exactly match the above capacities plan, as there is no point, for example, in introducing a 340 NRB line at United Breweries to produce 0,4% of the demand. Therefore, on the next L.P. run, pack production was restricted to the places suggested by Tables 9.3B and 9.3C.

The cost increased to R7 793 500 per year, an increase of R272 550 per year. For production distribution (1 000 Hℓ) see Table 9.5A.

TABLE 9.5A: Production in 1 000 Hℓ Per Plant Per Pack

| PLANT | ISANDO | ALRODE | CHAMDOR | ROSSLYN | UNITED BR | BLOEM-FONTEIN | TOTAL |
|---|---|---|---|---|---|---|---|
| PACK | | | | | | | |
| 750 | 1 488 | 1 034 | 784 | 513 | 537 | 276 | |
| 500 NRB | 77 | 0 | 0 | 304 | 0 | 0 | |
| 450 CAN | 400 | 660 | 326 | 59 | 0 | 0 | |
| 375 PINT | 119 | 137 | 0 | 0 | 0 | 0 | |
| 340 CAN | 395 | 278 | 0 | 159 | 0 | 0 | |
| 340 NRB | 222 | 378 | 0 | 123 | 0 | 0 | |
| 340 RBAMS | 47 | 0 | 0 | 0 | 0 | 0 | |
| 50L CASK | 25 | 0 | 0 | 0 | 0 | 0 | |
| TOTAL | 2 774 | 2 487 | 1 110 | 1 159 | 537 | 276 | 8 343 |

Total Cost for the Plan - R7 793 550 / year

TABLE 9.5B: Production In Per Cent Out Of Total N.P. Production, Per Plant Per Pack

| PLANT | ISANDO | ALRODE | CHAMDOR | ROSSLYN | UNITED BR | BLOEM-FONTEIN | TOTAL |
|---|---|---|---|---|---|---|---|
| PACK | | | | | | | |
| 750 | 17,8 | 12,4 | 9,4 | 6,2 | 6,5 | 3,3 | |
| 500 NRB | 0,9 | 0 | 0 | 3,6 | 0 | 0 | |
| 450 CAN | 4,8 | 7,9 | 3,9 | 0,7 | 0 | 0 | |
| 375 PINT | 1,4 | 1,7 | 0 | 0 | 0 | 0 | |
| 340 CAN | 4,7 | 3,3 | 0 | 1,9 | 0 | 0 | |
| 340 NRB | 2,7 | 4,5 | 0 | 1,5 | 0 | 0 | |
| 340 RBAMS | 0,6 | 0 | 0 | 0 | 0 | 0 | |
| 50L CASK | 0,3 | 0 | 0 | 0 | 0 | 0 | |
| TOTAL | 33,2% | 29,8% | 13,3% | 13,9% | 6,5% | 3,3% | 100,0% |

Total Cost for the Plan - R7 793 550 / year

SINGLE PACK PLANTS - LP RUN 6

In the case of single pack breweries, the aim, as was stated previously and as discussed in the relevant chapter is: reduced investment and running cost in a plant that produces only one kind of pack. On the other hand, increased transport cost will be accrued.

The decision of which pack to allocate to which plant was influenced mainly by two factors: the pack distribution suggested in Table 9.5 and by considering the present position of packaging lines at the different factories. It was still necessary to leave some plants as multi-pack production centres as must be the case in practice, to enable flexibility and to reduce risk. The results are summarised in Table 9.6A (1 000 Hℓ) and Table 9.6B (percentage of total N.P. production).

TABLE 9.6A: Production in 1 000 Hℓ Per Plant Per Pack

| PLANT | ISANDO | ALRODE | CHAMDOR | ROSSLYN | UNITED BR | BLOEM-FONTEIN | TOTAL |
|---|---|---|---|---|---|---|---|
| PACK | | | | | | | |
| 750 | 925 | 2 177 | 654 | 0 | 600 | 274 | |
| 500 NRB | 48 | 0 | 29 | 0 | 0 | 0 | |
| 450 CAN | 460 | 0 | 668 | 565 | 0 | 0 | |
| 375 PINT | 254 | 0 | 61 | 0 | 0 | 0 | |
| 340 CAN | 494 | 0 | 160 | 179 | 0 | 0 | |
| 340 NRB | 626 | 0 | 97 | 0 | 0 | 0 | |
| 340 RBAMS | 45 | 0 | 2 | 0 | 0 | 0 | |
| 50L CASK | 24 | 0 | 0 | 0 | 0 | 0 | |
| TOTAL | 2 877 | 2 177 | 1 671 | 744 | 600 | 274 | 8 343 |

Total Cost for the Plan - R8 448 475 / year

OR IN PER CENT

SINGLE PACK PLANTS - LP RUN 6

In the case of single pack breweries, the aim, as was stated previously and as discussed in the relevant chapter is: reduced investment and running cost in a plant that produces only one kind of pack. On the other hand, increased transport cost will be accrued.

The decision of which pack to allocate to which plant was influenced mainly by two factors: the pack distribution suggested in Table 9.5 and by considering the present position of packaging lines at the different factories. It was still necessary to leave some plants as multi-pack production centres as must be the case in practice, to enable flexibility and to reduce risk. The results are summarised in Table 9.6A (1 000 Hℓ) and Table 9.6B (percentage of total N.P. production).

TABLE 9.6A: Production in 1 000 Hℓ Per Plant Per Pack

| PLANT | ISANDO | ALRODE | CHAMDOR | ROSSLYN | UNITED BR | BLOEM-FONTEIN | TOTAL |
|---|---|---|---|---|---|---|---|
| PACK | | | | | | | |
| 750 | 925 | 2 177 | 654 | 0 | 600 | 274 | |
| 500 NRB | 48 | 0 | 29 | 0 | 0 | 0 | |
| 450 CAN | 460 | 0 | 668 | 565 | 0 | 0 | |
| 375 PINT | 254 | 0 | 61 | 0 | 0 | 0 | |
| 340 CAN | 494 | 0 | 160 | 179 | 0 | 0 | |
| 340 NRB | 626 | 0 | 97 | 0 | 0 | 0 | |
| 340 RBAMS | 45 | 0 | 2 | 0 | 0 | 0 | |
| 50L CASK | 24 | 0 | 0 | 0 | 0 | 0 | |
| TOTAL | 2 877 | 2 177 | 1 671 | 744 | 600 | 274 | 8 343 |

Total Cost for the Plan - R8 448 475 / year

OR IN PER CENT

TABLE 9.6B: Production In Per Cent Out of Total N.P. Production, Per Plant Per Pack

| PLANT | ISANDO | ALRODE | CHAMDOR | ROSSLYN | UNITED BR | BLOEM-FONTEIN | TOTAL |
|---|---|---|---|---|---|---|---|
| PACK | | | | | | | |
| 750 | 11,1 | 26,0 | 7,8 | 0 | 7,2 | 3,3 | |
| 500 NRB | 0,6 | 0 | 0,3 | 0 | 0 | 0 | |
| 450 CAN | 5,5 | 0 | 8,0 | 6,8 | 0 | 0 | |
| 375 PINT | 3,1 | 0 | 0,7 | 0 | 0 | 0 | |
| 340 CAN | 5,9 | 0 | 1,9 | 2,1 | 0 | 0 | |
| 340 NRB | 7,5 | 0 | 1,2 | 0 | 0 | 0 | |
| 340 RBAMS | 0,5 | 0 | 0 | 0 | 0 | 0 | |
| 5L CASK | 0,3 | 0 | 0 | 0 | 0 | 0 | |
| TOTAL | 34,5% | 26,1% | 20,0% | 8,9% | 7,2% | 3,3% | 100,0% |

Total Cost for the Plan - R8 448 475 / year

The cost has increased to R8 448 475 per year, which is an increase of R654 350 per year over and above the situation suggested in Tables 9.5A and 9.5B.

BLOEMFONTEIN - LP RUN 7

As was indicated earlier (Table 9.2), Bloemfontein capacity and thus pack production is far less than required according to the optimum solution suggested by the L.P. model. Because Bloemfontein is remote and the transport costs to Bloemfontein are much higher than all other transport costs within the region, it has been postulated that a large portion of the increased transport cost in later runs is due to Bloemfontein. (This postulation was based very much on the reports generated by the L.P., which are not attached because of their weight.) Leaving all other parameters as they were in run 6, but releasing the restrictions on Bloemfontein, that is no capacity restriction and no pack restriction, resulted in the following yearly production plan.

TABLE [illegible] Production Plan in 1 000 Hℓ Per Plant Per Pack

| PLANT | ISANDO | ALRODE | CHAMDOR | ROSSLYN | UNITED BR | BLOEMFONTEIN | TOTAL |
|---|---|---|---|---|---|---|---|
| PACK | | | | | | | |
| 750 | 974,7 | 2 100,2 | 657,3 | 0 | 600,0 | 297,4 | |
| 500 NRB | 54,5 | 0 | 22,9 | 0 | 0 | 0 | |
| 450 CAN | 483,3 | 0 | 503,1 | 424,1 | 0 | [illegible]82,4 | |
| 375 PINT | 231,1 | 0 | 60,9 | 0 | 0 | 22,8 | |
| 340 CAN | 483,9 | 0 | 125,6 | 143,1 | 0 | 80,3 | |
| 340 NRB | 555,6 | 0 | 97,2 | 0 | 0 | 70,9 | |
| 340 RBAMS | 43,3 | 0 | 2,4 | 0 | 0 | 1,5 | |
| 50L CASK | 24,2 | 0 | 0,6 | 0 | 0 | 0 | |
| TOTAL | 2 850,6 | 2 100,2 | 1 470,0 | 567,2 | 600,0 | 755,3 | 8 343,3 |

Total Cost of the Plan - R5 035 620 / year

The same information, is presented as a per cent out of total regional production, per pack, per plant - in Table 9.7B.

TABLE 9.7B: Pack Production Share As Per Cent Of Total N.P. Production

| PLANT | ISANDO | ALRODE | CHAMDOR | ROSSLYN | UNITED BR | BLOEM-FONTEIN | TOTAL |
|---|---|---|---|---|---|---|---|
| PACK | | | | | | | |
| 750 | 11,7 | 25,2 | 7,9 | 0 | 7,2 | 3,6 | |
| 500 NRB | 0,7 | 0 | 0,3 | 0 | 0 | 0 | |
| 450 CAN | 5,8 | 0 | 6,0 | 5,0 | 0 | 3,4 | |
| 375 PINT | 2,8 | 0 | 0,7 | 0 | 0 | 0,3 | |
| 340 CAN | 5,8 | 0 | 1,5 | 1,7 | 0 | 0,9 | |
| 340 NRB | 6,7 | 0 | 1,2 | 0 | 0 | 0,8 | |
| 340 RBAMS | 0,5 | 0 | 0 | 0 | 0 | 0 | |
| 50L CASK | 0,3 | 0 | 0 | 0 | 0 | 0 | |
| TOTAL | 34,3% | 25,2% | 17,6% | 6,7% | 7,2% | 9,0% | 100,0% |

Total Cost of the Plan - R5 035 620 / year

The above shows that, from a transportation point of view, there are good reasons to increase Bloemfontein's capacity.

RELEASING PACK PRODUCTION TO CURRENT SITUATION - LP RUN 8

In this run, the current pack production configuration was set, excluding Bloemfontein which was left with an unlimited capacity in all packs. The cost of the plan was R4 590 900, a drop of R444 720 from the single pack option. This means that, excluding the Bloemfontein region, the cost of changing to a single pack plant in two out of the 5 plants, is about R0,5 m a year. The production plan is shown in the following tables:

TABLE 9.8A: Production Plan in 1 000 Hℓ Per Plant Per Pack

| PLANT | ISANDO | ALRODE | CHAMDOR | ROSSLYN | UNITED BR | BLOEM-FONTEIN | TOTAL |
|---|---|---|---|---|---|---|---|
| PACK | | | | | | | |
| 750 | 1 307,4 | 1 323,7 | 650,9 | 512,9 | 537,3 | 297,4 | |
| 500 NRB | 77,3 | 0 | 0 | 0 | 0 | 0 | |
| 450 CAN | 369,2 | 471,7 | 263,7 | 305,9 | 0 | 283,4 | |
| 375 PINT | 232,0 | 0 | 60,0 | 0 | 0 | 22,8 | |
| 340 CAN | 319,9 | 267,6 | 46,3 | 118,8 | 0 | 80,3 | |
| 340 NRB | 439,2 | 0 | 90,5 | 123,1 | 0 | 70,9 | |
| 340 RBAMS | 38,8 | 0 | 2,4 | 4,5 | 0 | 1,5 | |
| 50L CASK | 24,9 | 0 | 0 | 0 | 0 | 0 | |
| TOTAL | 2 808,7 | 2 063,0 | 1 113,7 | 1 065,2 | 537,3 | 755,4 | 8 343,3 |

Total Cost for the Plan - R4 590 900 / year

The same information is presented as a per cent out of total regional production, per pack, per plant in Table 9.8B.

TABLE 9.8B: Pack Production Share as Per Cent of Plant Total

| PLANT | ISANDO | ALRODE | CHAMDOR | ROSSLYN | UNITED BR | BLOEMFONTEIN | TOTAL |
|---|---|---|---|---|---|---|---|
| PACK | | | | | | | |
| 750 | 15,7 | 15,9 | 7,8 | 6,1 | 6,4 | 3,6 | |
| 500 NRB | 0,9 | 0 | 0 | 0 | 0 | 0 | |
| 450 CAN | 4,4 | 5,6 | 3,2 | 3,7 | 0 | 3,4 | |
| 375 PINT | 2,8 | 0 | 0,7 | 0 | 0 | 0,3 | |
| 340 CAN | 3,8 | 3,2 | 0,6 | 1,4 | 0 | 1,0 | |
| 340 NRB | 5,3 | 0 | 1,0 | 1,5 | 0 | 0,8 | |
| 340 RBAMS | 0,5 | 0 | 0 | 0 | 0 | 0 | |
| 50L CASK | 0,3 | 0 | 0 | 0 | 0 | 0 | |
| TOTAL | 33,7% | 24,7% | 13,3% | 12,8% | 6,4% | 9,1% | 100,0% |

Total Cost for the Plan - R4 590 900 / year

OPTIMUM PACK CONFIGURATION - LP RUN 9

Finally, an unrestricted pack production configuration was run - total production per plant was restricted, excluding Bloemfontein, to represent roughly current brewing capacity.

The cost of the plan is reduced from R4 590 900 to R4 474 500 - a drop of about R116 000 per year.

The production plan is shown in the following tables.

TABLE 9.9A: Production Plan in 1 000 Hℓ Per Plant Per Pack

| PLANT | ISANDO | ALRODE | CHAMDOR | ROSSLYN | UNITED BR | BLOEM-FONTEIN | TOTAL |
|---|---|---|---|---|---|---|---|
| PACK | | | | | | | |
| 750 | 1 577,1 | 1 053,9 | 650,9 | 516,1 | 534,2 | 297,4 | |
| 500 NRB | 31,8 | 0 | 10,5 | 14,0 | 0,5 | 0 | |
| 450 CAN | 419,3 | 20,5 | 264,7 | 275,8 | 28,4 | 282,4 | |
| 375 PINT | 118,9 | 421,7 | 48,5 | 54,6 | 2,8 | 22,8 | |
| 340 CAN | 372,7 | 67,3 | 38,6 | 108,7 | 10,2 | 80,3 | |
| 340 NRB | 193,8 | 222,5 | 58,4 | 120,6 | 2,6 | 70,9 | |
| 340 RBAMS | 25,6 | 277,4 | 2,4 | 4,5 | 0,8 | 1,5 | |
| 50L CASK | 21,8 | 12,5 | 0,7 | 2,5 | 0 | 0 | |
| TOTAL | 2 761,5 | 2 075,8 | 1 074,7 | 1 096,7 | 579,4 | 755,4 | 8 343,3 |

Total Cost for the Plan - R4 474 558 / year

The same information is presented as per t of total N.P. production in Table 9.9B.

TABLE 9.9B: Pack Production Share as Per Cent Of Total N.P. Production

| PLANT | ISANDO | ALRODE | CHAMDOR | ROSSLYN | UNITED BR | BLOEM-FONTEIN | TOTAL |
|---|---|---|---|---|---|---|---|
| PACK | | | | | | | |
| 750 | 18,9 | 12,63 | 7,8 | 6,2 | 6,4 | 3,6 | |
| 500 NRB | 0,4 | 0 | 0,1 | 0,2 | 0 | 0 | |
| 450 CAN | 5,0 | 0,3 | 3,2 | 3,3 | 0,4 | 3,4 | |
| 375 PINT | 1,4 | 5,0 | 0,6 | 0,6 | 0 | 0,3 | |
| 750 CAN | 4,5 | 0,8 | 0,5 | 1,3 | 0,1 | 1,0 | |
| 340 NRB | 2,3 | 2,7 | 0,7 | 1,4 | 0 | 0,9 | |
| 340 RBAMS | 0,3 | 3,3 | 0 | 0 | 0 | 0 | |
| 50L CASK | 0,3 | 0,2 | 0 | | 0 | 0 | |
| TOTAL | 33,0% | 24,9% | 12,9% | [illegible],1% | 6,9% | 9,2% | 100,0% |

Total Cost for the Plan - R4 474 558 / year

SUMMARY OF NUMERIC RESULTS

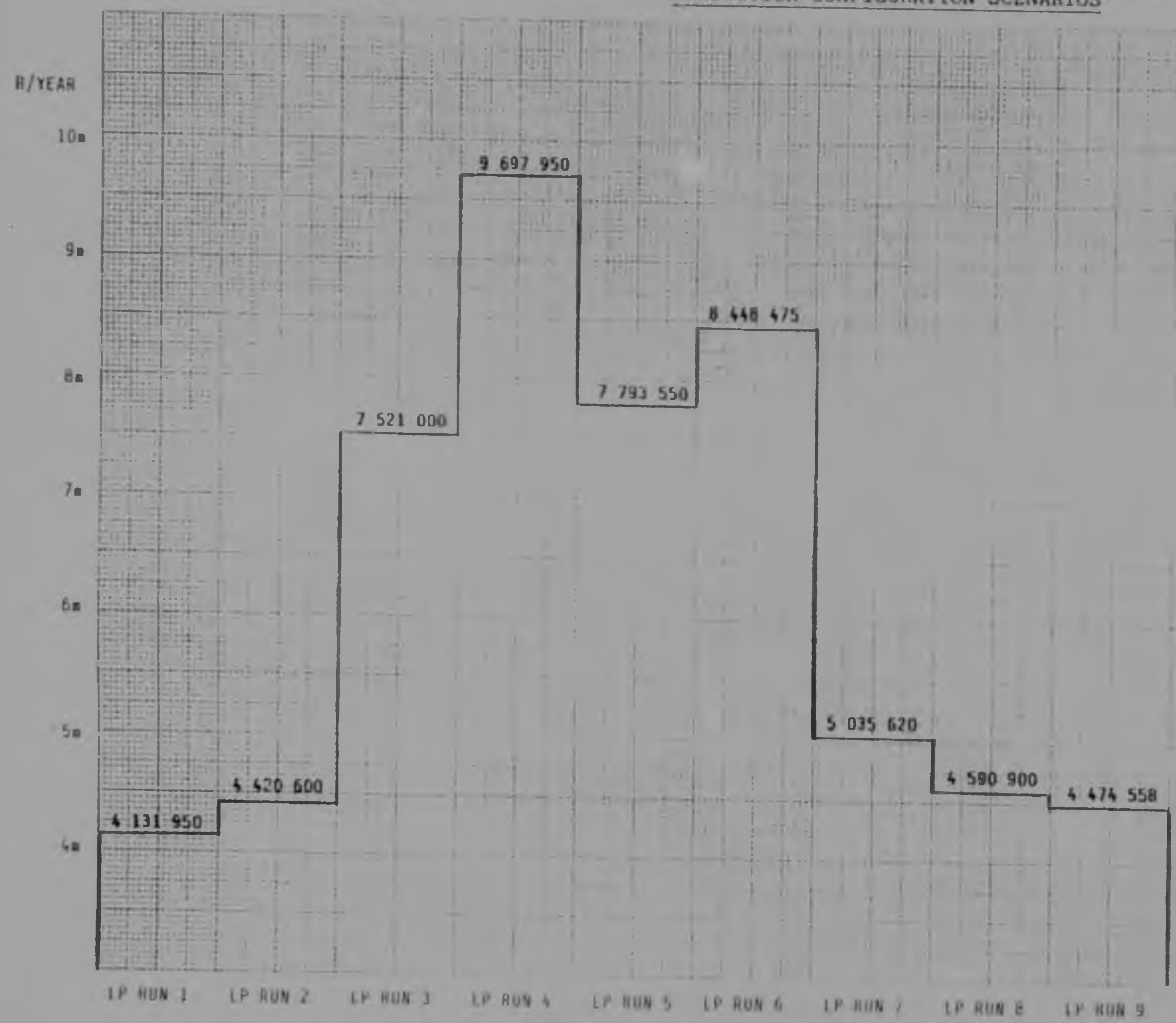
In total, 9 different LP models were run and to obtain an overview of the results, the 9 different scenarios and their costs are presented diagramatically.

In order to compare the transport costs with all other costs in this study, the present value of a series of the expenses is calculated. Assuming a depreciation factor of 3% results in a factor of 33,3($\frac{1}{0,03}$ =33) for an infinite series or a factor of 12,2($\frac{1-0,97^{15}}{1-0,97}$ =12,2) for a series of 15 annual equal payments. Doing the calculation this way assumes that: cost of capital is 16%, inflation 12% and that distribution cost increases will be roughly 1% above inflation. It further assumes that the volume of distribution will remain constant. Although this is not the case as sales should (hopefully) increase in the future, the distribution costs incurred by a certain pack production configuration would remain roughly constant while further demand would be supplied by a new capacity that would be introduced at a later stage.

The distribution cost and present values for the different options (LP runs) with the description of each option are presented in Table 9.10.

FIGURE 9.1: SUMMARY OF COSTS OF DISTRIBUTION UNDER DIFFERENT PRODUCTION CONFIGURATION SCENARIOS

SALES:- 8 343 300 Hℓ/YEAR




LP RUN 1 - Theoretical optimum. No restrictions.

LP RUN 2 - Restricting transport.

LP RUN 3 - Limited capacity in each plant. Total capacity about 10 500 000 Hℓ/year.

LP RUN 4 - Further restricting total production capacity to 8 750 000 Hℓ/year.

LP RUN 5 - More "reasonable" pack production configuration. Total capacity about 10 500 000 Hℓ/year.

LP RUN 6 - Single pack plants.

LP RUN 7 - Releasing Bloemfontein.

LP RUN 8 - Current pack production configuration. Bloemfontein not restricted.

LP RUN 9 - Free production configuration. Capacity still limited except Bloemfontein.

TABLE 9.10: Summary of Numeric Results and Costs of Distribution Under Different Production Configuration Scenarios (Costs are in thousands and rounded off to the nearest thousand)

| LP RUN NO. | DESCRIPTION | COST R/YEAR | 15 YEARS P.V. | INFINITE SERIES P.V. |
|---|---|---|---|---|
| 1 | THEORETICAL OPTIMUM<br>Theoretical optimum - all parameters were left unrestricted and unlimited. | 4 132 | 50 410 | 137 731 |
| 2 | RESTRICTED TRANSPORT<br>The same as 1. but minor transport routes were restricted. | 4 421 | 53 931 | 147 353 |
| 3 | RESTRICTING TOTAL PLANT CAPACITY<br>The same as 2. but total N.P. production capacity was restricted to about 10 500 000 Hℓ/yr | 7 521 | 91 756 | 250 699 |
| 4 | VERY RESTRICTED PLANT CAPACITY<br>The same as 3. but total N.P. production capacity was further restricted to 8 750 000 Hℓ/yr. | 9 698 | 118 314 | 323 264 |
| 5 | RESTRICTING PACK PRODUCTION<br>Total N.P. Production again restricted to ± 10 500 00 Hℓ/year + limiting the production of some packs to specific plants. | 7 794 | 95 081 | 259 704 |
| 6 | SINGLE PACK BREWERIES<br>The same as 5. but 2 more breweries were restricted to producing single packs. | 8 448 | 103 071 | 201 615 |

TABLE 9.10: Continued

| LP RUN NO. | DESCRIPTION | COST R/YEAR | 15 YEARS P.V. | INFINITE SERIES P.V. |
|---|---|---|---|---|
| 7 | RELEASING BLOEMFONTEIN<br><br>The same as 6. but Bloemfontein capacity was unlimited and all packs could be produced there. | 5 036 | 61 435 | 167 853 |
| 8 | CURRENT PACK PRODUCTION<br><br>The same as 7 with current pack production configuration. | 4 590 | 56 009 | 153 029 |
| 9 | OPTIMUM PACK CONFIGURATION<br><br>N.P. capacity restricted to about 10 000 000 Hℓ/yr (as in 5, 6, 7 and 8) Bloemfontein unlimited (as in 8.). All plants able to produce all packs. | 4 475 | 54 590 | 149 152 |

There may be few ways to interpret the results. One has to decide whether to use the 15 years Present Value or the infinite series Present Value. Furthermore, one can divide the cost figures by the total yearly production (8 343 300 Hℓ) to obtain cost per Hℓ, again either by using the 15 years Present Value or infinite series.

Whatever figures are used, the difference between the 4 different options should be kept in mind. Especially when comparing figures (as will be done for example when dealing with the single pack brewery option). One has to make sure he is comparing potatoes with potatoes and not with telephones.

This introduces a problem as, in the whole study, cost figures are calculated per Hℓ and the interpretation of transport cost per Hℓ is not obvious, because averages and continuity cannot normally be assumed.

The above argument indicates the need of a separate location study for each and every new packaging capacity that is planned. However, for the purpose of this study, (as it tends to be a very macro one) averages and continuity will be assumed, thus indicating general trends - should we or shouldn't we try to design single pack breweries, for example.

In analysing the results (see Table 9.10), it is apparent that the most significant single factor is Bloemfontein production capacity (see LP run 6 and 7). Increasing packaging capacity at Bloemfontein from the current capacity of about 200 000 Hℓ per year to more than 800 000 Hℓ per year will reduce transport (and holding) cost of all packs by more than R3 500 000 per year. The real numbers are even higher, probably something like 4 000 000, because in LP run 6 Bloemfontein was "allowed" to produce 274 000 Hℓ per year which it cannot in real life. Using R3 500 000 per year, the present value of a 15 year annuity is 12,2 x 3 500 000 = R42 700 000. Dividing this by 481 300 (755 300 - 274 000, the difference between Bloemfontein packaging capacity in LP run 6 and 7) results in 3 500 000 : 481 300 = 7,27 R/(Hℓ per year) in Bloemfontein before tax or about R3,9/(Hℓ per year) capacity in Bloemfontein after tax. This is a relatively high figure compared with the cost of capacity (see Chapter 7 - "Cost of Capacity" for detailed calculations) of about R9/(Hℓ per year) capacity. (Note however Chapter 7 - "Cost of Capacity" deals only with packaging capacity and ignores brewing cellar utilities, etc..) It suggests that the introduction of new capacity in Bloemfontein is cost effective if, by so doing, some other production capacity could be prevented or delayed in N.P.. It is further suggested that a study, concentrating on the Bloemfontein question, should be initiated.

The difference between LP runs 3, 5 and 6 for current Bloemfontein capacity and LP runs 7, 8 and 9 for unrestricted Bloemfontein production, represents the effect of pack configuration. It can be seen (Table 9.10) that movement from the optimal case (LP run 3) to the single pack breweries (LP run 6) introduces an additional transportation cost of R11 315 000 (103 071 000 - 91 756 000) in P.V. terms (15 years time span). Under the unrestricted Bloemfontein scenario (LP runs 7 and 9), a single pack brewery option introduces an additional transportation cost of R6 845 000 (61 435 000 - 54 590 000) again in P.V. terms (15 years time span). This figure is smaller than the previous one. This should be expected becasue the less restricted the situation is, the more opportunity the model has to compensate for the restrictions imposed by moving to single pack plants.

By not moving to single pack plants, S.A.B. therefore gains about R10 000 000 in present value terms before tax or about R5 000 000 after after tax. These cost figures will be compared at a later stage to an estimate of gains if S.A.B. moves towards single pack plants.

Dividing these figures by the total production volume used in the LP runs (8 343 300 Hℓ) results in a cost of about R1,4/Hℓ and R0,82/Hℓ for the restricted and unrestricted Bloemfontein scenarios, respectively.

The above figures represent the gain or loss relative to theoretical optimal location. Because of practical limitation, the production location of all packs will never be optimal (from the transport point of view). This means the cost incurred by moving to a single pack plant is only about R8 000 000 for the restricted Bloemfontein scenario (LP runs 5 and 6) and about R2 500 000 for the unrestricted Bloemfontein case, or about R0,96/Hℓ and R0,3/Hℓ, respectively, when determining the cost in Rands per Hℓ.

## CONCLUSIONS

1) Bloemfontein restricted capacity has a major effect on transport costs in the order of about R42 000 000 P.V. terms before tax.

2) The question of introducing additional packaging capacity at Bloemfontein should be separately studied.

3) The cost of the move from theoretical optimum (LP run 1) to the restricted pack production situation (LP run 5) is large (about R45 000 000), but most of it is due to the Bloemfontein problem.

4) A single pack plant policy will introduce additional transport costs in the order of about R10 000 000 in P.V. terms before tax, or about 1,2 R/Hℓ if a cost per Hℓ is to be used based on the difference between a single pack plant option to the theoretical optimal location case.

5) If S.A.B. moves from its current policy (which is not optimal locationwise due to practical constraints) to a single pack plant policy, an increase in transportation cost is to be expected in the order of R0,96/Hℓ or R0,3/Hℓ depending on Bloemfontein capacity.

## CHAPTER 10: EFFICIENCY

S.A.B. calculates the efficiency of its production lines by comparing the actual output to the packaging line output, assuming the filler had been running continuously. It is believed that this approach leads S.A.B. to poor performance and an alternative method will be suggested and presented.

This topic is closely related to the Production Line Profile issue presented in Chapter 11, where by using the same kind of arguments, a different method of designing production lines has been suggested.

At present there are two types of efficiency calculations used in S.A.B. i.e. machine efficiency and factory efficiency. In both, the actual output $\emptyset$ Hℓ is divided by a theoretical output which could be achieved had the filler been run continuously for t hours. For factory efficiency t is taken to be the total shift time (say $t_1$) and for machine efficiency t is calculated to be $t_1$ minus allowed stops such as QC checks, lunch, brand or pack changes, start up and shut down. Thus $t_2 = t_1$ - allowed stops. Let the filler rating be R (in Hℓ/Hr). The efficiency E is therefore calculated to be:

I Factory efficiency $E_1 = \frac{\emptyset}{t_1 \times R}$ (x 100 to convert it to percentage)

II Machine efficiency $E_2 = \frac{\emptyset}{t_2 \times R}$ (x 100 to convert it to percentage)

as $t_2 < t_1$, $E_2$ must be > than $E_1$.

The above method is used as a measure of performance to monitor how efficiently S.A.B. production lines are run. It is based on the output of the filler as the critical component of the production line. All other machinery in the production line is designed to serve the filler in such a way as to allow the filler continuous operation.

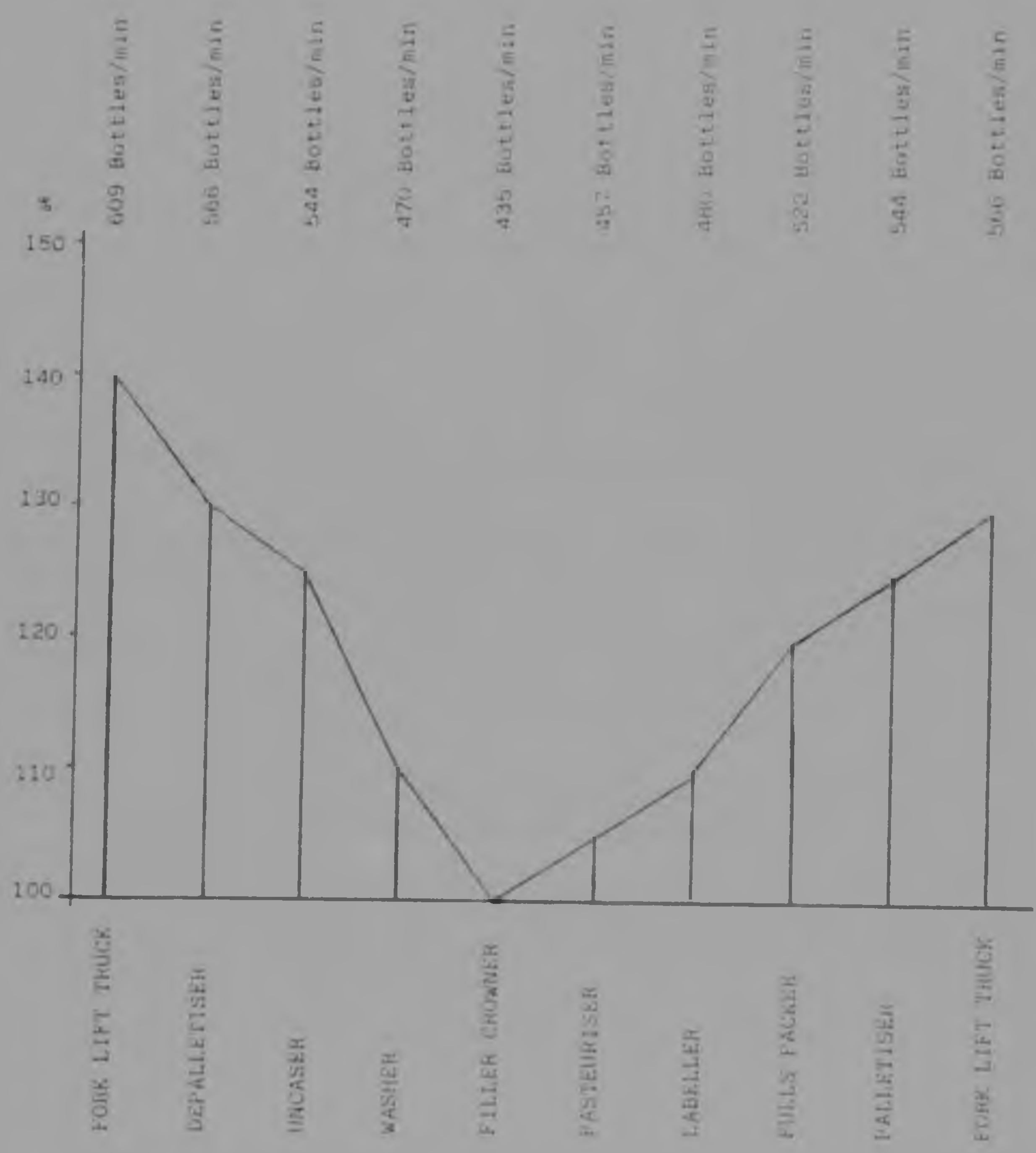
Once the production line has been built, the present method of measuring efficiency at S.A.B., is a suitable measure of performance. Because E = 100 actually represents the maximum output that can be extracted from a line as a whole, it represents full utilisation of the filler which is designed to be the slowest component of the production line.

However, the efficiencies as calculated give S.A [illegible] indication of how well it is using its resources.

Consider a typical production line profile. For simplicity only the main components will be considered i.e. fork lift truck, depalletiser, uncaser, washer, filler and crowner, pasteuriser, labeller, fulls packer, palletiser and another fork lift truck. The production rate of each component varies in such a way that the production rate up stream and down stream from the filler is gradually increased (V shape).

In the following diagram the profile of line 6 at Isando (producing 750 QDC) is presented.

FIGURE 10.1: PROFILE OF BOTTLING LINE 6 - ISANDO



The basic definition of efficiency is the ratio between output and input. The goal of S.A.B. should be (in this context) to extract more and more out of less and less. To produce as much beer as possible (not exceeding quality limits) with as little as possible input of resources.

The efficiency $E = \frac{\emptyset}{t \times R}$ takes no account of the fact that some of the machines have higher capacity than the others. Say line 6 will run at 100% efficiency, it means that the filler is running at its fullest capacity (100%), but the uncaser which can (if not limited by the filler) produce at a relative rate of 125% is being used only 100% - a utilisation of $\frac{100}{125}$ = 0,8.

Let $n$ be number of machines in a production line.
Let $R_i$ be the production rating of machines i (Hℓ/Hr).
Let $\emptyset$ and $t$ denote as the output previously achieved in a time t.

Thus an expression for the efficiency, that will take into account all machines in the production line, is:

$$\text{III} \quad E = \frac{N \times \emptyset}{t \times \sum_{i=1}^{N} R_i} \times 100$$

This expression will result in 100% efficiency only if all machines are 100% utilised.

Because it is illogical to disregard costs of machinery (one should be much more concerned about an expensive machine idling than about a cheap one) the cost of different machinery in the production line has to be introduced:

Let $C_i$ be the cost of machine i.

Now an appropriate measure of performance will be:

$$\text{IV} \quad E = \frac{\emptyset \times \sum_{i=1}^{N} C_i}{t \times \sum_{i=1}^{N} C_i R_i} \times 100$$

In this expression, again only when all machines are fully utilised will E be 100%. If the rating of one (or more) of the machines is higher than the minimum required to achieve output Ø in time t - the efficiency E will drop. The higher the cost of that machine, the bigger the drop in the efficiency E will be.

Thus, when designing a production line, the Ø, the required output, is normally known and the design should be concerned with choosing such machines and components as to maximise the efficiency.

$$\text{IV} \quad E = \frac{\emptyset \times \sum_{i=1}^{N} C_i}{t \times \sum_{i=1}^{N} C_i R_i} \times 100$$

Expression IV takes into account costs (C) and rates (R) of the machines. The cost of a machine should include purchasing cost and operating cost. The operating cost should take into account maintenance, engineering costs, labour required and all other costs that, S.A.B. incurs by using that machine.

## CONCLUSIONS

1) The efficiency, as calculated now by S.A.B., is not a valid measure for designing and engineering purposes.

2) Efficiency should measure the ratio between output and input.

3) Efficiency therefore must take into account all components in a production line (not only the filler) and weigh them according tc their costs which is a measure of the input involved.

4) Expression IV for efficiency:

$$E = \frac{\varnothing \times \sum_{i=1}^{N} C_i}{t \times \sum_{i=1}^{N} C_i R_i} \times 100$$

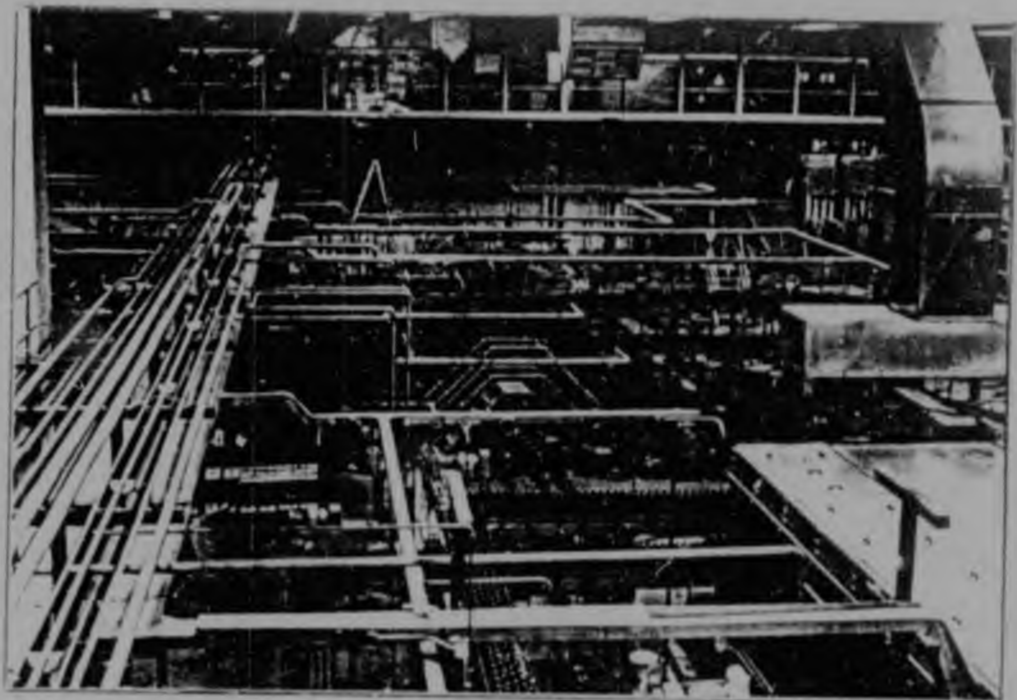
($\varnothing$ for output, $C_i$ - cost of machine i, $R_i$ - rate of machine i and t - time) is suggested as an efficiency measure.

5) A production line profile, as is currently used in S.A.B., tends to decrease the efficiency, as defined in expression 4, below that which has been calculated in the conventional way.

## CHAPTER 11: PRODUCTION LINE PROFILE

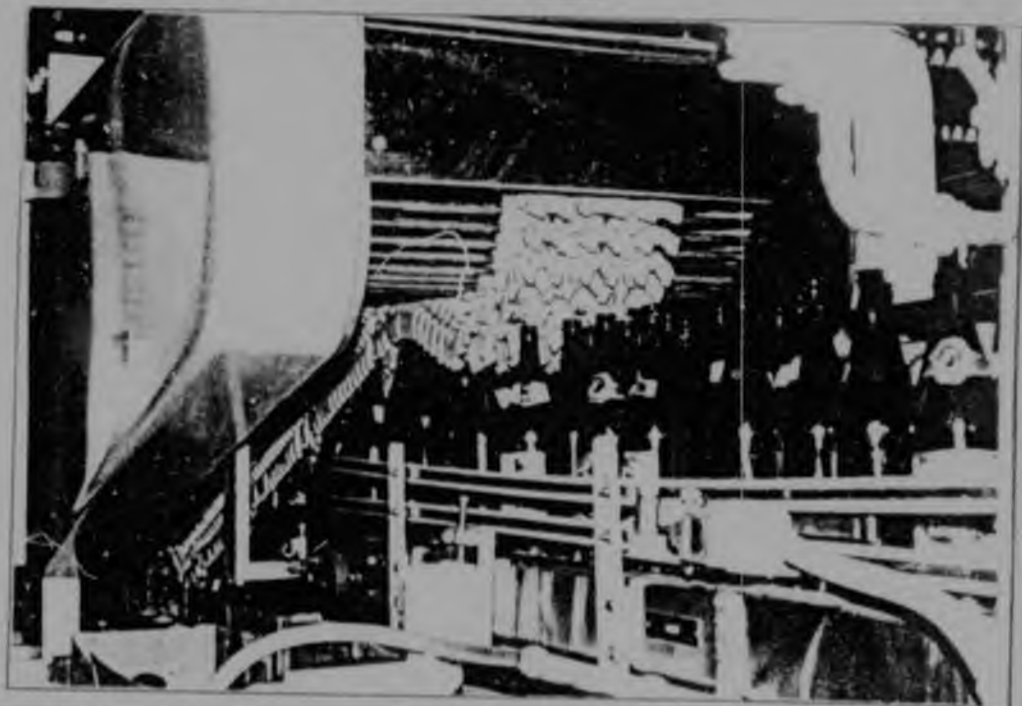
Line profile is the profile of the relative machine ratings within a production line. S.A.B. packaging lines have a V profile which means that the filler has a certain rating and the machines upstream and downstream from the filler have increasingly higher ratings. The main argument against the above is that this approach doesn't necessarily optimise the situation. A different approach to that currently used in S.A.B., which leads to a possibly different line profile, will be presented.

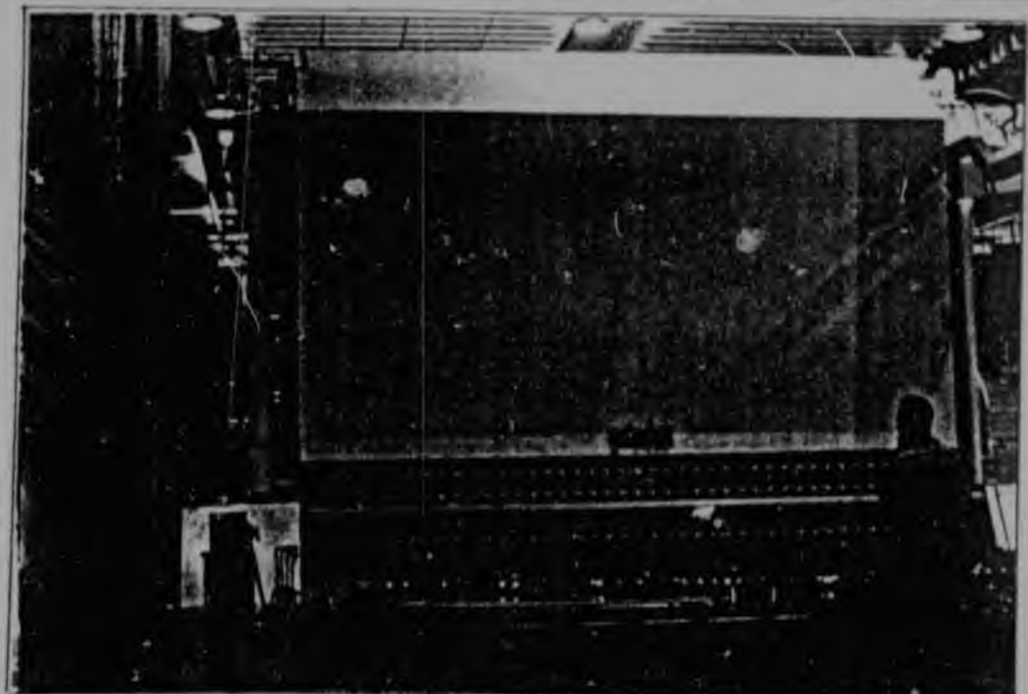
As it stands now, the principal component of the packaging line is the filler. The line rating is considered to be the filler rating. Performance of the line is thus measured relative to the filler parameters. The filler is considered to be the most important component of the line mainly because the filler actually performs the basic task of filling bottles with beer. The production line profile is set up in such a way that up and down stream from the filler all machines will be fast enough to let the filler run continuously. This leads to the V shape, presented diagramatically.



(1) General View of Packaging Hall

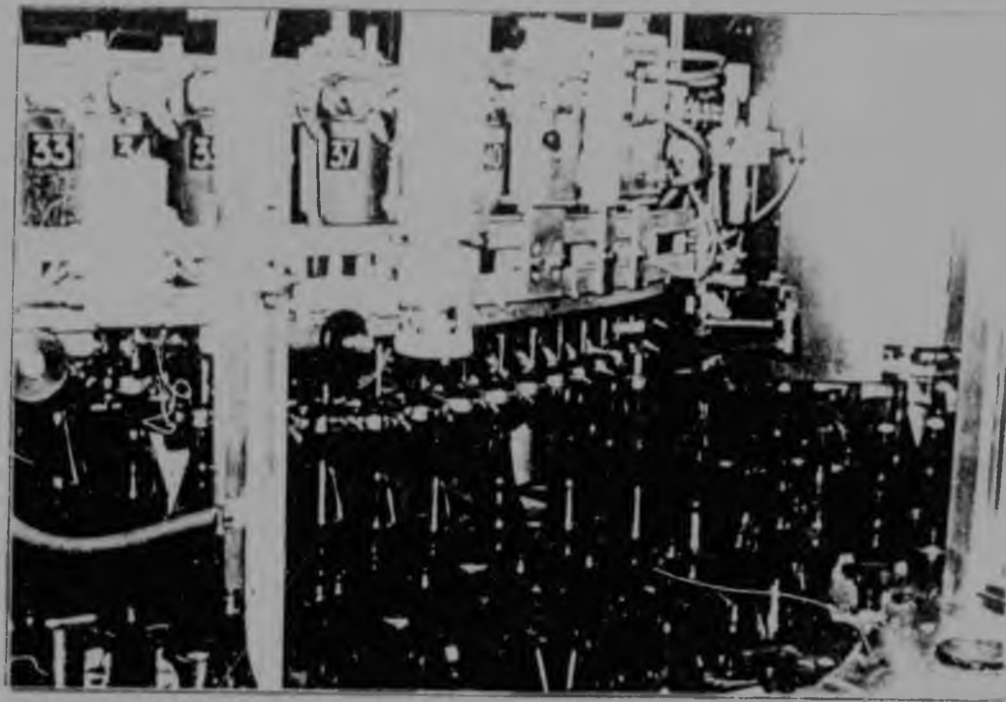
(2) 750 mℓ RB - Uncaser



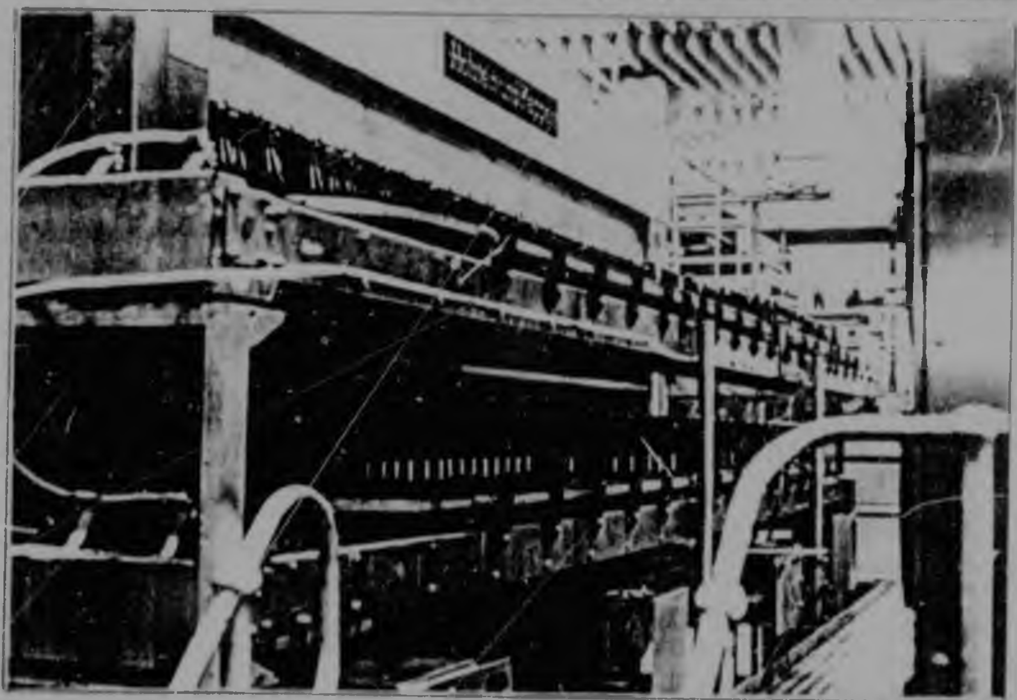


(3) 750 mℓ RB - Washer

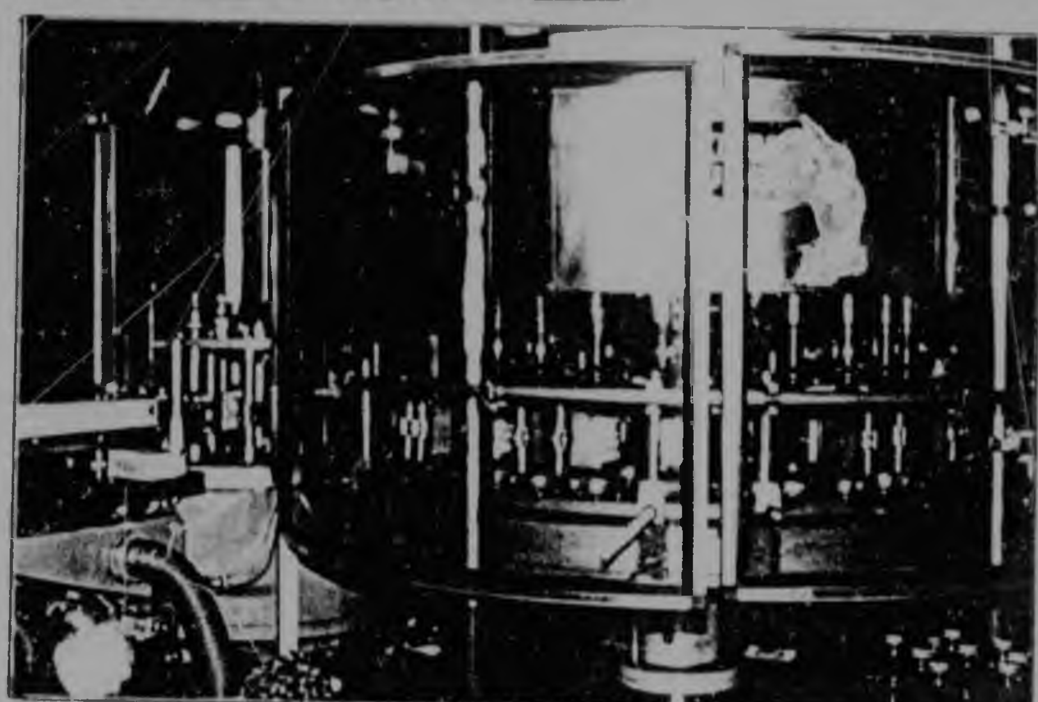
4 750 mℓ RB -
Bottle Filler

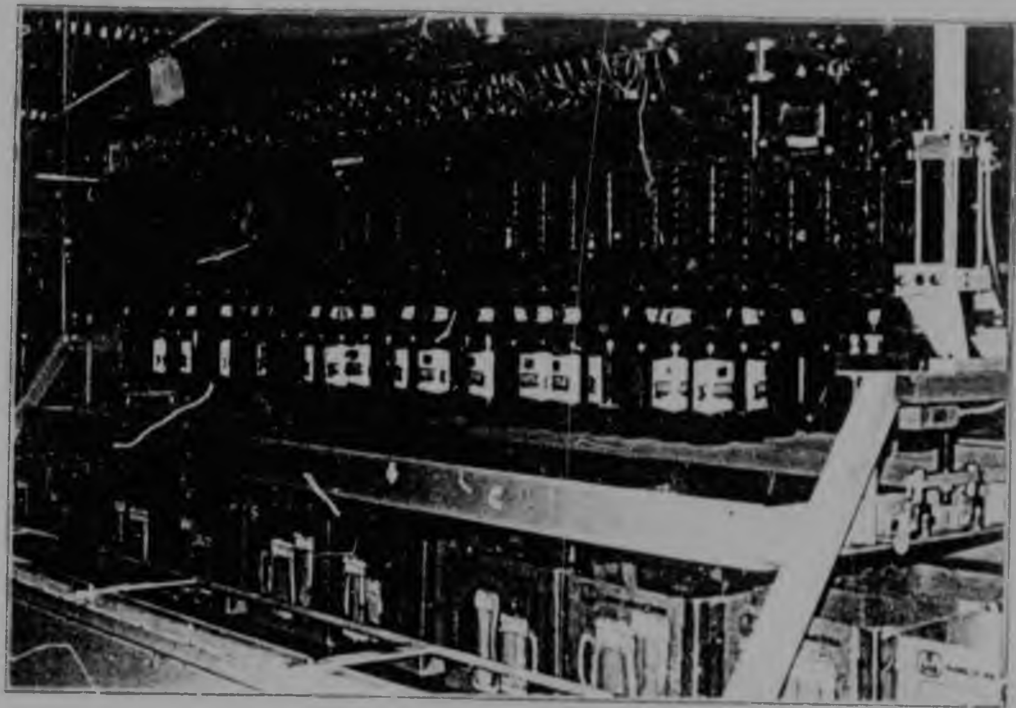


5 750 mℓ RB -
Double Deck
Pasteuriser



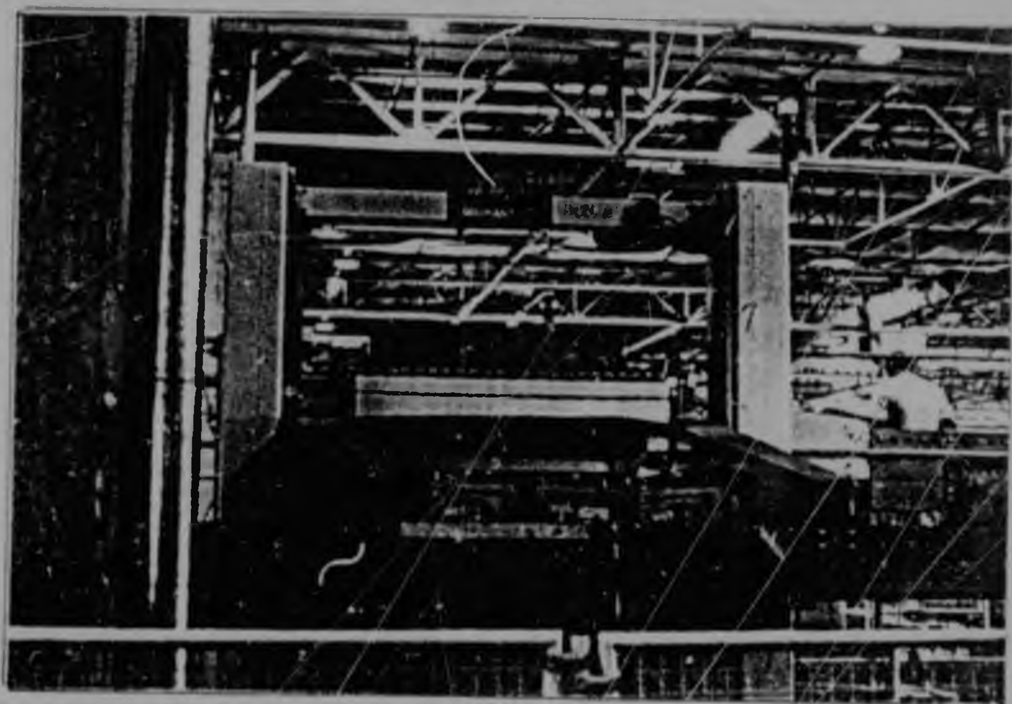
6 750 mℓ RB -
Labeller

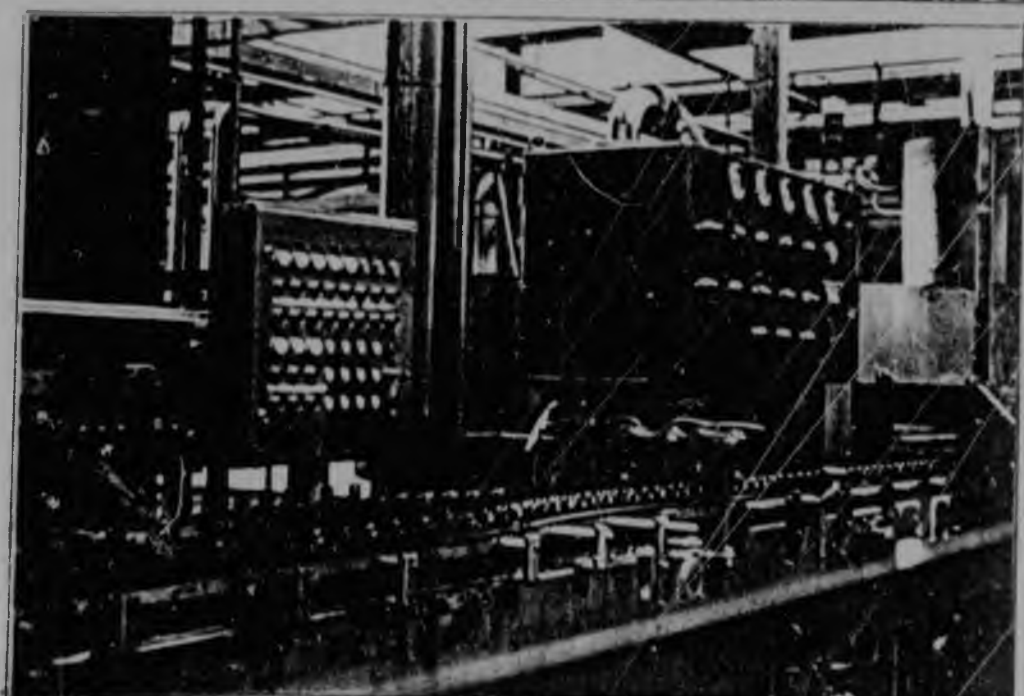




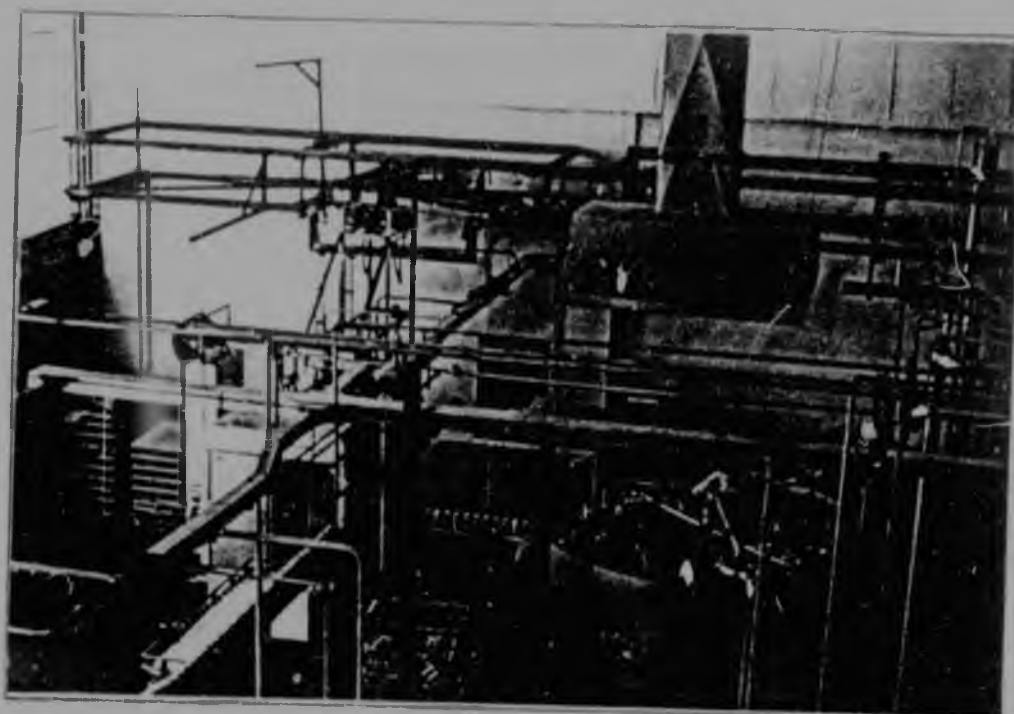
(7) 750 mℓ RB -
Caser

(8) 750 mℓ RB -
Palletiser

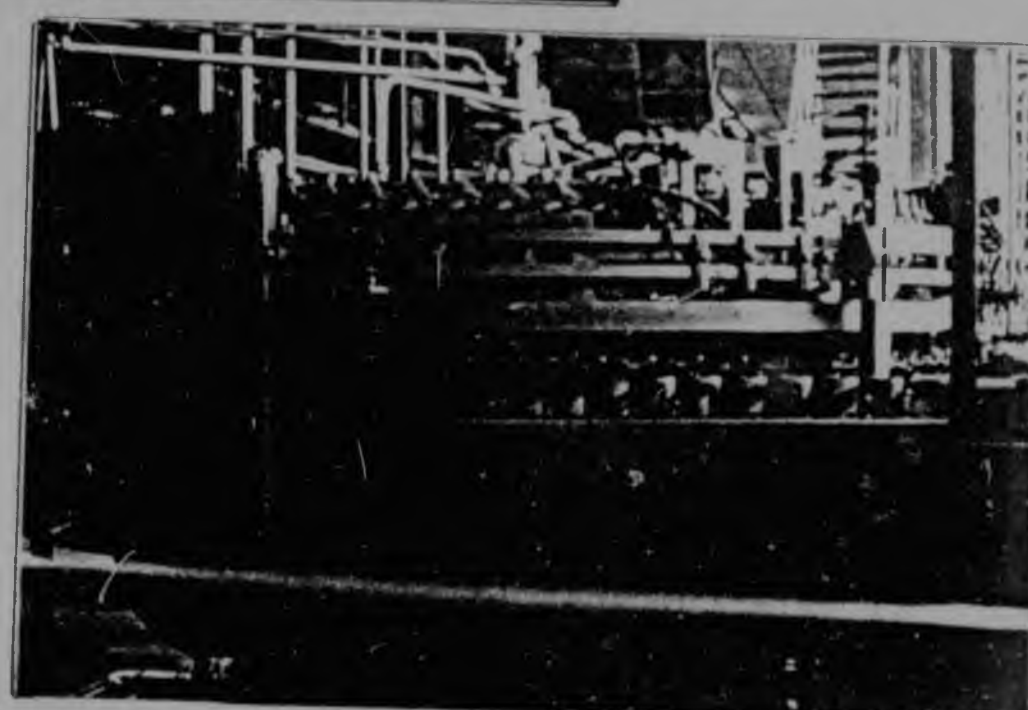




(9) Control Unit of
340 mℓ NRB
Filler



(1) Canning Line -
Filler & Seamer

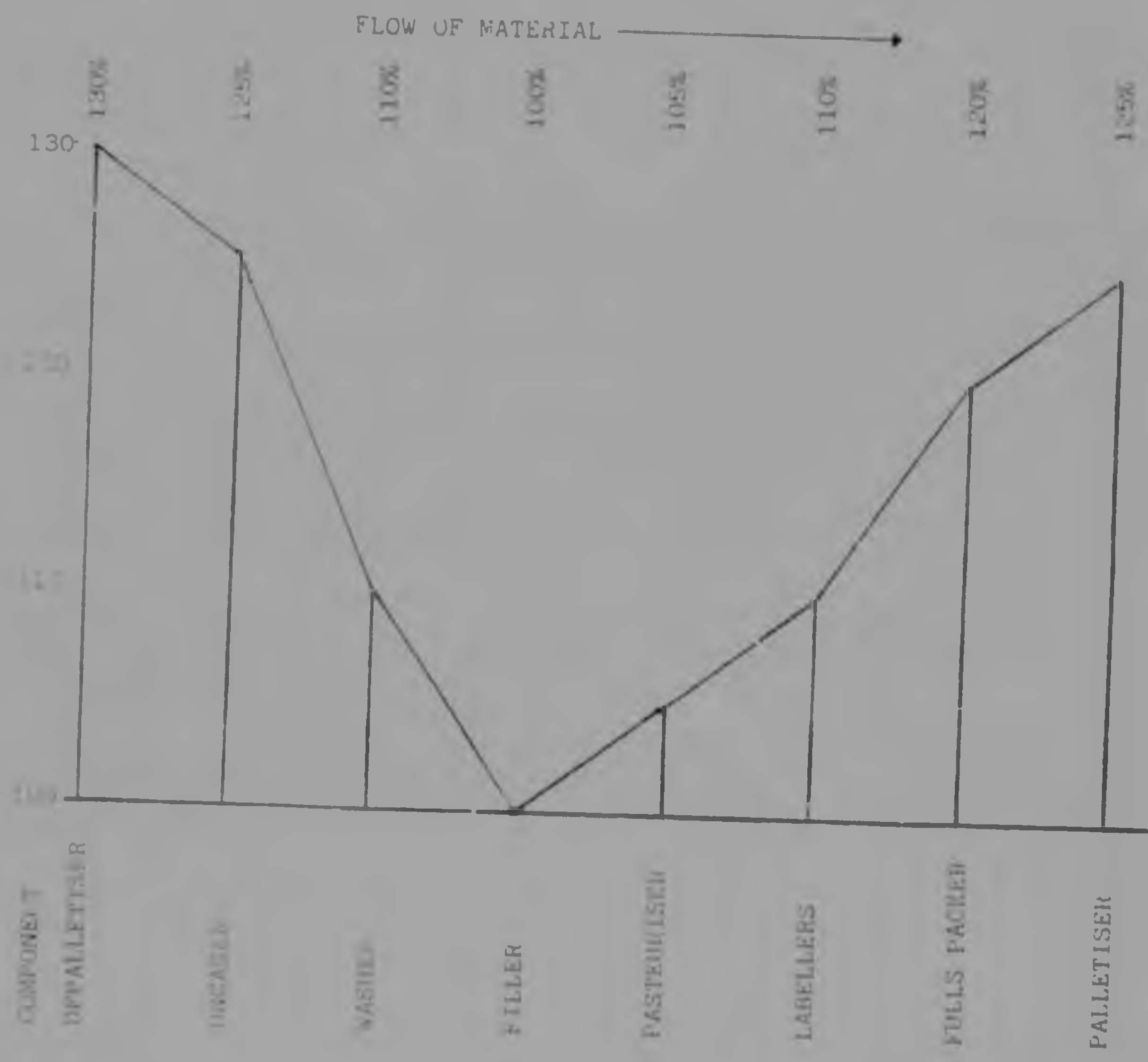


(2) Canning Line -
Filler

(3) Canning Line -
Conveyor

FIGURE 11.1: PACKAGING LINE CAPACITY PROFILE

Rating is in per cents and the filler is used as a base - 100%.



The reasoning behind the V shape is that because of uncontrolled stoppages of different machines in the line, one needs to provide extra capacity up and down stream which is buffered by means of short term storages (conveyors and accumulation tables). This extra capacity enables parts of the line to "catch up" in the event of short failures thus preventing the filler from stopping. This is probably the correct way of doing things if the goal is to increase efficiency as is currently defined in S.A.B. - 'ratio of actual output to filler rating'.

As an example, consider the next table. The rating of the different machinery is a typical machine rating used in S.A.B.. Not all components of the line are presented for the sake of simplicity.

TABLE 11.1: SIMPLIFIED COST BREAK DOWN OF A 750'S LINE

| MACHINE | COST (R) | RATING | COST x RATING ('000) |
|---|---|---|---|
| 2 Depalletisers | 79 000 | 130 | 10 270 |
| Pallet Conveyor | 240 000 | 130 | 31 200 |
| Carton & Tray Conveyor and Grid | 1 357 000 | 130 | 176 410 |
| Unpacker | 197 000 | 125 | 24 625 |
| Bulk Glass Depalletiser | 94 000 | 125 | 11 750 |
| Bottle Conveyor System | 1 130 000 | 125 | 141 250 |
| Washer | 1 195 000 | 110 | 131 450 |
| Filler & Crowner | 643 000 | 100 | 64 300 |
| Pasteuriser | 607 000 | 105 | 63 735 |
| Labellers | 425 000 | 110 | 46 750 |
| Packer | 255 000 | 120 | 30 600 |
| Palletiser, Stackers, Conveyors & Bulk Glass | 739 000 | 130 | 96 070 |
| | 6 961 000 | 1 440 | 828 410 |

Say the machine efficiency of this line is planned to be 80%, that is, it is planned to produce in average 42 000 x 0,8 = 33 600 bottles per hour. Using the efficiency formula developed in the Chapter 10 - "Efficiency", which takes into account all machinery in the line giving higher weight to expensive machines,

$$\text{EFFICIENCY} = \frac{\text{OUTPUT} \times C_i}{t \times C_i \times R_i}$$

where $C_i$ and $R_i$ are the cost and the rating of component i. The efficiency of the above line is now recalculated as:

$$\text{EFFICIENCY} = \frac{100 \times 0{,}8 \times 6\ 961\ 000}{1 \times 828\ 410\ 000} = 0{,}6722$$

or 67%.

The above shows that in a typical S.A.B. packaging line, the capital efficiency (if it can be so called) is significantly lower than what is called, in S.A.B., machine efficiency and is actually the filler efficiency.

These results suggest that the line profile should change or at least be reconsidered. One possibility is to give the most expensive component of the line (the washer in a Returnable bottle line) the lowest rating and let all other components serve this component of the machine. Another possibility is to design all components of the line so that they have the same rating and then design big enough buffers between them.

If the approach of equal capacities is considered, the capacity of each machine should be thought of as the practical average output of the machine after normal machine stoppages. A probability study, to evaluate the required stock building capabilities between different machines, should be undertaken.

The optimal solution is probably somewhere in between. However, it is not intended here to find quantitatively an optimal line profile for which quantitative techniques ave to be used. A reasonable approach to such a problem can be made in a probability study, and/or in a time measurement and work study on the production line and/or in a simulation study.

CONCLUSIONS

1) There is a significant difference between line efficiency, as currently defined by S.A.B., and line efficiency as it should be calculated. This is mainly due to the V profile of a typical production line.

2) Because the filler is not the most expensive component of the line, the concept of designing a packaging line around the filler should be reconsidered.

3) Using efficiency, as defined in this study, one should try to reduce ratings of expensive machinery to increase efficiency. This of course assumes that the cost of a machine is a constantly increasing function of its rating (size).

4) Using conclusion 3) and assuming the V shape is still desired, the washer, which is the most expensive component, and the conveyor system should be designed to have the lowest rating (while the conveyor system is also used to accommodate short term buffer stocks).

5) A quantitative study, such as a simulation study should be employed to determine optimal line profile.

# CHAPTER 12: SINGLE PACK PLANT

The option of a single pack plant will be considered in this chapter. Currently S.A.B. operates 6 plants in the Northern Provinces region, each one producing between 2 and 6 different packs. The current S.A.B. policy is to develop new plants and introduce, in any such plant, packaging capacity roughly to the ratio of the relevant sales. So typically, in a new plant, 2 or 3 lines will be 750's lines, 1 or 2 packaging lines will be canning lines and another non-returnable packaging line will be installed.

It was shown in a previous chapter (Chapter 9 - "Location") that by adopting a single pack plant strategy, an additional cost of about R0,96/Hℓ is incurred. This figure assumes that Bloemfontein capacity is restricted. Within the Northern Provinces, excluding the Bloemfontein area, it was found that a cost of about R0,3/Hℓ is incurred when changing to a single pack plant. In other words, R0,3 is the present value of the additional transportation expenses incurred on average by locating a 1 Hℓ per year capacity at a single pack plant (present value of the next 15 years expenses). This figure will be compared with an estimate of the potential saving (per unit capacity) if a single pack plant is introduced.

The areas of possible gain when designing and operating single pack plants are: reduction in designing and construction costs; improved utilisation in respect of plant and machine efficiency; simpler management control; and higher reliability of production lines.

The losses due to increased transportation costs and higher risk, however, should not be neglected.

The approach that has been adopted in the following discussion is a conservative one. In general, the benefits of moving toward a single pack plant have been underestimated or even sometimes neglected, and the losses due to single pack plant policy have been overestimated. This has been done to prevent errors in adopting single pack plants when this should not be done. This is considered to be a more serious mistake than not adopting the single pack plant when it is necessary because this represents no change from the current situation. In any case it is suggested that a more thorough study which concentrates on the pure engineering side of the problem, should be initiated.

REDUCTION IN DESIGNING AND CONSTRUCTION COSTS

It should be cheaper to design 8 identical lines than to design 8 lines of which 3 or 4 are different types. This will not, however, be taken into account accordingly.

Reduction in capital investment can be achieved by eliminating some machinery. On average, about 20% of the empty bottles in a Returnable bottling line are (or should be) new bottles. This situation allows 1 line out of 5 to be without a washer and introduces a saving of about R1 000 000. The capacity of these 5 lines may be around 4 000 000 Hℓ/year resulting in a saving of R0,25 per capacity unit of 1 Hℓ per year.

In addition, more savings could possibly be achieved by interfacing machinery between different lines. The potential of introducing higher levels of automation should also be borne in mind. However, in order to maintain a conservative view, these effects will not be taken into account.

IMPROVED UTILISATION

It is estimated that significantly better learning curves can be achieved when operating a single pack plant. An improvement from plant efficiencies of about 60% to plant efficiencies of 75% - 80% can be achieved. Estimates that the gain could be even higher are common. For the purpose of this study a 10% gain is assumed. Using the cost of capacity figures (Chapter 7 - "Cost of Capacity"), 1 capacity unit (1 Hℓ per year) costs S.A.B. about R19. The improvement from 60% plant efficiency to 70% plant efficiency can be regarded as additional capacity which S.A.B. would achieve without any financial outlay. For the same plant and the same labour, S.A.B. would now extract 1/0,6 x 0,7 = 1,17 capacity units (Hℓ/year), a gain of 0,17 capacity unit or 0,17 x 19 = R3,23/(Hℓ per year). (Reference 12.1)

## MANAGEMENT ADVANTAGES

Low, medium and high management can be more easily trained in a single pack plant. The number of such managerial positions could be reduced by placing more responsibility on a single position. For the purpose of this study no effort will be made to attach "numbers" to this 'economy of scale' effect.

## OPERATION, RELIABILITY AND CONTROL

It is believed that a single pack plant would be easier to control and would be more reliable. A line can be dedicated to a certain brand and a certain set of bright beer tanks. There would, therefore, be no need for pack and brand change stoppages, or label changes, etc.. This would also contribute to a higher performance of all the facilities surrounding the packaging hall. These effects would further contribute to the savings when operating a single pack plant but will not be quantified in this discussion.

## INCREASED TRANSPORTATION COST

A loss of R0,3/Hℓ per year capacity will be assumed.

## RISK

Operating a single pack plant introduces a number of risks. Industrial unrest, sabotage, fire or any other unexpected disaster may cause a huge plant to stop. If this happens to a single pack plant, S.A.B. would be in the inconvenient situation of having a large shortfall in the supply of one pack. This is not an optimal situation but the alternative of a multi-pack plant is not much better in this respect. In the case of such a shut down, S.A.B. would have a small shortfall in many packs instead of a large shortfall in one pack. In Hℓ's the shortfall would still remain the same assuming a certain brewery size with either a single or multi- packaging plant. It is also felt by S.A.B. Management that single pack plant policy might reduce S.A.B.'s flexibility in respect of production and operation.

The following table summarises the pro's and con's of a single pack plant.

TABLE 12.1: SINGLE PACK PLANT - PRO'S AND CON'S

| DESCRIPTION | ESTIMATED GAIN IN R/Hℓ PER YEAR CAPACITY |
|---|---|
| Distribution Cost | -R0,3 |
| RISK | NOT QUANTIFIED but probably negative |
| Design and Construction | + 0,25 + unquantified positive factors |
| Improved Utilisation | + 3,23 |
| Management Advantages | Unquantified but definitely positive |
| OPERATION, RELIABILITY AND CONTROL | Unquantified but definitely positive |

SUM OF ALL NUMBERS: + 2,98

It is therefore, estimated that single pack plant operations might introduce at least a saving of, on average, R2,98/(1 H. per year) capacity. This number is based on the Present Value of all gains and losses during a period of 15 years after the capacity had been introduced. In the next 10 years, S.A.B. is planning to introduce more than 12 000 000 Hℓ per year capacity. Introducing this capacity under single pack plant policy could lead to a saving of at least R36 000 000.

The above estimate is an absolute minimal estimate as it is based on cost of capacity of only R19/(Hℓ per year) capacity, which is only the cost of the packaging line and its labour. Any increase in efficiency will, without doubt, activate some savings to upstream and downstream operations such as material handling, distribution, brewing and beer storage. So in effect the gains calculated on R19/(Hℓ per year) capacity should have been calculated on a much higher figure. It is suggested that a full study on this issue be initiated.

The implementation of single pack plants would without doubt introduce a number of practical problems of which the first is probably capacity.

S.A.B. cannot concentrate only on building 750's lines for the next 5 years because the Company will in the mean time run out of capacity in other packs. Within Northern Provinces (excluding Bloemfontein) at least one plant (probably 2) would have to remain multi-pack plants. This is essential for 4 main reasons:

a. to act as production centres for minor packs - packs that it would not pay to build single pack plants for;

b. to act as production centres of minor brands that are packed in major packs - this assumes that the single pack plant will not produce some (or all) of the minor brands;

c. to produce various packs in the intermediate stages of introducing big single pack plants;

d. to act as training centres.

CONCLUSIONS

1) Single pack plant policy can result in a saving of at least R36 000 000 in the next 10 years.

2) R36 000 000 is an extremely modest and conservative figure. A significantly higher saving could, most probably, be achieved.

3) At least one multi-pack plant has to exist in order to allow easy and efficient single pack plant implementation.

4) A study, with greater concentration on the potential engineering savings involved with a single pack plant, should be undertaken.

## CHAPTER 13: SHIFT CONFIGURATION EFFECTS

In the following chapter, the effect of different shift activities on our two major packs, 750 RB and cans, will be estimated. It is based very much on a previously made study. (Reference 13.1)

In the above study 8 different activities were considered.

| | | | | |
|---|---|---|---|---|
| Activity 1 - | 45 | hr/week | - 1 . 9 | hrs x 5 days |
| Activity 2 - | 57,5 | hr/week | - 1 . 11,5 | hrs x 5 days |
| Activity 3 - | 90 | hr/week | - 2 . 9 | hrs x 5 days |
| Activity 4 - | 115 | hr/week | - 2 . 11,5 | hrs x 5 days |
| Activity 5 - | 120 | hr/week | - 3 . 8 | hrs x 5 days |
| Activity 6 - | 128 | hr/week | - 3 . 8 | hrs x 6 days |
| Activity 7 - | 168 | hr/week | - 3 . 8 | hrs x 7 days |
| Activity 8 - | 92 | hr/week | - 4 day week | |

Only activities 3, 4, 5, 6 and 7 will be considered here as they represent the current situation (activities 3, 4) and the maximum utilisation situation (activities 6, 7).

The complements for canning lines and 750's lines are assumed to be as shown in the following table. This table also presents the cost numbers assumed.

All costs are before tax.

TABLE 13.1: COMPLEMENTS AND WAGES FOR 750'S AND CANNING LINES

| GRADE | NUMBER OF WORKERS | | NT WAGES R PER HR | OT x 1½ R PER HR | OT x 2 R PER HR | NIGHT SHIFT ALLOW-ANCE R/SHIFT |
|---|---|---|---|---|---|---|
| | CANNING LINE | 750 LINE | | | | |
| 6 | | | 3,3139 | 4,1946 | 5,5928 | 1,79 |
| 5 | | | 3,0153 | 3,8450 | 5,1266 | 1,63 |
| 4 | 3 | 3 | 2,4126 | 3,0786 | 4,1048 | 1,40 |
| 3 | 1 | 2 | 2,0666 | 2,6321 | 3,5094 | 1,08 |
| 2 | 7 | 11 | 1,8380 | 2,3390 | 3,1186 | 1,01 |
| 1 | | 13 | 1,6714 | 2,1246 | 2,8328 | 0,95 |
| TOTAL | 11 | 29 | | | | |

The canning complement is the one used in Reference 13.1 and the 750's complement is the current complement of the 2 quarts lines at Isando. These are the weekly paid complements and do not include monthly paid people.

From the above, the cost of a crew hour is:

TABLE 13.2: CANNING LINE CREW HOUR COSTS

| GRADE | NO | NT R/Hr | OT x 1,5 R/Hr | OT x 2 R/Hr | NIGHT ALLOWANCE R/SHIFT |
|---|---|---|---|---|---|
| 4 | 3 | 7,2378 | 9,2358 | 12,3144 | 4,2 |
| 3 | 1 | 2,0666 | 2,6321 | 3,5094 | 1,08 |
| 2 | 7 | 12,866 | 16,373 | 21,8302 | 7,07 |
| TOTAL | 11 | 22,1704 | 28,2409 | 37,654 | 12,35 |

TABLE 13.3: 750'S LINE CREW HOUR COSTS

| GRADE | NO | NT R/Hr | OT x 1,5 R/Hr | OT x 2 R/Hr | NIGHT ALLOWANCE R/SHIFT |
|---|---|---|---|---|---|
| 4 | 3 | 7,2378 | 9,2358 | 12,3144 | 4,2 |
| 3 | 2 | 4,1332 | 5,2642 | 7,0188 | 2,16 |
| 2 | 11 | 20,218 | 25,729 | 34,3046 | 11,11 |
| 1 | 13 | 21,7282 | 27,6198 | 36,8264 | 12,35 |
| TOTAL | 29 | 53,3172 | 67,8488 | 90,4642 | 29,82 |

## TABLE 13.4: CANNING LINE - WEEKLY WAGES

| ACTIVITY | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|
| FACTORY HOURS | 90 Hrs | 115 Hrs | 120 Hrs | 128 Hrs | 168 Hrs |
| NORMAL TIME | 90 x 22,1704 = 1 995,3 | 90 x 22,1704 = 1 995,3 | 135 x 22,1704 = 2 993 | 135 x 22,1704 = 2 993 | 180 x 22,1704 = 3 990,4 |
| OVERTIME 1½ | | 30 x 28,2409 = 847,2 | | 3 x 28,2409 = 84,72 | 16 x 28,2409 = 451,8 |
| OVERTIME 2 | | | | | 16 x 37,654 = 602,5 |
| NIGHT ALLOWANCE | 5 x 12,35 = 61,8 | 5 x 12,35 = 61,8 | 10 x 12,35 = 123,5 | 10 x 12,35 123,5 | 14 x 12,35 = 123,5 |
| NON PRODUCTIVE OVERTIME COST | 5 x 17,1990 = 86 | | | | |
| TOTAL COST (R) | 2 143 | 2 904 | 3 117 | 3 201 | 5 218 |

TABLE 13.4: CANNING LINE - WEEKLY WAGES

| ACTIVITY | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|
| FACTORY HOURS | 90 Hrs | 115 Hrs | 120 Hrs | 128 Hrs | 168 Hrs |
| NORMAL TIME | 90 x 22,1704<br>= 1 995,3 | 90 x 22,1704<br>= 1 995,3 | 135 x 22,1704<br>= 2 993 | 135 x 22,1704<br>= 2 993 | 180 x 22,1704<br>= 3 990,4 |
| OVERTIME 1½ | | 30 x 28,2409<br>= 847,2 | | 3 x 28,2409<br>= 84,72 | 16 x 28,2409<br>= 451,8 |
| OVERTIME 2 | | | | | 16 x 37,6[illegible]<br>= 602,5 |
| NIGHT ALLOWANCE | 5 x 12,35<br>= 61,8 | 5 x 12,35<br>= 61,[illegible] | 10 x 12,35<br>= 123,5 | 10 x 12,35<br>123,5 | 14 x 12,35<br>= 123,5 |
| NON PRODUCTIVE OVERTIME COST | 5 x 17,1990<br>= 86 | | | | |
| TOTAL COST (R) | 2 143 | 2 904 | 3 117 | 3 201 | 5 218 |

TABLE 13.5: QUARTS LINE – WEEKLY WAGES

| ACTIVITY | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|
| FACTORY HOURS | 90 Hrs | 115 Hrs | 120 Hrs | 128 Hrs | 168 Hrs |
| NORMAL TIME | 90 x 53,3172<br>= 4 798,5 | 90 x 53,3172<br>= 4 798,5 | 135 x 53,3172<br>= 7 197,8 | 135 x 53,3172<br>= 7 197,8 | 180 x 53,3172<br>= 9 597 |
| OVERTIME 1½ | | 30 x 67,8488<br>= 2 035,5 | | 3 x 67,8488<br>= 203,5 | 16 x 67,8488<br>= 1 085,6 |
| OVERTIME 2 | | | | | 16 x 90,4642<br>= 1 447,4 |
| NIGHT ALLOWANCE | 5 x 29,82<br>= 149,1 | 5 x 29,82<br>= 149,1 | 10 x 29,82<br>= 298,2 | 10 x 29,82<br>= 298,2 | 14 x 29,82<br>= 417,5 |
| NON PRODUCTIVE OVERTIME COST | 5 x 67,8488<br>= 339,2 | | | | |
| TOTAL COST (R) | 5 286 | 6 983 | 7 496 | 7 690 | 12 547 |

Assuming a canning line rated at 200 hℓ/hr and 750's line at 315 hℓ/hr, taking into account allowed stops in different activities, the following tables summarise the situation.

TABLE 13.[illegible]: CANNING LINE

YEARLY PRODUCTION AND COST UNDER DIFFERENT SHIFT ACTIVITIES

| ACTIVITY | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|
| FACTORY HOURS | 2x9x5 = 90 | 2[illegible]1,5x5 = 115 | 3x8x5 = 120 | 3x8x6 = 128 | 3x8x7 = 168 |
| ALLOWED STOPS | | | | | |
| START UP | | 0,5 | 0,5 | 0,5 | 0,5 |
| SHIFT CHANGE | | 2,0 | 2,0 | 2,5 | 3,5 |
| BRAND CHANGE (2/WK) | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 |
| MAINTENANCE | 9,0 | 11,5 | 12,0 | 12,75 | 16,75 |
| SHUT DOWN | | 1,5 | 1,5 | 1,5 | |
| CONTAINER CHANGES | | | | | |
| Q.C. CHECKS | 1,5 | 1,5 | 2,0 | 2,0 | 2,0 |
| TEA BREAK | | | 3,75 | 4,0 | 5,25 |
| TOTAL ALLOWED STOPS | 11,5 | 18,0 | 22,75 | 24,25 | 29.0 |
| MACHINE HOURS | 78,5 | 97,0 | 97,25 | 103,75 | 139,0 |
| MACHINE EFFICIENCY | 80 | 80 | 80 | 80 | 80 |
| RATED OUTPUT Hℓ/HR | 200 | 200 | 200 | 200 | 200 |
| VOLUME/WEEK | 12 560 | 15 520 | 15 560 | 16 600 | 22 240 |
| WEEKS/YEAR | 46 | 46 | 46 | 46 | 46 |
| VOLUME/YEAR | 577 760 | 713 920 | 715 760 | 763 600 | 1 023 040 |
| UTILISATION (BASED ON MAX. THEORETICAL CAPACITY) | 32,97% | 40,75% | 40,85% | 43,58% | 58,39% |
| PAYCOST R/WEEK | 2 143 | 2 904 | 3 117 | 3 201 | 5 218 |
| PAYCOST R/YEAR (52 WEEKS) | 111 436 | 151 008 | 162 084 | 166 452 | 271 336 |
| ADDITIONAL PROD. Hℓ | 0 | 136 160 | 138 000 | 185 840 | 445 280 |
| ADDITIONAL COST R | 0 | 39 572 | 50 648 | 55 016 | 159 900 |
| COST PER Hℓ R/Hℓ | 0 | 0,2906 | 0,3670 | 0,2960 | 0,350 |

TABLE 13.7: QUARTS LINE

YEARLY PRODUCTION AND COST UNDER DIFFERENT SHIFT ACTIVITIES

| ACTIVITY | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|
| FACTORY HOURS | 2x9x5 = 90 | 2x11,5x5 = 115 | 3x8x5 = 120 | 3x8x6 = 128 | 3x8x7 = 168 |
| ALLOWED STOPS | | | | | |
| START UP | | 0,5 | 0,5 | 0,5 | 0,5 |
| SHIFT CHANGE | | 2,0 | 2,0 | 2,5 | 3,5 |
| BRAND CHANGE | 1,0 | 1,0 | 1,0 | 1,0 | 1,0 |
| MAINTENANCE | 9,0 | 11,5 | 12,0 | 12,75 | 16,75 |
| SHUT DOWN | | 1,5 | 1,5 | 1,5 | |
| CONTAINER CHANGE | | | | | |
| TEA BREAK | | | 3,75 | 4,0 | 5,25 |
| TOTAL ALLOWED STOPS | 10,0 | 16,5 | 20,75 | 22,25 | 27,0 |
| MACHINE HOURS | 80 | 98,5 | 99,25 | 105,75 | 141,0 |
| MACHINE EFFICIENCY | 75 | 75 | 75 | 75 | 75 |
| RATED OUTPUT Hℓ/HR | 315 | 315 | 315 | 315 | 315 |
| VOLUME/WEEK | 20 160 | 24 822 | 25 011 | 26 649 | 35 532 |
| WEEKS/YEAR | 46 | 46 | 46 | 46 | 46 |
| VOLUME/YEAR | 927 360 | 1 141 812 | 1 150 506 | 1 225 854 | 1 634 472 |
| UTILISATION (BASED ON MAX. THEORETICAL CAPACITY) | 33,6% | 41% | 41,69% | 44,[illegible]2% | 59,23% |
| PAYCOST R/WEEK | 5 151 | 6 983 | 7 496 | 11 100 | 12 547 |
| PAYCOST R/YEAR (52 WEEKS) | 267 852 | 363 116 | 389 792 | 577 200 | 652 444 |
| ADDITIONAL PROD. Hℓ | 0 | 214 452 | 223 146 | 298 494 | 707 112 |
| ADDITIONAL COST R | 0 | 95 264 | 121 940 | 309 348 | 384 592 |
| COST PER Hℓ R/Hℓ | 0 | 0,4442 | 0,5464 | 1,036 | 0,5439 |

The above calculations do not take into account many other factors that should be considered when evaluating shift configuration options, such as industrial relations, risk, facilities at the plant (canteen, for example), transportation to and from the plant and others. The above calculations should serve as a base to any study attempting to improve by means of shift configuration changes. After any such option has been considered and resulted in a significant economic gain, all other factors should be taken into account.

The figure of interest is the marginal cost per Hℓ when increasing capacity by means of shift configuration changes relative to the cost per Hℓ under the current operating method. In the first stage this will be done purely on a variable labour cost basis. In the second stage, the possible savings in capital investment will be introduced.

All calculations in this chapter are before tax.

The marginal labour costs in R/Hℓ for activities 4, 5, 6 and 7 are shown in the previous tables in the last row (COST PER Hℓ R/Hℓ). The cost per Hℓ under activity 3 is obtained by dividing total paycost by total volume produced. The other marginal costs are calculated by dividing the additional cost (relative to activity 3) by the additional volumes.

The results are summarised in the following table.

TABLE 13.8: MARGINAL LABOUR COST (R PER Hℓ) FOR DIFFERENT ACTIVITIES

| ACTIVITY / PACK | 3<br>2x9x5<br>= 90 Hrs | 4<br>2x11,5x5<br>= 115 Hrs | 5<br>3x8x5<br>= 120 Hrs | 6<br>3x8x6<br>= 128 Hrs | 7<br>3x8x7<br>= 168 Hrs |
|---|---|---|---|---|---|
| 750 | 0,2964 | 0,4115 | 0,5150 | 0,4204 | 0,5339 |
| CANS | 0,1929 | 0,2906 | 0,3670 | 0,2960 | 0,3500 |

Another method of presenting the same information is average labour cost per Hℓ. This is achieved by dividing the total yearly labour cost by the total yearly production for every activity.

TABLE 13.9: AVERAGE LABOUR COST (R) PER Hℓ FOR DIFFERENT ACTIVITIES

| ACTIVITY / PACK | 3<br>2x9x5<br>= 90 Hrs | 4<br>2x11,5x5<br>= 115 Hrs | 5<br>3x8x5<br>= 120 Hrs | 6<br>3x8x6<br>= 128 Hrs | 7<br>3x8x7<br>=168 Hrs |
|---|---|---|---|---|---|
| 750 | 0,2964 | 0,3180 | 0,3388 | 0,3266 | 0,3992 |
| CANS | 0,1929 | 0,2115 | 0,2265 | 0,2180 | 0,2652 |

It is apparent that, labourwise, activity 3 which is the one currently used in S.A.B., is significantly cheaper than all the other activities.

Taking into account capital savings introduce some complexity. Different activity levels mean different usage of machinery. It is normally assumed that a typical production line life is about 15 years. If this is assumed to remain true under different activity levels, the total amount of beer produced throughout the life cycle of a production line is dependent entirely on the shift configuration (hence on the utilisation). This introduces a difference in the capital cost component in the cost per Hℓ.

The capital cost per Hℓ will be calculated by dividing the total investment in capital by the total volume produced.

ASSUMPTIONS: 750's line - cost (machinery and civil work only) R15 000 000
Can Line - cost (machinery and civil work only) R 8 000 000
Total production - as calculated and presented in the previous tables.

TABLE 13.10: CALCULATION OF CAPITAL COST PER Hℓ PRODUCTION

750's Line

| Activity | 3<br>2x9x5<br>= 90 | 4<br>2x11,5x5<br>= 115 | 5<br>3x8x5<br>= 120 | 6<br>3x8x6<br>= 128 | 7<br>3x8x7<br>= 168 |
|---|---|---|---|---|---|
| Yearly Production (in Hℓ) | 927 360 | 1 141 812 | 1 150 506 | 1 225 854 | 1 634 472 |
| Total Production (15 years) | 13 910 400 | 17 127 180 | 17 257 590 | 18 387 810 | 24 517 080 |
| Cost of Plant (R) | 15 000 000 | 15 000 000 | 15 000 000 | 15 000 000 | 15 000 000 |
| Cost per Hℓ (R/Hℓ) | 1,0783 | 0,8758 | 0,8692 | 0,8158 | 0,6118 |

Canning Line

| | | | | | |
|---|---|---|---|---|---|
| Yearly Production (in Hℓ) | 577 560 | 713 920 | 715 760 | 763 600 | 1 023 040 |
| Total Production (15 years) | 8 666 400 | 10 708 800 | 10 736 400 | 11 454 000 | 15 345 600 |
| Cost of Plant (R) | 8 000 000 | 8 000 000 | 8 000 000 | 8 000 000 | 8 000 000 |
| Cost per Hℓ (R/Hℓ) | 0,9231 | 0,7470 | 0,7451 | 0,6984 | 0,5213 |

Adding the labour and capital cost per Hℓ, results in:

TABLE 13.11: LABOUR AND CAPITAL COST PER Hℓ

UNDER DIFFERENT SHIFT ACITIVITIES

750's Line

| Activity | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|
| Capital Cost R/Hℓ | 1,0783 | 0,6758 | 0,8692 | 0,8158 | 0,6118 |
| Labour Cost R/Hℓ | 0,2964 | 0,4115 | 0,5150 | 0,4204 | 0,5339 |
| Total Cost R/Hℓ | 1,3747 | 1,2873 | 1,3842 | 1,2362 | 1,1457 |

Canning Line

| | | | | | |
|---|---|---|---|---|---|
| Capital Cost R/Hℓ | 0,9231 | 0,7470 | 0,7451 | 0,6984 | 0,5213 |
| Labour Cost R/Hℓ | 0,1929 | 0,2906 | 0,3670 | 0,2960 | 0,3500 |
| Total Cost R/Hℓ | 1,1160 | 1,0376 | 1,1121 | 0.9944 | 0,8713 |

The results show that a maximum gain of R0,2290/Hℓ (1,3747 - 1,1457 = 0,2290) on 750's and R0,2447 (1,116 - 0,8713 = 0,2447) on cans may be achieved due to high utilisation through shift configuration changes. This, however, assumes that a line will run for 15 years regardless of its utilisation. It further assumes that all other costs, such as maintenance, electricity, water, raw materials, are a fixed amount per Hℓ and do not depend on quantities produced.

If, however, it is assumed that the total amount of Hℓ's produced in the life time of a packaging line is constant, the life cycle of the packaging line will be shorter under high utilisation operation. This will result in a constant capital component (R/Hℓ) and costwise the difference between different shift activities will only be the direct labour cost per Hℓ. If this the case, the 2x9x5 shift activity is the optimal one.

The truth lies somewhere in between and the main parameter needed to determine the optimum shift activity is the amount of Hℓ's that will be produced under different shift activities.

CONCLUSIONS

1) Different shift activities can introduce significant changes in utilisation from about 33% (under current 2x9 shift activity) up to about 58%.

2) Based on labour cost per Hℓ, 2x9x5 shift activity is the cheapest.

3) Assuming the life cycle of a packaging line is not a function of the amount produced (highly unlikely) and is constant for 15 years, there are significant advantages to be gained from high utilisation shift activities.

4) The different shift activities should be studied further and, if possible, modified (negotiation with labour, for example) in order to optimise or improve labour operations. Activities 6 and 7 seem to have the highest potential.

5) The effects of different shift activities on the utilisation of other components, except the packaging line and its labour, were ignored. These effects should be studied and will probably tend to increase the gain associated with high utilisation activities.

## CHAPTER 14: PRODUCTION PROFILE THROUGHOUT THE YEAR

As beer demand is not constant throughout the year, S.A.B. needs to vary production or build up stock during the year in order to meet demand. There are three basic ways to meet demand i.e. to have as low a capacity as possible and to relie on stock building, to have excess capacity which will be used during peak time, or some combination of the two. The options of not supplying demand and subcontracts are not relevant and will not be discussed, the issue is however studied in Chapter 8 - "Required Packaging Capacity Model".

The aim of the following is to determine feasible solutions and to indicate the optimal one (costwise) among them.

The method that will be used is commonly used for aggregate planning purposes. It compares accumulating demand to accumulating production in a graphical way. (Reference 14.1)

The technique is, however, enhanced here to deal with percentages i.e. the relative amount of the yearly total. This is done to enable the results to be general enough so as to apply to any year considered.

The cumulative demand is drawn on the graph presented in this chapter. It represents a typical pattern of demand throughout the year (detailed numbers are presented in appendix no. 14.1). In order to meet this demand, the cumulative production has to be above the cumulative demand graph (see example below).

FIGURE 14.1: ILLUSTRATION OF CUMULATIVE DEMAND - GRAPHICAL REPRESENTATION

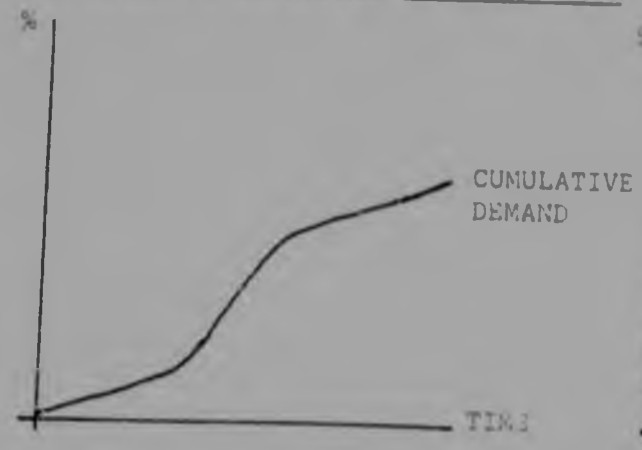
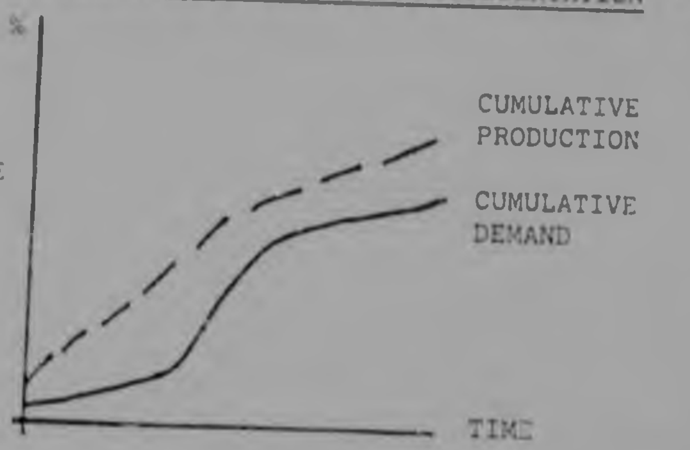


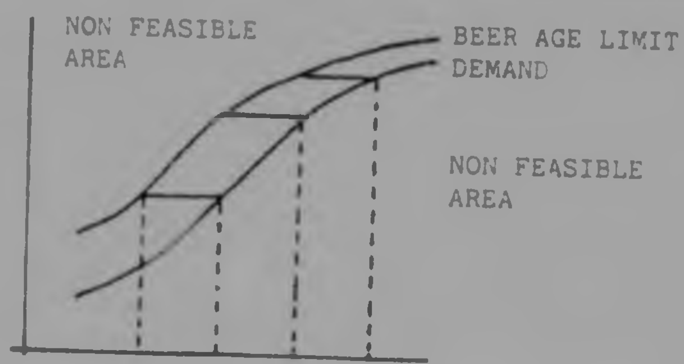

FIGURE 14.2: ILLUSTRATION OF CUMULATIVE PRODUCTION - GRAPHICAL REPRESENTATION



The vertical axes show percentage of yearly demand and can always be replaced by absolute amount of $H\ell$. The horizontal axes show time in weeks or months. The aim of the following discussion is to determine a feasible and optimal pattern to the cumulative production curve which is the graphical representation of a production plan.

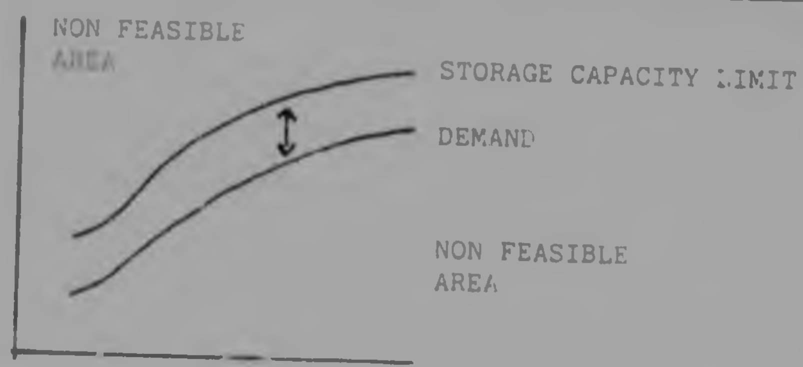
There are three basic constraints on the production: beer age, storage capacity and production rate. It is S.A.B.'s policy to keep beer age below 3 weeks. This can be represented by a horizontal line (parallel to the time axes). The cumulative production line should never be more than 3 weeks ahead (to the left) of the demand curve.

FIGURE 14.3: ILLUSTRATION OF BEER AGE LIMIT - GRAPHICAL REPRESENTATION




Storage capacity in S.A.B. is about 6% of annual demand. S.A.B. cannot store, in its own storage facilities, more than 6% of total demand. This can be represented as a vertical distance of 6% above demand curve.

FIGURE 14.4: ILLUSTRATION OF STORAGE CAPACITY LIMIT - GRAPHICAL REPRESENTATION

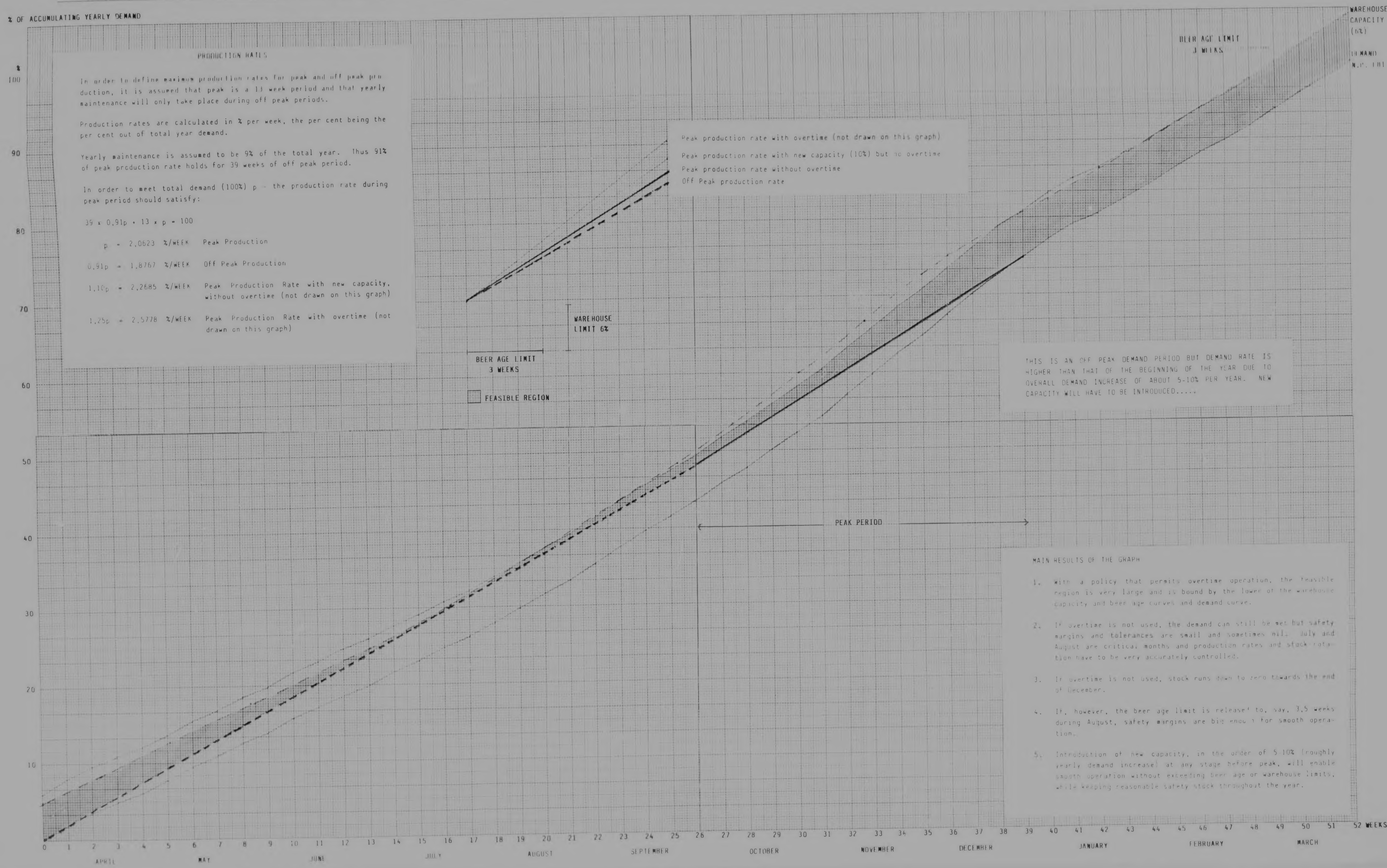


APPENDIX 1.5

N P BUDGET 1984

| BRAND | 750 ML | 375 RB | 340 RB | 340 NRB | 340 CAN | 450 CAN | DRAUGHT | TOTAL |
|---|---|---|---|---|---|---|---|---|
| Lion | 12.66 | 1,64 | | 3,79 | 3,32 | 4,17 | 0,15 | 25.73 |
| Carling | 7,46 | 0.45 | - | 1,42 | 2,03 | 6.12 | - | 17.48 |
| Castle | 34,51 | 1,40 | - | 2 70 | 2,89 | 8,09 | - | 49.59 |
| C.M.S. | 1.77 | 0.13 | - | - | - | 1.58 | - | 3.48 |
| Amstel | - | - | 0.61 | 0.84 | 1,31 | - | - | 2,76 |
| Hansa | 0.14 | 0.11 | - | 0,28 | 0 31 | - | 0.12 | 0.96 |
| Total | 56,54 | 3,73 | 0.61 | 9,03 | 9,86 | 19,96 | 0,27 | 100,00 |

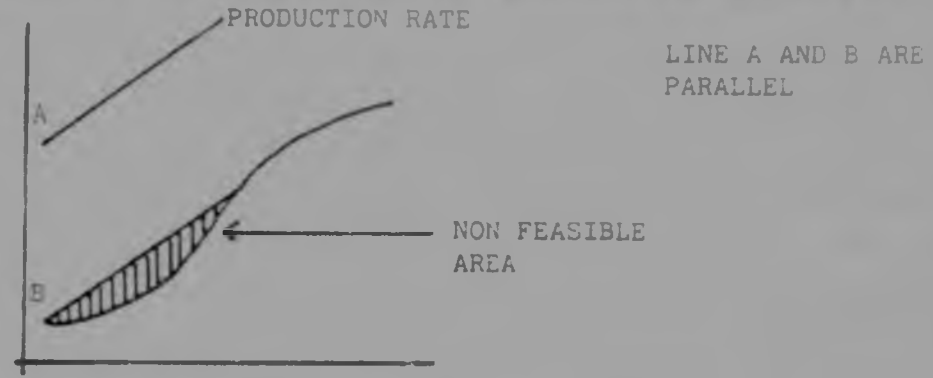
FIGURE 14.6: GRAPHICAL REPRESENTATION OF POSSIBLE AGGREGATE PRODUCTION PLANS TAKING INTO ACCOUNT DEMAND, WAREHOUSING, BEER AGE AND PRODUCTION RATE LIMITS



| | | |
|---|---|---|
| [illegible] | Grid System | 247 250 |
| [illegible] | Carton conveyor - excluding trasn conveyor | 943 000 |
| [illegible] | Electronic Switchboard (H & K) | 196 970 |
| | Instrument Panel (H & K | 15 910 |
| [illegible] | Switchboard (H & K | 107 930 |
| [illegible] | Field Wiring (H & K | 21 970 |
| [illegible] | P.F. Corrections (H & K | 171 720 |
| [illegible] | Field Wiring (H & K) | 395 960 |
| [illegible] | [illegible] including wiring - approximately (SUDMO, | 75 760 |
| [illegible] | Delivery (electrical equipment | 128 800 |
| [illegible] | [illegible]ivery | 922 300 |
| [illegible] | Piping Insulatio | 6 440 |
| [illegible] | Line Analysers | 69 000 |
| [illegible] | Op[illegible]r Platforms | 28 750 |
| [illegible] | Label Re[illegible]val Syste[illegible] | 23 000 |
| [illegible] | Lubricati[illegible] - conveyor | 28 750 |
| [illegible] | Lubrication - plant | 28 750 |
| [illegible] | H.[illegible]. Clea[illegible] reticulation | 6 440 |
| 41 | [illegible]lar[illegible]s | 19 550 |
| [illegible] | [illegible]ff-loa[illegible]in[illegible] | 138 000 |
| [illegible] | [illegible] | 345 000 |
| 44 | Electrical P[illegible] | 69 000 |
| [illegible] | Mechanical/Electrical Labou[illegible] | 617 550 |
| [illegible] | Crown Remover | 40 250 |
| [illegible] | Crown [illegible]evator | 126 500 |
| [illegible] | [illegible] Conveyor | 39 100 |
| [illegible] | [illegible] Stacker | 20 700 |

Production rate is expressed by the angle of the production curv . The higher the production rate is, the bigger the angle is.

TABLE 14.8: ILLUSTRATION OF PRODUCTION RATE - GRAPHICAL REPRESENTATION




The graph on the next page shows the feasible region for production, using, the above described method. Beer age limit is assumed to be unchangeable and warehousing limits will not be considered as a controllable variable although they are.

On he graph the following information is plotted:

a) N.P. (Northern Provinces) F81 demand (N.P. F81 demand igures - appendix no. 14.1);

b) a 6% warehouse limit;

c) a beer age limit of 3 weeks; and

d) production limits.

When overtime operation is not allowed, a feasible region is shown to exist but to be very narrow around August and December due to beer age limits and safety stocks, respectively.

If, however, overtime operation is permitted or new capacity is introduced before peak, the feasible region is much wider (this is not plotted on the graph but it is possible to envisage it). Within this feasible region, a trade off between overtime operation and stock building policy exists and is analysed in the following paragraphs.

within the feasible region the question of overtime or stock building is a matter of comparing the additional cost per Hℓ that is produced using overtime and the holding cost. These numbers vary by pack, brand and depot (the variation on depot is due to the freight cost). Holding cost will be calculated on the basis of variable cost and 20% annually out of that variable cost. Cost of overtime is based on the additional labour cost on the packaging line. Holding cost is assumed to be a linear function of the time. The holding cost of goods that are stored for 2 weeks is twice as big as the holding cost due to 1 week storage. This is different to overtime cost. Overtime production increases the cost per Hℓ by a certain and constant amount. By dividing the overtime cost by the holding cost per week, the maximum number of weeks that it still pays to stock beer instead of producing it, using overtime, is found. The figures are presented in the following table (for detailed calculation refer to appendix no. 14.2).

TABLE 14.1: CALCULATION OF ECONOMIC NUMBER OF HOLDING WEEKS

| PACK | VARIABLE COST R/Hℓ | HOLDING COST PER WEEK/Hℓ | OVERTIME ADDITIONAL COST (R/Hℓ) | MAX. NO. OF HOLDING WEEKS |
|---|---|---|---|---|
| 750 Mℓ | 50,35 | 0,1936 | 0,1336 | 0,70 |
| 375 PINT | 50,50 | 0,1942 | 0,1032 | 0,53 |
| 340 NRB | 75,82 | 0,2916 | 0,1014 | 0,35 |
| 340 CAN | 82,70 | 0,3181 | 0,0495 | 0,15 |
| 450 CAN | 83,18 | 0,3199 | 0,0771 | 0,24 |

Variable cost:- Reference 14.2

Holding cost = Variable Cost x 0,2 : 52

Overtime Cost:- see appendix no. 14.2

Max. no. of Holding Weeks:- Overtime Cost : Holding Cost per Week

CONCLUSIONS

1) Without the use of overtime operation, demand can only just be met without exceeding beer age and warehouse limits, provided yearly maintenance is done before September or after December.

2) If such a policy is adopted, a tight stock and production control is required as the margins are very small. This involves accurate forecasting, a strict first in first out operation and high production reliability.

3) Overtime operation is cheaper than the alternative of storing beer. Therefore there is no real need to use a no overtime policy.

4) S.A.B. currently uses overtime during peak period because its management believe this is the only way, capacitywise, to meet demand. This is the right approach but for the wrong reason. S.A.B. should use overtime because it is cheaper than the stock building option.

5) If and when cost of capital changes (drops) and/or shift configuration and labour cost change (rise), the policy of overtime operation during peak should be reconsidered.

## CHAPTER 15: CONCLUSIONS

Throughout this study various aspects of the S.A.B. packaging environment are analysed. The S.A.B. packaging system is shown to be the major part of S.A.B. activities. This is shown with regard to costs and plant complexity. It is, therefore, concluded that packaging constitutes the major concern at S.A.B..

Packaging capacity is defined (see Chapter 3), based on an absolute theoretical maximum and the utilisation of S.A.B. production lines is shown to be very low, in the region of 30 - 35% (see Chapter 4).

Because of the high relative cost of the packaging plant, an alternative way to approach the relationship between brewing and packaging capacity is advocated. This should in principal yield a lower relative packaging capacity in order to save capital investments. In order to quantify possible capital savings, the actual costs of a packaging plant and packaging capacity are calculated. The average cost of a packaging production capacity of 1 Hℓ per year is calculated to be R20 in present value terms, before tax.

In Chapter 8, a formal way of approaching capacity problems is demonstrated, based on the concept that the cost of under capacity is finite and therefore can, and should, be balanced against the cost of introducing new production capacity.

In a separate chapter (Chapter 9), the effect of different pack production location is found using a linear programming technique. The cost difference between the current situation and the case of a single pack plant is shown to be R0,3/Hℓ. This increased transportation cost is compared, in Chapter 12, with the advantages of a single plant operation. Cost advantages were found to be at least R36 million and a single pack plant has therefore been recommended.

In two different chapters (Chapters 10 and 11) a new approach to efficiency measurement and line design is presented. This is based on machine costs and can be defined as capital efficiency rather than machine or plant efficiency.

The question of different shift activities is presented in Chapter 13. Significant saving potential in high utilisation activities is demonstrated.

Using labour cost per Hℓ, a 5 day week with 2 x 9 hours shift activity is shown to be the cheapest. The saving potential in capital investment is, however, shown to be significant under higher utilisation activities.

The question of production profile throughout a typical year is presented in Chapter 14. A graphic method is demonstrated. The beer age limit and warehousing limits are shown to be redundant, a production plan without the use of overtime is shown to be feasible, and finally overtime operation is calculated to be cheaper than the stock building option.

Throughout the project a number of separate studies are recommended such as an estimation of under capacity cost, marketing research into the possible influence on pack share, industrial negotiation in order to find more effective shift activity, and studies to estimate technical and economical advantages of a single pack plant.

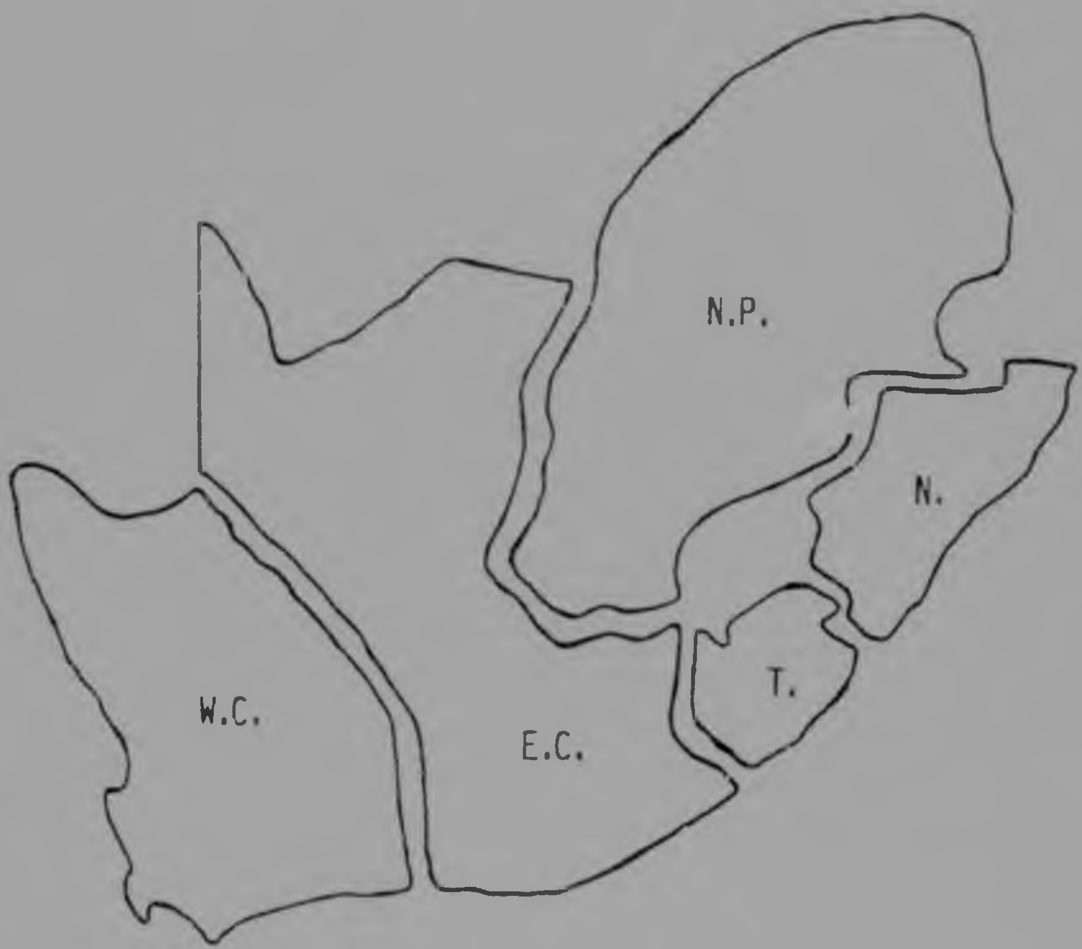
The project results have been presented to S.A.B. management and a process of implementation of some of the recommendations, as well as initiation of recommended studies, has begun.

It is hoped, however, that the approaches and methods, concepts and arguments presented in this study will continuously be enhanced and developed, keeping in mind the ever existing goal of improvement.

# APPENDICES

APPENDIX 1.1

PROBLEM SITUATION




| | | | |
|---|---|---|---|
| N.P. | - | Northern Provinces | 73.2% |
| N. | - | Natal | 13.3% |
| T. | - | Transkei | 1.2% |
| E.C. | - | Eastern Cape | 4.5% |
| W.C. | - | Western Cape | 7.8% |

APPENDIX 1.2

N.P. BREWERIES & DEPOTS

APPENDIX 1.2

N.P. BREWERIES & DEPOTS

## APPENDIX [illegible].3

## NORTHERN PROVINCES PACK MIX (hℓ x $10^3$)

### High Growth Scenario

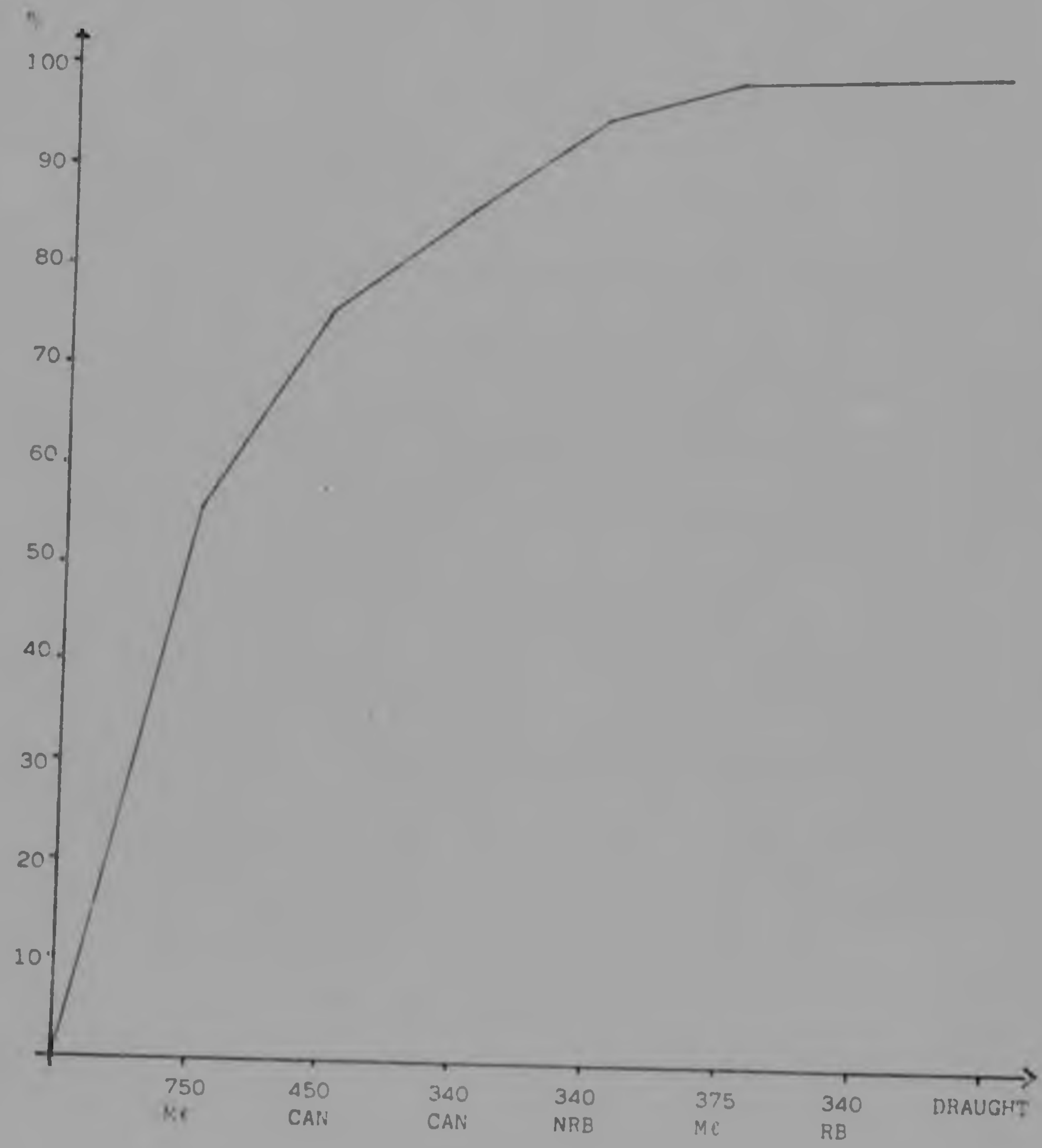
| | 750 Mℓ | 375 Mℓ | 340 RB | 340 NRB | 450 CAN | 340 CAN | DRAUGHT |
|---|---|---|---|---|---|---|---|
| F82 (Act) | 4 241 | 306 | 43 | 657 | 1 529 | 705 | 19 |
| 83 | 4 865 | 333 | 53 | 683 | 1 838 | 893 | 18 |
| 84 | 5 502 | 377 | 58 | 812 | 1 934 | 899 | 19 |
| 85 | 6 452 | 417 | 68 | 936 | 2 290 | 1 015 | 23 |
| 86 | 7 780 | 485 | 81 | 1 131 | 2 638 | 1 238 | 27 |
| 87 | 9 117 | 553 | 95 | 1 311 | 3 160 | 1 422 | 32 |
| 88 | 9 999 | 554 | 87 | 1 419 | 3 547 | 1 522 | 35 |
| 89 | 10 963 | 570 | 95 | 1 539 | 3 990 | 1 634 | 38 |
| 90 | 11 981 | 582 | 104 | 1 664 | 4 472 | 1 747 | 42 |
| 91 | 13 133 | 570 | 114 | 1 824 | 5 016 | 1 870 | 46 |
| 92 | 14 425 | 550 | 125 | 1 975 | 5 625 | 2 000 | 50 |

### Low Growth Scenario

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| F82 (Act) | 4 241 | 306 | 43 | 657 | 1 529 | 705 | 19 |
| 83 | 4 521 | 311 | 49 | 614 | 1 753 | 860 | 16 |
| 84 | 4 663 | 342 | 60 | 726 | 1 836 | 811 | 17 |
| 85 | 4 860 | 407 | 63 | 815 | 1 955 | 815 | 18 |
| 86 | 5 220 | 499 | 70 | 948 | 2 196 | 878 | 20 |
| 87 | 5 705 | 566 | 78 | 1 066 | 2 498 | 966 | 22 |
| 88 | 6 210 | 634 | 98 | 1 183 | 2 769 | 1 049 | 24 |
| 89 | 6 666 | 700 | 106 | 1 294 | 3 023 | 1 [illegible]22 | 26 |
| 90 | 7 150 | 787 | 114 | 1 416 | 3 303 | 1 216 | 29 |
| 91 | 9 178 | 862 | 123 | 1 540 | 3 588 | 1 309 | 31 |
| 92 | 8 102 | 957 | 132 | 1 667 | 3 878 | 1 403 | 33 |

APPENDIX 1.4

An ABC Chart of the different pack volumes produced and sold by S.A.B. in the Northern Provinces.




| PACK | % | CUMULATIVE % |
|---|---|---|
| 750 mℓ | 56,5 | 56,5 |
| 450 Can | 20,0 | 76,5 |
| 340 Can | 9,9 | 86,4 |
| 340 NRB | 9,0 | 95,4 |
| 375 mℓ | 3,7 | 99,1 |
| 340 NRB | 0,6 | 99,7 |
| Draught | 0,3 | 100,0 |

The function that describes the 3 cases is:

$$\int_{M=CA_{Li}}^{CA_{Hi}} (L - M)H(L - M)dM$$

$$= H(L - CA_{Li}) \times \frac{(L - CA_{Li})^2}{2} - H(L - CA_{Hi}) \frac{(L - CA_{Hi})^2}{2}$$

APPENDIX 5.1

The following information is copied from "Capital Cost Analysis" and is used as a base for the determination of the general relationship of packaging to brewing capacity. (Reference 5.2)

60 000 hℓ/week

STANDARD BREWERY CAPITAL COSTS PLANT

R x 1 000

| DEPARTMENT | SUB-DEPARTMENT | DESCRIPTION/SCOPE | COSTS |
|---|---|---|---|
| Raw Materials | Malt Handling Plant | | 654,0 |
| | Maize Handling Plant | | 104,6 |
| | Hops Plant | | 654,0 |
| | Dextrose/Maltose Plant | | |
| | Liquid Starch Plant | | |
| | M & P Sundries Plant | | |
| | Sugar Handling Plant | | |
| | | SUB TOTAL | 1 412,6 |
| Brewhouse Plant | Brewing Plant | | 4 744,1 |
| | Wort Cooling | | 196,2 |
| | Yeast Propagation Plant | | 261,6 |
| | Yeast Storage Plant | | 244,5 |
| | Brewing CIP Plant | | 261,6 |
| | Spent Grains Plant | | 196,2 |
| | Waste Yeast Plant | | |
| | | SUB TOTAL | 5 404,1 |
| Cellars Plant | Collection Plant | | 5 578,2 |
| | Fermenting Plant | | 5 215,1 |
| | Maturation Plant | | 457,7 |
| | Cellars CIP Plant | | |
| | | SUB TOTAL | 11 251,1 |
| Filtration & Bright Beer Plant | Filtration Plant | | 1 046,3 |
| | Treatment Plant | | 157,0 |
| | Drip Beer Plant | | 392,4 |
| | Kieselguhr Store Plant | | 32,7 |
| | Sugar Dissolving Plant | | 91,5 |
| | Bright Beer Plant | | 1 662,4 |
| | Dilution Plant | | 366,2 |
| | | SUB TOTAL | 3 748,5 |

60 000 hℓ/week — STANDARD BREWERY CAPITAL COSTS PLANT — R × 1 000

| DEPARTMENT | SUB-DEPARTMENT | DESCRIPTION/SCOPE | COSTS |
|---|---|---|---|
| Packaging Lines | | | 34 005,4 |
| | Packaging Line No. 1 | | |
| | Packaging Line No. 2 | | |
| | Packaging Line No. 3 | | |
| | Packaging Line No. 4 | | |
| | Packaging Line No. 5 | | |
| | Packaging Line No. 6 | | |
| | | SUB TOTAL | 34 605,4 |
| Packaging Hall Plant | | | |
| | Drip Handling Plant | | 65,4 |
| | Cullet Handling Plant | | 65,4 |
| | Carton Forming & destruction | | 130,8 |
| | Caustic Reclamation | | 130,8 |
| | Cask washing & racking | | 196,2 |
| | Ventilation | | 654,0 |
| | | SUB TOTAL | 1 24[illegible],7 |
| Warehouse Plant | | | |
| | Mechanical Handling Plant | | 2 615,8 |
| | Fire Protection | | 654,0 |
| | | SUB TOTAL | 3 269,8 |
| Utilities Plant | | | |
| | Steam Plant | | 3 139,0 |
| | Refrigeration Plant | | 7 903,6 |
| | Electrical Plant | | 5 100,9 |
| | Air Plant | | 706,3 |
| | Water Plant | | 3 139,0 |
| | Effluent Plant | | |
| | $CO_2$ Plant | | 786,7 |
| | | SUB TOTAL | 15 773,3 |
| Site Works Plant | | | |
| | Site & Security Plant | | 192,4 |
| | Weighbridge | | 631,6 |
| | | SUB TOTAL | 824,1 |

60 000 hℓ/week | STANDARD BREWERY CAPITAL COSTS PLANT | R x 1 000

| | DEPARTMENT | SUB-DEPARTMENT | DESCRIPTION/SCOPE | COSTS |
|---|---|---|---|---|
| | Auxiliary Buildings | | | |
| | Fixed Equipment | | | |
| | | Fixed Workshop Equipment | | 130,9 |
| | | Fixed Stores Equipment | | 52,3 |
| | | Fixed Garage Equipment | | 130,9 |
| | | Fixed Laboratory Equipment | | 235,5 |
| | | Kitchen Fixtures | | 287,8 |
| | Security | | | |
| | | Security Fixtures | | 91,5 |
| | | | SUB TOTAL | 928,8 |
| | | | TOTAL PLANT | 77 860,5 |

60 000 hℓ/week — STANDARD BREWERY CAPITAL COSTS BUILDINGS — R x 1 000

| | DEPARTMENT | SUB-DEPARTMENT | DESCRIPTION/SCOPE | UNIT | RATE | COST |
|---|---|---|---|---|---|---|
| | Raw Materials | | | | | |
| | | Silos | | | | 1 333,9 |
| | | Hop Store | | 1 270 m² | 174 | 221,0 |
| | | Brewing Adjuncts Store | | 400 m² | 174 | 69,6 |
| | | | SUB TOTAL | | | 1 624,5 |
| | Brewhouse & By Products | | | | | |
| | | Brewhouse Complex | Includes Wort Cooling & Yeast | | | |
| | | By-Products Buildings | | 3 389 m² | 394,4 | 1 336,7 |
| | | | SUB TOTAL | | | 1 336,7 |
| | Cellars | | | | | |
| | | Ferment Buildings | | 2 673 m² | 266,8 | 713,2 |
| | | Maturation Buildings | | 2 546 m² | 313,2 | 797,4 |
| | | CIP Buildings | | 1 300 m² | 307,4 | 399,6 |
| | | Service Spine | | 2 831 m² | 371,2 | 1 050,8 |
| | | | SUB TOTAL | | | 2 961,0 |
| | Filtration & Bright Beer | | | | | |
| | | Filtration Area | | 1 292 m² | 382,8 | 494,6 |
| | | Kieselguhr Store | | 532 m² | 336,4 | 179,0 |
| | | Bright Beer Buildings | | 578 m² | 348 | 201,1 |
| | | | SUB TOTAL | | | 874,8 |
| | Packaging Lines | | | | | |
| | | Plant Foundations | Line No. 1 | | | 242,4 |
| | | | 2 | | | 242,4 |
| | | | 3 | | | 242,4 |
| | | | 4 | | | |
| | | | 5 | | | |
| | | | 6 | | | |
| | | | SUB TOTAL | | | 727,3 |
| | Packaging Hall | | | | | |
| | | Plant Foundations | | | | 1 566,0 |
| | | Packaging Offices & amenities | | 2 000 m² | 382,8 | 765,6 |
| | | Packaging Workshop & Stores | | 2 000 m² | 174 | 348,0 |
| | | | SUB TOTAL | | | 2 679,6 |

60 000 hℓ/week

STANDARD BREWERY CAPITAL COSTS BUILDINGS

R x 1 000

| DEPARTMENT | SUB-DEPARTMENT | DESCRIPTION/SCOPE | UNIT | RATE | COST |
|---|---|---|---|---|---|
| Warehouse | | | | | |
| | Warehouse Building | | 24 000 m² | 139,2 | 3 340,8 |
| | Distribution Offices | | 467 m² | 382,8 | 178,8 |
| | | SUB TOTAL | | | 3 519,6 |
| Utilities Building | | | | | |
| | Boilerhouse | | 1 000 m² | 203 | 203,0 |
| | Engine Room | | 1 200 m² | 203 | 243,6 |
| | Sub-Station and Switch Rooms | | 1 160 m² | 301,6 | 349,9 |
| | Water Civil Works | | | | 92,8 |
| | Effluent Treatment Civils | | | | 23,2 |
| | | SUB TOTAL | | | 912,5 |
| Site Works | | | | | |
| | Earthworks | | | | 1 856,0 |
| | Staging Roads & Paving | | | | 1 044,0 |
| | Fencing | | 3 700 m | 13,9 | 51,5 |
| | Gatehouse | | 114 m² | 359,6 | 40,9 |
| | Stormwater drains | | | | 97,8 |
| | Effluent drains | | | | 34,8 |
| | Landscaping | | | | 29,0 |
| | Rail Siding | | 4 500 m | 290 | 1 305,0 |
| | Loco Shed | | 169 m² | 150,8 | 25,5 |
| | | SUB TOTAL | | | 4 479,5 |
| Auxiliary Buildings | | | | | |
| | Workshops | | 1 233 m² | 174 | 214,6 |
| | Stores | | 927 m² | 174 | 161,4 |
| | Garage | | 859 m² | 348 | 298,9 |
| | Analytical Laboratory | | 693 m² | 394,8 | 273,3 |
| | Bottling/Pack. Lab. | | 500 m² | 348 | 174,0 |
| | Canteen/Kitchens | | 1 471 m² | 440,8 | 648,4 |
| | Admin. Offices | | 3 100 m² | 440,8 | 1 366,5 |
| | Amenities Building | | 1 638 m² | 440,8 | 722,0 |
| | | SUB TOTAL | | | 3 859,1 |

## APPENDIX 5.2

## GENERAL RELATIONSHIP OF PACKAGING TO BREWING CAPACITY

The following table is a copy of an appendix attached to a memo "Packaging Requirements" dated 07/05/82.

The following summerises the table:

| PLANT | PACKAGING AS A % OF BREWING (F85) |
|---|---|
| Isando | 106 |
| Alrode | 80 |
| Chamdor | 83 |
| Bloemfontein | 74 |
| United Breweries | 76 |
| Rosslyn | 87 |

And it can be seen that, generally, Packaging capacity is significantly less than brewing capacity in contrast to the excess packaging capacity required for Brewery 4 (20%).

PACKAGING ANALYSIS 1985 ('000 hl P.A.)

| | BREW | 750 RB | 375 RB | 340 RB | 500 NRB | 340 NRB | 450 CAN | 340 CAN | DRAUGHT | TOTAL | PACK CAPACITY | UTIL % | % NOTE 1 NOTE 2 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ISANDO: BREWING | 2 826 | | | | | | | | | | | | | |
| LINE 1 | | | | | | | | | | | | | 100 | 1 |
| | | | | | | | 322 | | | 322 | 322 | 100 | | |
| 4 | | | | | | | | 618 | | 618 | 618 | 100 | | |
| 5 | | | | | 114 | 47 | | | | 161 | 330 | 49 | | |
| 6 | | 575 | | | | | | | | 575 | 575 | 100 | | |
| 6A | | 670 | | | | | | | | 670 | 671 | 100 | | |
| DRAUGHT | | | 400 | 57 | | | | | | 457 | 457 | 100 | | |
| TOTAL | | | | | | | | | 23 | 23 | | | | |
| | | 1 245 | 400 | 57 | 114 | 47 | 322 | 618 | 23 | 2 826 | 2 995 | 94 | 105 | 2 |
| ALRODE: BREWING | 3 420 | | | | | | | | | | | | | |
| LINE 7 | | | | | | | | | | | | | 80 | 1 |
| 8 | | 728 | | | | | | | | 728 | 728 | 100 | | |
| 9 | | 576 | | | | | | | | 576 | 576 | 100 | | |
| 10 | | 772 | | | | | | | | 772 | 772 | 100 | | |
| TOTAL | | | | | | | 652 | | | 652 | 652 | 100 | | |
| | | 2 076 | | | | | 652 | | | 2 728 | 2 728 | 100 | 80 | 2 |
| CHAMDOR: BREWING | 2 009 | | | | | | | | | | | | | |
| LINE 2 | | | | | | | | | | | | | 83 | 1 |
| 3 | | | | | | 243 | | | | 243 | 243 | 100 | | |
| 4 | | | | | | | 652 | | | 652 | 652 | 100 | | |
| TOTAL | | 767 | | | | | | | | 767 | 767 | 100 | | |
| | | 767 | | | | 243 | 652 | | | 1 662 | 1 662 | 100 | 83 | 2 |
| BLOEMFONTEIN: BREWING | 238 | | | | | | | | | | | | | |
| LINE 1 | | | | | | | | | | | | | 74 | 1 |
| | | 127 | 7 | | | | 43 | | | 177 | 177 | 100 | 74 | 2 |
| UNITED BREW: BREWING | 670 | | | | | | | | | | | | | |
| LINE 1 | | | | | | | | | | | | | 76 | 1 |
| | | 512 | | | | | | | | 512 | 512 | 100 | 75 | 2 |
| ROSSLYN: BREWING | 4 513 | | | | | | | | | | | | | |
| LINE 1 | | | | | | | | | | | | | | |
| 2 | | 1 006 | | | | | | | | 1 006 | 1 006 | 100 | | |
| 3 | | | | | | 543 | | | | 543 | 543 | 100 | | |
| 4 | | | | | | | 727 | 443 | | 1 170 | 1 377 | 85 | | |
| 5 | | | | | | | | | | | | | | |
| TOTAL | | 1 006 | | | | 543 | 727 | 443 | | 2 719 | | | | |
| TOTAL PRODUCED | | 5 733 | 407 | 57 | 114 | 833 | 2 396 | 1 061 | 23 | 10 624 | | | | |
| TOTAL REQUIRED | | 6 458 | 468 | 57 | 114 | 833 | 2 396 | 1 061 | 23 | 11 410 | | | | |

NOTE: 1 = BREWING CAPACITY UTILISATION %
2 = PACKAGING/BREWING CAPACITY %

## APPENDIX 6.1

## CAPITAL COST SAVING POTENTIAL

The following is a cost breakdown of a typical S.A.B. 750 mℓ (quarts) packaging line with a capacity of 42 000 bottles per hour.

The cost figures represent an estimate of the costs of the above lines for mid 1983 (April 1983).

(Reference 6.1)

42 000 B.P.H. - QUARTS

| ITEM NO: | | (R) |
|---|---|---|
| 1 | Carton Unpacker | 196 730 |
| 2 | Handling two additional cartons | 14 780 |
| 3 | Bottle washer including thermal recovery, detergent neutralisation, detergent transfer, extended label discharge | 1 195 705 |
| 4 | 2 x Bottle inspector-Krones<br>2 x Chipped neck control C | 92 090<br>30 475 |
| 5 | Filler/Crowner | 643 070 |
| 6 | Decanting/Messers Metal Box | 25 346 |
| 7 | Pasteuriser | 607 323 |
| 8 | 2 x Level inspection (with slat reject) | 70 705 |
| 9 | 2 x Labellers | 425 425 |
| 10 | Packer | 254 750 |
| 11 | Handling two additional cartons | 48 300 |
| 12 | Bottle Conveyors | 1 130 450 |
| 13 | Carton cleaning, crate washer (carton inspection including in conveyors) | 39 100 |
| 14 | 2 x Carton make-up | 118 230 |
| 15 | Carton Accumulation | 28 535 |
| 16 | 2 x Depalletisers | 78 200 |
| 17 | Pallet Stacker | 21 620 |
| 18 | 3 x Palletisers | 361 970 |
| 19 | Pallet Conveyors | 241 500 |
| 20 | Bulk Glass Department | 93 185 |
| 21 | Pallet Stacker | 21 620 |
| 22 | Tray Conveyor to Grid System | 166 950 |

| | | |
|---|---|---|
| 23 | Grid System | 247 250 |
| 24 | Carton conveyor - excluding trash conveyor | 943 000 |
| 25 | Electronic Switchboard (H & K) | 196 970 |
| 26 | Instrument Panel (H & K) | 15 910 |
| 27 | Switchboard (H & K) | 107 930 |
| 28 | Field Wiring (H & K) | 21 970 |
| 29 | P.F. Corrections (H & K) | 171 720 |
| 30 | Field Wiring (H & K) | 395 960 |
| 31 | Mimic including wiring - approximately (SUDMO) | 75 760 |
| 32 | Delivery (electrical equipment) | 128 800 |
| 33 | Delivery | 922 300 |
| 34 | Piping Insulation | 6 440 |
| 35 | Line Analysers | 69 000 |
| 36 | Operator Platforms | 28 750 |
| 37 | Lable Removal System | 23 000 |
| 38 | Lubrication - conveyor | 28 750 |
| 39 | Lubrication - plant | 28 750 |
| 40 | H.P. Cleaning reticulation | 6 440 |
| 41 | Ancillaries | 19 550 |
| 42 | Off-loading | 138 000 |
| 43 | Walkways/Conveyor | 345 000 |
| 44 | Electrical Power | 69 000 |
| 45 | Mechanical/Electrical Labour | 617 550 |
| 46 | Crown Remover | 40 250 |
| 47 | Crown Elevator | 126 500 |
| 48 | Trash Conveyor | 39 100 |
| 49 | Pallet Stacker | 20 700 |

## CHAPTER 17: REFERENCES

5.1 Brewery 4 : Management Brief, December 1982 (an internal S.A.B. document).

5.2 Capital Cost Analysis, Standard Breweries Revision 1, 8 November 1980, Engineering Department, Central Office, S.A.B. Beer Division.

6.1 John Cluett, Design Manager: Vereeniging, Engineering Department, Central Office, S.A.B. Beer Division.

6.2 Roger Crosby, Financial Manager, S.A.B. Beer Division.

12.1 John Jones, Senior Consultant: Packaging, Central Office, S.A.B. Beer Division.

13.1 Ken Smith report, Alrode, 1982. (In this study only the labour costs on canning lines were considered, in chapter 13 it is extended to quarts lines as well and the capital saving potential is estimated.)

14.1 Ray Wild, Production And Operation Management, Chapter 11, Holt, Rinehart & Winston, 1980.

14.2 John Larsen, Strategic Planner, and information received from the Financial Manager, Central Office, S.A.B. Beer Division

The following were used as general background:

a) A.J. Merrett & Allen Sykes, The Finance and Analysis of Capital Projects.

b) H & K Journals (English edition).

| | | |
|---|---|---|
| 50 | Born Binders | 172 500 |
| 51 | Painting of Structural Walkways | 57 500 |
| 52 | Pipe Supports | 17 250 |
| 53 | Utility Pipe | 57 500 |
| 54 | Contingencies | 1 051 430 |
| | TOTAL | 12 096 589 |

APPENDIX 6.2

CAPITAL COST SAVING POTENTIAL

The following is a cost breakdown of a typical S.A.B. canning line with a capacity of 60 000 cans per hour.

The cost figure represents an estimate of the cc ˆ tne above line for mid 1983 (April 1983).

(Reference 6.1)

60 000 C.P.H. - CANS

| ITEM NO. | | (R) |
|---|---|---|
| 1 | Pallet Conveyor | 40 700 |
| 2 | Can depalletiser including: Infeed conveyor<br>: Empty Pall. Stacker<br>: Layer Pad Stacker<br>: Accumulation Conveyor | 159 000 |
| 3 | Rope Conveyor | 83 700 |
| 4 | Rinser 2-off | 17 400 |
| 5 | Filler in-feed can conveyor | 14 300 |
| 6 | Filler | 353 100 |
| 7 | Pasteuriser | 714 600 |
| 8 | Seamer | 391 800 |
| 9 | 2 x Level Inspections (with can reject) | 33 700 |
| 10 | Can Conveyors | 429 900 |
| 11 | Accumulation Table | 23 800 |
| 12 | 2 x Level Inspections (with slat reject) | 56 100 |
| 13 | Kiwi Coding | 18 900 |
| 14 | Shrink Wrap ) | |
| 15 | 6 Pack Conveyor ) | 481 500 |
| 16 | Tray Packer ) | |
| 17 | Delivery and Equipment - 13% | 273 900 |
| | Electrical Equipment | |
| 18 | Switchboards | 157 300 |
| 19 | Instrument Panels | 13 100 |
| 20 | Field Wiring | 151 700 |
| 21 | Delivery | 42 300 |

| | | |
|---|---|---|
| 22 | HTR Reticulation | 142 900 |
| 23 | Conveyors | 476 400 |
| 24 | Walkways (also MCC Supports) | 119 100 |
| 25 | Can in-feed system (Bulk and Reception) | 238 200 |
| 26 | Conveyor Lubrication | 29 800 |
| 27 | Plant Lubrication | 29 800 |
| 28 | H.P. Cleaning Reticulation | 5 900 |
| 29 | Line Analyser | 71 500 |
| 30 | Operator Platforms | 29 800 |
| 31 | Piping Insulation | 6 700 |
| 32 | Ancillaries | 21 400 |
| 33 | Offloading | 154 800 |
| 34 | Hunting | 19 000 |
| | Mechanical Electrical Costs | |
| 35 | Painting of Steel | 35 700 |
| 36 | Contingencies | 460 000 |
| | TOTAL | 5 297 800 |

APPENDIX 7.1

COST OF CAPACITY

The calculations performed in the main section are repeated here for calculation of P.V assuming infinite series.

Assuming all functions to be linear and continuous, the current cost o a capacity of 1 000 000 hℓ/year is calculated. The expected life is assumed to be 15 years, inflation 12%, cost of capital 16%, labour wages increases about 1% above inflation resulting in a discounting factor for wages of 3% (0,97).

The case is different for the Plant - the cost of plants generally in the long term do not exceed the inflation rate and therefore, should be discounted at a rate of about 16 - 10 = 6%. Allowing for technical innovations and development at a rate of another 5% per year, results in a discount factor of 11% (1/1,11 = 0,9). The present value of the investment on 750's line, after tax, using 16% as the opportunity cost, is (see Chapter 6 - "Capital Cost Saving Potential") 9,00m Rands (rating 315 hℓ/ha). Present value of capital investment on a canning line is assumed to be 5,3m Rands.

CASH FLOW: 750 LINE WITH LABOUR (INFINITE)

| | CAPITAL INVESTMENT (R) | LABOUR |
|---|---|---|
| 0 | 9 000 000 | 147 881 |
| 1 | | 147 881 |
| 2 | | 147 881 |
| 3 | | 147 881 |
| 4 | | 147 881 |
| 5 | | 147 881 |
| 6 | | 147 881 |
| 7 | | 147 881 |
| 8 | | 147 881 |
| 9 | | 147 881 |
| 10 | | 147 881 |
| 11 | | 147 881 |
| 12 | | 147 881 |
| 13 | | 147 881 |
| 14 | | 147 881 |
| 15 | 9 000 000 | 147 881 |
| . | . | . |
| . | . | . |
| . | . | . |
| . | . | . |

The above are the costs associated with a 750 capacity of 927 360 hℓ/year.

Labour real cost per year after tax - 274 872 x (1 - 0,462) = 147 881.

Labour - infinite annuity of R147 881 per year discounted at 3%:

$$\frac{147\ 881}{1-0,97} = 4\ 929\ 367$$

Capital investment in new capacity, after tax, is R9 000 000 once every 15 years (see Chapter 6 - "Capital Cost Saving Potential").

Discount factor for 15 years - $\left(\frac{1}{1,11}\right)^{15}$ = 0,209 , therefore the P.V. of a series of such expenses is:

$$\begin{aligned} & 9\ 000\ 000 \\ + & 9\ 000\ 000 \times 0,209 \\ + & 9\ 000\ 000 \times 0,209^2 \\ + & \\ \cdot & \\ + & \\ \cdot & \end{aligned}$$

infinitely resulting in a P.V. of $\frac{9\ 000\ 000}{1 - 0,209}$ = R11 378 000

Adding the P.V. of labour and capital:

$$\begin{array}{r} 4\ 929\ 367 \\ +\underline{11\ 378\ 000} \\ 16\ 307\ 370 \end{array}$$

OR for 1 000 000 Hℓ:- 16 307 370 x $\frac{1\ 000\ 000}{927\ 360}$ = 17 584 724

R17 584 724 per 1m Hℓ/year Capacity

OR R17,584 per Hℓ/year Capacity.

CASH FLOW: CANNING LINE WITH LABOUR (INFINITE)

| | CAPITAL INVESTMENT (R) | LABOUR |
|---|---|---|
| 0 | 5 300 000 | 59 952 |
| 1 | | 59 952 |
| 2 | | 59 952 |
| 3 | | 59 952 |
| 4 | | 59 952 |
| 5 | | 59 952 |
| 6 | | 59 952 |
| 7 | | 59 952 |
| 8 | | 59 952 |
| 9 | | 59 952 |
| 10 | | 59 952 |
| 11 | | 59 952 |
| 12 | | 59 952 |
| 13 | | 59 952 |
| 14 | | 59 952 |
| 15 | 5 300 000 | 59 952 |
| . | . | . |
| . | . | . |
| . | . | . |
| . | . | . |

The above are the costs associated with a canning capacity of 577 760 Hℓ/year.

Labour real cost per year after tax - 111 436 x (1 - 0,462) = 59 952

Labour - infinite annuity of R59 952 per year discounted at 3%:

$$\frac{59\ 952}{1-0,97} = 1\ 998\ 400$$

Capital investment in new capacity, after tax, is R5 300 000 once every 15 years (see Chapter 6 - "Capital Cost Saving Potential").

Discount factor for 15 years - $\left(\frac{1}{1,11}\right)^{15} = 0,209$ , therefore the P.V. of a series of such expenses is:

$$\begin{aligned} & 5\ 300\ 000 \\ + & 5\ 300\ 000 \times 0,209 \\ + & 5\ 300\ 000 \times 0,209^2 \\ & . \\ & . \\ & . \\ & . \end{aligned}$$

infinitely resulting in a P.V. of $\frac{5\ 300\ 000}{1 - 0,209}$ = R 6 700 379

Adding the P.V. of labour and capital:

$$\begin{array}{rr} & 1\ 998\ 400 \\ + & \underline{6\ 700\ 379} \\ & 8\ 698\ 779 \end{array}$$

OR for 1 000 000 Hℓ:- 8 698 779 x $\frac{1\ 000\ 000}{577\ 760}$ = 15 056 042

R15 056 042 per 1m Hℓ/year capacity

OR R15,056 per Hℓ/year Capacity.

## APPENDIX 8.1

## CAPACITY MODEL SCREENS

The different input and output screens of the 5 runs discussed in the chapter are presented in appendix no. 8.5 in the first screen. A set of 9 questions are answered by the user setting up the parameters.

The next 5 screens are 5 different runs. In each screen the first 5 columns are input columns and the next 5 are output columns.

| | | |
|---|---|---|
| Period | - | description of the period. |
| Total Sales | - | at that model (quarterly model) total year sales. |
| % Share | - | at that model (quarterly model), the per cent share of that quarter of yearly sales. |
| Capacity | - | Production capacity of the quarter, basically calculated by multiplying the weekly capacity by number of weeks in the period (in the quarter). |
| Cost | - | Cost of introducing a new capacity (if such a capacity is to be introduced). |
| EX UN CAP | - | the expected under capacity for that period using the tolerance parameters given in the first screen and probability distribution assumed by the model (at that stage - uniform distribution). |
| UN CAP COST | - | the present value of the expected loss due to under capacity using depreciation factor and cost per HC not supplied from the first screen. |
| CAP COST | - | the present value of the cost (columns). |
| TOT COST | - | UN CAP COST + CAP COST |
| ACCU COST | - | total cost in present value terms up to that period. |

## APPENDIX 8.2

## REQUIRED PACKAGING CAPACITY MODEL:

## INTEGRATION OF A FUNCTION INVOLVING THE FUNCTION H

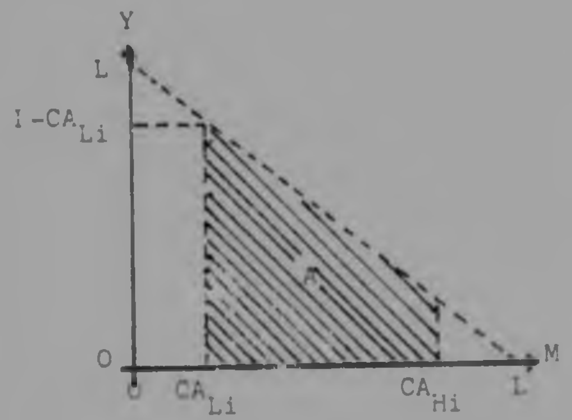
Integrating a function involving the function H.

Refers to the Required Packaging Capacity Model formulation.

$$\int_{M=CA_{Li}}^{CA_{Hi}} (L - M) \times H(L - M)dM$$

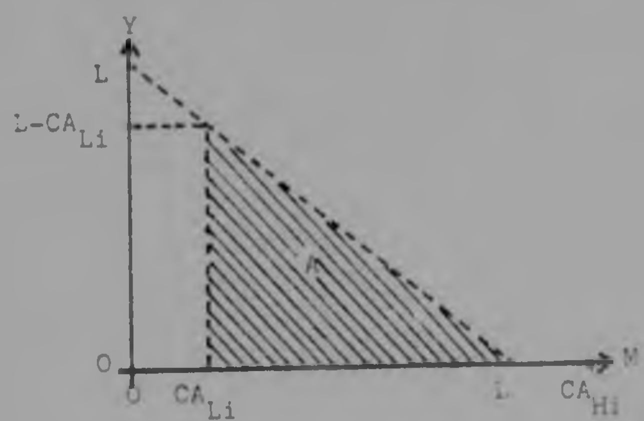
is the area under the curve $Y = F(M) = L - M$ in the region of $L - M \geq 0$.

$$A = \frac{(L - CA_{Li})^2}{2} - \frac{(L - CA_{Hi})^2}{2}$$




If L (sales) happens to be lower than the maximum capacity $CA_{Hi}$ i.e. $L < CA_{Hi}$

$$A = \frac{(L - CA_{Li})^2}{2}$$




If S (sales) is even lower than the lowest capacity i.e. $L < CA_{Li}$, it means that there is no chance of running out of capacity and $A = 0$.

APPENDIX 8.3

REQUIRED PACKAGING CAPACITY COMPUTERISED MODEL

The following is a rough description of the computerised model for helping and guiding a decision maker in deciding future capacity introductions.

The system is stored at work space PA and invoked by typing PCAP1.

The names of all the functions of that system start with P.

| | |
|---|---|
| The function PEUC | calculates the expected under capacity. |
| The function PEC | calculates the expected cost of a plan. This function is modified at the second version of the mode (PCAP2), the cost of introducing new capacity is read from the screen. |
| The function P INPUT 1 | promotes the user to enter basic parameters. |
| The function P INPUT 2 | promotes the user to enter the sales forecast and the capacity plan. |
| The function P INPUT 3 | displays the results and promotes the user for a further trial, or to end the session. |
| The function P ERRORS | detects common errors and stops execution. |

It is important to note some assumptions, hard coded into the model:

PEUC assumes uniform distribution of sales and capacity between the lowest and highest case. If another distribution has to be assumed, the function PEUC has to be modified or replaced.

Another assumption hard coded is that there is a loss only in the case of under capacity and no loss or gain in the event of over capacity except the loss due to unnecessary capital investment, calculated in the functio PEC.

A list of all major variables in the programme is presented to help any future modifications of the programme.

VARIABLES:

| | |
|---|---|
| NUM | Number of periods. |
| CC | Capital investment in Rands per capacity of 1 hℓ per year. |
| RL | Revenue loss due to under capacity - Rands per Hℓ not supplied. |
| RC | Cost of Capital. |
| STA | Sales tolerance in % Above sales forecast. |
| STB | Sales tolerance in % Below sales forecast. |
| CTA | Capacity tolerance in % Above capacity planned. |
| CTB | Capacity tolerance in % Below capacity planned. |
| PCAO | Present Capacity. |
| | |
| TS | Total forecasted sales. |
| PS | Pack (or brand) share in %. |
| PCA | Planned Capacity. |
| SH | Highest sales. |
| SL | Lowest sales. |
| CAH | Highest capacity. |
| CAL | Lowest capacity. |
| ES | Expected sales (= TS x $\frac{PS}{100}$) |

## APPENDIX 8.4

## LOG ON PROCEDURES

The two computerised models are written in APL and are stored in workspace PA on mini disk, under I.D. IDDO, S.A.B. IBM Computer. Once a password is obtained (Systems Department the user has to undertake a series of steps.

| STEP NUMBER | COMMAND TO BE TYPED | MEANING |
|---|---|---|
| 1 | L IDDO PASSWORD | Initialise communication with the computer. |
| 2 | APL | Invoke the APL processor. |
| 3 | )LOAD PA | Loading the workspace the programmes are stored in. |
| 4.1 | PCAP1 | To invoke the first version of the model. |
| 4.2 | PCAP2 | To invoke the modified version of the model. |

## APPENDIX 8.5

| | |
|---|---|
| IF YOU WANT TO QUIT ENTER 0 | 0 |
| CAPITAL INVESTMENT IN NEW CAPACITY RANDS PER HL/ANNUM | 10000000 |
| ESTIMATED COST OF NOT SUPPLYING BEER IN RANDS PER HL NOT SUPPLIED | 40 |
| COST OF CAPITAL TO BE USED | 4 |
| ESTIMATED SALES TOLERANCE (+/-) ABOVE SALES FORCAST | 7 |
| ESTIMATED SALES TOLERANCE (+/-) BELOW SALES FORCAST | 10 |
| ESTIMATED CAPACITY TOLERANCE (+/-) ABOVE PLANNED CAPACITY | 2 |
| ESTIMATED CAPACITY TOLERANCE (+/-) BELOW PLANED CAPACITY | 5 |
| WHAT IS THE CURRENT CAPACITY? | 1423 |

RUN 1

TRY DIFFERENT CAPACITY PLANS TO FIND MINIMUM COST

| PERIOD | TOT SALES | ..SHORT | CAPACITY | EXCT. | EX.OW.CAP | UNUSE. COST | CAP COST | TOT COST | ACCU.COST |
|---|---|---|---|---|---|---|---|---|---|
| [illegible] | 13100.00 | 21.00 | 3423 | 0 | .00 | .1 | .00 | .00 | .00 |
| [illegible] | 13440.00 | 21.00 | 3473 | 0 | .00 | 10.91 | .00 | 10.91 | 10.91 |
| [illegible] | 13440.00 | 32.00 | 4043 | 20000 | 272.41 | 9466.54 | 17777.93 | 27466.89 | 27477.79 |
| [illegible] | 13300.00 | 21.00 | [illegible] | 0 | .00 | 19.31 | .00 | 19.31 | 27497.10 |
| [illegible] | 15000.00 | 21.00 | 4343 | 176000 | .00 | .00 | 103562.82 | 103562.82 | 131059.92 |
| [illegible] | 15800.00 | 24.00 | [illegible] | 0 | .00 | .0 | .00 | .00 | 131059.92 |
| [illegible] | 15800.00 | 32.00 | [illegible] | 0 | 100.14 | 5975.17 | .00 | 5975.17 | 137035.09 |
| [illegible] | 16000.00 | 24.00 | 4367 | 0 | .00 | .0 | .00 | .00 | 136135.09 |
| [illegible] | 17300.00 | 21.00 | 4367 | 0 | .00 | .00 | .00 | .00 | 136135.09 |
| [illegible] | 17300.00 | 21.00 | 4323 | 0 | 1.12 | 31.19 | .00 | 31.19 | 156166.28 |
| [illegible] | 17300.00 | 32.00 | 5184 | 115000 | 44.63 | 100.51 | 81937.1 | 82???.31 | 218393.59 |
| [illegible] | 17300.00 | 24.00 | 5182 | 0 | .00 | .0 | .00 | .00 | 218393.59 |
| [illegible] | 19000.00 | 21.00 | 5187 | 0 | .00 | .0 | .00 | .00 | 218393.59 |
| [illegible] | 19000.00 | 21.00 | 5187 | 0 | .00 | .0 | .00 | .00 | 218393.59 |
| [illegible] | 19000.00 | 32.00 | 5760 | 150000 | 44.50 | 1410.01 | 83289.80 | 84699.99 | 303093.58 |
| [illegible] | 19900.00 | 21.00 | 5509 | 0 | .00 | .0 | .00 | .00 | 303093.58 |
| [illegible] | 20800.00 | 21.00 | 5509 | 0 | .00 | .0 | .00 | .00 | 303093.58 |
| [illegible] | 20800.00 | 25.00 | 5509 | 0 | .00 | .0 | .00 | .00 | 303093.58 |
| [illegible] | 20900.00 | 21.00 | 5509 | 0 | 410.74 | 7798.7 | .00 | 7798.7 | 310891.89 |
| 190 4* | 20800.00 | 24.00 | 5509 | 0 | .44 | 11.68 | .00 | 11.68 | 310903.52 |
| 191 1* | 20800.00 | 21.00 | 5509 | 0 | .00 | .0 | .00 | .00 | 310903.52 |
| [illegible] | 20800.00 | 21.00 | 5509 | 0 | .00 | .0 | .00 | .00 | 310903.52 |

TOTAL EXPECTED COST (PRESENT VALUE) IS 310903.52. THE LOWEST WAS 310903.52

ENTER OPTION-0-QUIT,1 SECOND PLAN,2 RESTART, 3 RESTORE BEST PLAN ************

RUN 2

TRY DIFFERENT CAPACITY PLANS TO FIND MINIMUM COST

| PERIOD | TOT ALT | HOURS | CAPACITY | COST | EX OVERTIME | OH CAP | UNIT CAP COST | TOT COST | ACCUM COST |
|---|---|---|---|---|---|---|---|---|---|
| F85 1? | 13460.00 | 21.00 | 3423 | 0 | .00 | .00 | .00 | .00 | .00 |
| F86 2? | 13460.00 | 23.00 | 3423 | 0 | .29 | 10.71 | .00 | 10.71 | 10.71 |
| [illegible] | 13460.00 | [illegible] | 4043 | 70000 | 23.41 | 9606.[illegible] | 12779.93 | 22460.09 | 22477.[illegible] |
| [illegible] | 13460.00 | 14.00 | 3557 | 0 | .56 | 19.31 | .00 | 19.31 | 27492.[illegible] |
| F8? 1? | 15000.00 | 11.00 | 3557 | 0 | 5.95 | 175.86 | .00 | 175.86 | 27697.56 |
| [illegible] | 15000.99 | [illegible] | [illegible] | 0 | 121.58 | 3917.[illegible] | .00 | 3917.38 | 31611.9[illegible] |
| F87 2? | 15000.00 | 22.00 | 4950 | 130000 | 154.96 | 5075.37 | 95749.64 | 100024.82 | 132436.78 |
| F87 1? | 15000.00 | 24.00 | 4363 | 0 | .00 | .00 | .00 | .00 | 132436.78 |
| F88 ? | 17300.00 | [illegible] | 4363 | 0 | .00 | .00 | .00 | .00 | 132436.78 |
| F89 ? | 17300.00 | [illegible] | 4363 | 0 | 1.15 | 31.19 | .00 | 31.19 | 133467.97 |
| F88 2? | 17300.00 | 32.00 | 4950 | 0 | 569.54 | 14798.[illegible] | .00 | 14798.[illegible] | 147266.54 |
| F88 ? | 17300.00 | 24.00 | 4363 | 0 | 30.42 | 510.[illegible] | .00 | 510.[illegible] | 147776.63 |
| F89 1? | 19000.00 | 21.00 | 4363 | 0 | [illegible] | 37.29 | .00 | 37.29 | 147813.89 |
| F89 2? | 19000.00 | 23.00 | 4363 | 0 | 401.57 | 2346.25 | .00 | 2346.25 | 150160.13 |
| F89 ? | 19000.00 | 32.00 | 5269 | 130000 | [illegible] | 1810.31 | [illegible] | 154663.32 | 304823.45 |
| F89 1? | 19000.00 | 24.00 | 5509 | 0 | .00 | .00 | .00 | .00 | 304823.45 |
| F90 1? | 20800.00 | 21.03 | 5507 | 0 | .00 | .00 | .00 | .00 | 304823.45 |
| F90 2? | 20800.00 | 23.00 | 5509 | 0 | .00 | .00 | .00 | 7798.27 | 312621.72 |
| F90 ? | 20800.00 | 32.00 | 6760 | 0 | 119.24 | 7798.27 | .00 | 11.68 | 312633.40 |
| F90 1? | 20800.00 | 24.00 | 5509 | 0 | .68 | 11.38 | .00 | .00 | 312633.40 |
| F91 1? | 20800.00 | 21.00 | 5507 | 0 | .00 | .00 | .00 | .00 | 312633.40 |
| F91 2? | 20800.00 | 23.00 | 5509 | 0 | .00 | .00 | .00 | .00 | 312633.40 |

TOTAL EXPECTED COST (PRESENT VALUE) IS 312633.398 THE LOWEST WAS 110903.523

ENTER OPTION 0 QUIT,1 SECOND PLAN,2 RESTART, 3 RESTORE BEST PLAN***************

EVA 3

TRY DIFFERENT CAPACITY PLANS TO FIND MINIMUM COST

| PERIOD | TOT SALES | AV.CHARGE | CAPACITY | COST | EX DEFICIT | DEFICIT | CAP COST | TOT COST | ACCU COST |
|---|---|---|---|---|---|---|---|---|---|
| [illegible] | 12480.00 | 21.00 | 3423 | 0 | .00 | .00 | .00 | .00 | .00 |
| [illegible] | 13440.00 | 23.00 | 3423 | 0 | .[illegible] | 10.91 | .00 | 10.91 | 10.91 |
| [illegible] | 13400.00 | 32.00 | 4363 | 146000 | .00 | .00 | 129793.47 | 129793.47 | 129804.38 |
| [illegible] | 13360.00 | 21.00 | 4363 | 0 | .00 | .00 | .00 | .00 | 129804.38 |
| [illegible] | 15000.00 | 21.00 | 4363 | 0 | .00 | .00 | .00 | .00 | 129804.38 |
| [illegible] | 15000.00 | 23.00 | 4363 | 0 | .00 | .00 | .00 | .00 | 129804.38 |
| [illegible] | 15000.00 | 32.00 | 5094 | 174000 | .00 | .00 | 95749.64 | 95749.64 | 225554.02 |
| [illegible] | 15000.00 | 24.00 | 5107 | 0 | .00 | .00 | .00 | .00 | 225554.02 |
| [illegible] | 17200.00 | 21.00 | 5107 | 0 | .00 | .00 | .00 | .00 | 225554.02 |
| [illegible] | 17300.00 | 23.00 | 5107 | 0 | .00 | .00 | .00 | .00 | 225554.02 |
| [illegible] | 17300.00 | 32.00 | 5094 | 0 | 14.63 | 380.11 | .00 | 380.11 | 225934.13 |
| [illegible] | 17300.00 | 24.00 | 5107 | 0 | .00 | .00 | .00 | .00 | 225934.13 |
| [illegible] | 19000.00 | 21.00 | 5107 | 0 | .00 | .00 | .00 | .00 | 225934.13 |
| [illegible] | 19000.00 | 23.00 | 5107 | 0 | .00 | .00 | .00 | .00 | 225934.13 |
| [illegible] | 19000.00 | 32.00 | 6260 | 150000 | 53.50 | 1410.31 | 83289.68 | 84699.99 | 310634.12 |
| [illegible] | 19000.00 | 24.00 | 5509 | 0 | .00 | .00 | .00 | .00 | 310634.12 |
| [illegible] | 20800.00 | 21.00 | 5509 | 0 | .00 | .00 | .00 | .00 | 310634.12 |
| [illegible] | 20800.00 | 23.00 | 5509 | 0 | .00 | .00 | .00 | .00 | 310634.12 |
| [illegible] | 20800.00 | 32.00 | 6260 | 0 | 310.74 | 7798.27 | .00 | 7798.27 | 318432.39 |
| [illegible] | 20800.00 | 24.00 | 5509 | 0 | .64 | 11.68 | .00 | 11.68 | 318444.07 |
| [illegible] | 20800.00 | 21.00 | 5509 | 0 | .00 | .00 | .00 | .00 | 318444.07 |
| [illegible] | 20800.00 | 23.00 | 5509 | 0 | .00 | .00 | .00 | .00 | 318444.07 |

TOTAL EXPECTED COST (PRESENT VALUE) IS 318444.067 THE LOWEST WAS 310903.523

ENTER OPTION 0 QUIT,1 SECOND PLAN ,2 RESTART, 3 RESIDUE BEST PL[illegible] 1

THE PLAN

[illegible] 4

TRY DIFFERENT CAPACITY PLANS TO FIND MINIMUM COST

| [illegible] | TOT SALES | [illegible] | CAPACITY | COST | [illegible] | [illegible] | [illegible] COST | [illegible] COST | CUM COST |
|---|---|---|---|---|---|---|---|---|---|
| [illegible] 1· | 1[illegible]60.00 | 21.00 | [illegible] | 0 | .00 | .00 | .00 | .00 | .00 |
| FB6 2· | 13460.00 | 23.00 | 3423 | 0 | .29 | 15.91 | .00 | 10.91 | 10.91 |
| [illegible] | 13460.00 | 22.00 | [illegible] | 9000 | [illegible]92.41 | [illegible]6.96 | 17720.93 | 27466.07 | 27477.19 |
| [illegible] 1· | 13860.00 | 21.00 | [illegible] | 0 | .96 | 9.31 | .00 | 19.31 | 27497.40 |
| FB7 1· | 13800.00 | 21.00 | 3557 | 0 | 5.95 | 1[illegible]5.46 | .00 | 195.46 | 27692.56 |
| [illegible] | [illegible]00.00 | 23.00 | [illegible] | 126000 | .09 | .0[illegible] | [illegible]9.63 | 99519.63 | 127272.19 |
| [illegible] | 15800.00 | [illegible].00 | [illegible] | 0 | 446.96 | [illegible]5.17 | .00 | 5075.[illegible] | 132347.37 |
| FB7 4· | 15800.00 | 24.00 | 4743 | 0 | .00 | .00 | .00 | .00 | 132347.37 |
| [illegible] 1· | 1[illegible]300.00 | 21.00 | [illegible] | 0 | .00 | .00 | .00 | .00 | 132347.37 |
| [illegible] | 17300.00 | 23.00 | [illegible] | 0 | [illegible].15 | 1.49 | .00 | 31.19 | 132378.[illegible]6 |
| FB8 3· | 17300.00 | 32.00 | 5074 | 126000 | 14.43 | 708.31 | 81842.20 | 82227.31 | 214605.86 |
| FB8 4· | 17300.00 | 24.00 | [illegible]87 | 0 | .00 | .00 | .00 | .00 | 214605.86 |
| [illegible] | 19000.00 | 21.00 | 5[illegible] | 0 | .00 | .00 | .00 | .00 | 214605.86 |
| [illegible] | 19000.00 | 21.00 | [illegible]187 | 0 | .00 | .00 | .00 | .00 | 214605.86 |
| [illegible] | 19000.00 | 32.00 | [illegible].60 | 150000 | 63.50 | [illegible]9.31 | 8[illegible].68 | [illegible]699.99 | 299305.85 |
| [illegible] 4· | 19000.00 | 21.00 | [illegible] | 0 | .00 | .00 | .00 | .00 | 299305.85 |
| FB9 1· | 20800.00 | 21.00 | 5509 | 0 | .00 | .00 | .00 | .00 | 299305.85 |
| [illegible] | 20800.00 | 23.00 | [illegible]509 | 0 | .00 | .00 | .00 | .00 | 299305.85 |
| [illegible] | 20800.00 | 32.00 | 6[illegible]60 | 0 | 419.74 | [illegible]3.27 | .00 | 7798.27 | 307104.1[illegible] |
| [illegible] 4· | 20800.00 | 24.00 | 5509 | 0 | .64 | 11.68 | .00 | 11.68 | 307115.80 |
| [illegible] 1· | 20800.00 | 21.00 | [illegible]509 | 0 | .00 | .00 | .00 | .00 | 307115.80 |
| [illegible] 2· | 20800.00 | 24.00 | 5509 | 0 | .00 | .00 | .00 | .00 | 307115.80 |

TOTAL EXPECTED COST PRESENT VALUE IS 307115.799 THE LOWEST WAS 307115.799

ENTER OPTION-0 QUIT,1-SECOND PLAN ,2 RESTART, 3 RESTORE BEST PLAN++++++++++++++ 1

RUN 5

THE DIFFERENT CAPACITY PLANS TO FIND MINIMUM COST

| [illegible] | COST [illegible] | [illegible] | CAPACITY | [illegible] | E | E-SQD | UN-CAP | COST CAP | COST | TOT COST | ACCUMULATE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | 13460.00 | 21.00 | 3423 | 0 | | .00 | .00 | | .00 | .00 | [illegible] |
| [illegible] | 13460.00 | 21.00 | 3423 | 0 | | .29 | 10.21 | | .00 | 10.21 | 10.21 |
| [illegible] | [illegible] | [illegible] | [illegible] | 20000 | | 272.41 | 7686.36 | | 17779.93 | [illegible] | [illegible] |
| [illegible] | 13460.00 | 24.00 | [illegible] | 0 | | .56 | 15.31 | | .00 | 15.31 | 22497.10 |
| [illegible] | 13000.00 | 21.00 | 3557 | 0 | | 5.35 | 151.48 | | .00 | 151.48 | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | 123.98 | 3719.18 | | .00 | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | 120000 | | 166.94 | 5079.17 | | 95749.14 | [illegible] | 132436.[illegible] |
| [illegible] | [illegible] | 24.00 | [illegible] | 0 | | .00 | .00 | | .00 | .00 | 132436.70 |
| [illegible] | [illegible] | [illegible] | [illegible] | 0 | | .00 | .00 | | .00 | .00 | 132436.[illegible] |
| [illegible] | 13350.00 | 25.00 | 4363 | 0 | | 1.12 | 31.19 | | .00 | 31.19 | 132467.9[illegible] |
| [illegible] | 13500.00 | 12.00 | 5098 | 120000 | | 14.63 | 38[illegible].11 | | 81897.20 | [illegible] | 21[illegible] |
| [illegible] | [illegible] | 24.00 | [illegible] | 0 | | .00 | .00 | | .00 | .00 | [illegible] |
| [illegible] | 19000.00 | 24.00 | 5107 | 0 | | .00 | .00 | | .00 | .00 | 214695.[illegible] |
| [illegible] | 17000.00 | 23.00 | 5107 | 0 | | .00 | .00 | | .00 | .00 | 214695.[illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | 150000 | | 61.50 | 1410.41 | | 83280.18 | [illegible] | 299195.36 |
| [illegible] | 19000.00 | 24.00 | 5508 | 0 | | .00 | .00 | | .00 | .00 | 299195.26 |
| [illegible] | 20800.00 | 21.00 | 5509 | 0 | | .00 | .00 | | .00 | .00 | [illegible] |
| [illegible] | 20800.00 | [illegible] | 5509 | 0 | | .00 | .00 | | .00 | .00 | 299195.[illegible] |
| [illegible] | 20800.00 | 17.00 | 6260 | 0 | | 410.74 | 7790.17 | | .00 | 7790.17 | 307193.53 |
| [illegible] | 20800.00 | 24.00 | 5509 | 0 | | .44 | 11.08 | | .00 | 11.08 | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | 0 | | .00 | .00 | | .00 | .00 | 307205.21 |
| [illegible] | 20800.00 | [illegible] | 5509 | 0 | | .00 | .00 | | .00 | .00 | 307205.21 |

[illegible] EXPECTED COST [illegible] VALUE IS 307205.[illegible] THE LOWEST WAS 307[illegible]

[illegible] 0 [illegible] 2 [illegible] FLOW 3 RESTART 4 RESTORE [illegible] 1

## APPENDIX 14.1

### N.P. F81 WEEKLY DEMAND PERCENTAGES

| | WEEK END-ING | DEMAND % | CUMU-LATIVE DEMAND % | | WEEK END-ING | DEMAND % | CUMU-LATIVE DEMAND % |
|---|---|---|---|---|---|---|---|
| APR 3 | 1 | 1,81 | 1,81 | OCT 2 | 27 | 2,16 | 45,72 |
| 10 | 2 | 1,70 | 3,51 | 9 | 28 | 2,11 | 47,83 |
| 17 | 3 | 1,29 | 4,80 | 16 | 29 | 2,36 | 50,19 |
| 24 | 4 | 1,28 | 6,08 | 23 | 30 | 2,10 | 52,29 |
| MAY 1 | 5 | 1,61 | 7,69 | 30 | 31 | 2,16 | 54,45 |
| 8 | 6 | 1,69 | 9,38 | NOV 6 | 32 | 2,80 | 57,23 |
| 15 | 7 | 1,48 | 10,86 | 13 | 33 | 2,56 | 59,81 |
| 22 | 8 | 1,61 | 12,47 | 20 | 34 | 2,63 | 62,44 |
| 29 | 9 | 1,47 | 13,94 | 27 | 35 | 2,35 | 64,79 |
| JUNE 5 | 10 | 1,67 | 15,61 | DEC 4 | 36 | 2,75 | 67,54 |
| 12 | 11 | 1,54 | 17,15 | 11 | 37 | 2,72 | 70,26 |
| 19 | 12 | 1,38 | 18,53 | 18 | 38 | 2,69 | 72,95 |
| 26 | 13 | 1,36 | 19,89 | 25 | 39 | 1,99 | 74,94 |
| JULY 3 | 14 | 1,72 | 21,61 | JAN 1 | 40 | 2,29 | 77,23 |
| 10 | 15 | 1,51 | 23,12 | 8 | 41 | 1,85 | 79,08 |
| 17 | 16 | 1,52 | 24,64 | 15 | 42 | 1,50 | 80,58 |
| 24 | 17 | 1,50 | 26,14 | 22 | 43 | 1,75 | 82,33 |
| 31 | 18 | 1,75 | 27,89 | 29 | 44 | 1,85 | 84,18 |
| AUG 7 | 19 | 2,04 | 29,93 | FEB 5 | 45 | 2,11 | 86,29 |
| 14 | 20 | 1,68 | 31,61 | 12 | 46 | 1,84 | 88,13 |
| 21 | 21 | 1,69 | 33,30 | 19 | 47 | 1,71 | 89,84 |
| 28 | 22 | 2,15 | 35,45 | 26 | 48 | 1,91 | 91,75 |
| SEPT 4 | 23 | 2,19 | 37,64 | MAR 5 | 49 | 2,23 | 93,98 |
| 11 | 24 | 2,08 | 39,72 | 12 | 50 | 2,02 | 96,00 |
| 18 | 25 | 1,85 | 41,57 | 19 | 51 | 2,00 | 98,00 |
| 25 | 26 | 1,99 | 43,56 | 26 | 52 | 2,00 | 100,00 |

## APPENDIX 14.2

## OVERTIME COST CALCULATIONS

The following is the calculation of the additional cost, per Hℓ, per pack when produced in overtime production.

Five typical Northern Provinces production lines were used for the purpose of the calculation.

| | | | | | | |
|---|---|---|---|---|---|---|
| PACK | | 750 Mℓ | 450 CAN | 340 CAN | 340 NRB | 375 PINTS |
| PRODUCTION LINE | | ROSSLYN LINE 1 | ROSSLYN LINE 3 | ISANDO LINE 3 | ROSSLYN LINE 2 | ISANDO LINE 6A |
| RATE AFTER EFFICIENCY AND COST | Hℓ/HR | 201,20 | 140,60 | 133,30 | 117,00 | 103,00 |
| NORMAL TIME COST | R/HR | 113,50 | 54,67 | 37,70 | 58,49 | 44,58 |
| OVERTIME | R/HR | 140,39 | 65,51 | 44,39 | 70,35 | 75,21 |
| ADDITIONAL COST | R/HR | 26,89 | 10,84 | 6,6 | 11,86 | 10,63 |
| ADDITIONAL COST PER Hℓ | R/Hℓ | 0,1336 | 0,0771 | 0,0495 | 0,1014 | 0,1032 |

The costs are labour costs (R/HR) under normal time and overtime operation. The cost per Hℓ is calculated by dividing the cost by the rate. The cost being the difference between normal time cost and overtime cost, which is the additional cost per Hr when moving to an overtime operation.