Fig: 4. 8. 3.

Cost of Live Storage vs Conventional Storage

	Live Storage	Conventional Storage
Floor area needed	11500 m^2 70% eff. 6 storeys	23000 m^2 70% efficiency
Height needed	11 m	5 m
Cost of building x	1150 000,00 R100/m^2	1 300 000,00 R56/m^2
Cost of racking & conveyor	1 950 000,00	-
Cost of land at R40/m^2	460 000,00	920 000,00
TOTAL CAPITAL OUTLAY (discounted over 10 years).	3 560 000,00	2 220 000,00
Materials handling equipment	310 000,00 Stacker cranes	160 000,00 Forklifts
Labour	5400,00 p.a.	21 000,00 p.a.
Running costs	8 000,00 p.a.	18 000 p.a.
Total p.a.	395 000,00	256 000,00
Difference	139 000,00	

x Live storage frame reduces building costs considerably.

As can be seen Live storage cannot yet be justified on a cost basis in South Africa - as land prices are not high enough to warrant these high expenses. However, if one considers that the construction of live storage racks can increase existing storage space considerably such that it might mean that an existing property may have its life extended.

Furthermore, the construction of live storage warehouses might mean that a smaller property would be suitable for a warehouse and smaller properties might be more centrally situated with respect to the market.

Also tax savings on the much higher investments involved in the live storage alternative would also reduce the actual difference in the amounts of money needed.

4.9. MAKING OF ORDERS

Consider a typical beverage warehouse which distributes ± 30 packages.

A normal day's order will consist of a mix of all these packages. Some customers will only take one or two cases of a specific product. This means that entire pallets of products cannot be loaded onto a truck.

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Mixed pallets must thus be assembled. This order picking occupies a considerable amount of time and effort.

Typically 60% of all pallets leaving the factory will be mixed pallets. This means up to ± 1 000 pallets a day need to be assembled during an order make up period to load the trucks when they return from their day's deliveries.

4.9.1. Hand-order picking

Nearly all order picking is done by hand throughout the world.

Trolleys of all sorts are used to fetch the various cases of products from the warehouse floor.

4.9.2. Automatic order picking

As yet automatic order picking has not yet reached South Africa in the beverage industry.

This is because of the cost of such systems, freely available labour and the large number of packages handled by South African concerns. However automatic and semi-automatic order picking systems are likely to become more prominent in the future.

CHAPTER 5

DISTRIBUTION OF PRODUCT TO AND FROM THE CONSUMER

5.1. AIMS

5.1.1. To reduce the number of trucks used.

5.1.2. To reduce labour.

5.1.3. To reduce time spent on distribution.

5.1.4. To improve customer service.

5.1.5. To help select correct trucks.

5.1.6. To comply with all laws and proposed laws.

Consider a typical high volume distributor in a metropolitan area such as Johannesburg. He would need to service ± 10 000 outlets per week. For highly perishable goods e.g. milk, he would visit these customers daily, and in the beverage industry, weekly.

5.2. BACKGROUND

When the author started his investigation, the main idea was to examine exactly what was happening during the distribution of the product from the warehouse to the customer. The aim was not to influence the distribution network, but to observe all "goings on".

A period of approximately 6 months was spent doing these observations, mainly in the Johannesburg/Nigel area, most of the actual time studies being done at Nigel Bottling Industries (N. B. I.).

5. 3. ANALYSIS OF SELF RECORDING SHEETS

To achieve the aim mentioned above, it was decided to place a self recording sheet on each delivery vehicle (see Fig: 5. 3. 1.). These self recording sheets were to be filled out by the drivers during their deliveries.

The aim of introducing these self recording sheets was to separate out the variation in the time taken to handle a given number of cases and time taken to drive a given distance.

Some 5 000 self recording sheets were processed, in all cases 3 helpers and one driver being considered.

A graph of the time taken to handle a given number of cases was then drawn up (see Fig: 5. 3. 2.) and a straight line was fitted to the graph.

A co-efficient of determination (see appendix 1) of $r^2 = 0,91$ was found.

A second graph of the time taken to cover a given distance was also done (see Fig: 5. 3. 3.) and a coefficient of determination of $r^2 = 0,94$ was found.

FIG: 5.3.1.

Driver : .... Date : .... No. of Truck Helpers ..

DRIVER'S SELF RECORDING SHEET

Time Arrived	Time Left	Cases Dropped/Picked Up			Name of Store	Town	Speedo Reading
		Ret. Fulls	N/R Fulls	Empty			

FIG: 5.3.1.

Driver : .... Date : .... No. of Truck Helpers ..

DRIVER'S SELF RECORDING SHEET

Time Arrived	Time Left	Cases Dropped/Picked Up			Name of Store	Town	Speedo Reading
		Ret. Fulls	N/R Fulls	Empty			

FIG : 5.3.2

GRAPH OF TIME TAKEN TO DELIVER A GIVEN NO. OF CASES - OBTAINED FROM SELF-RECORDING SHEETS

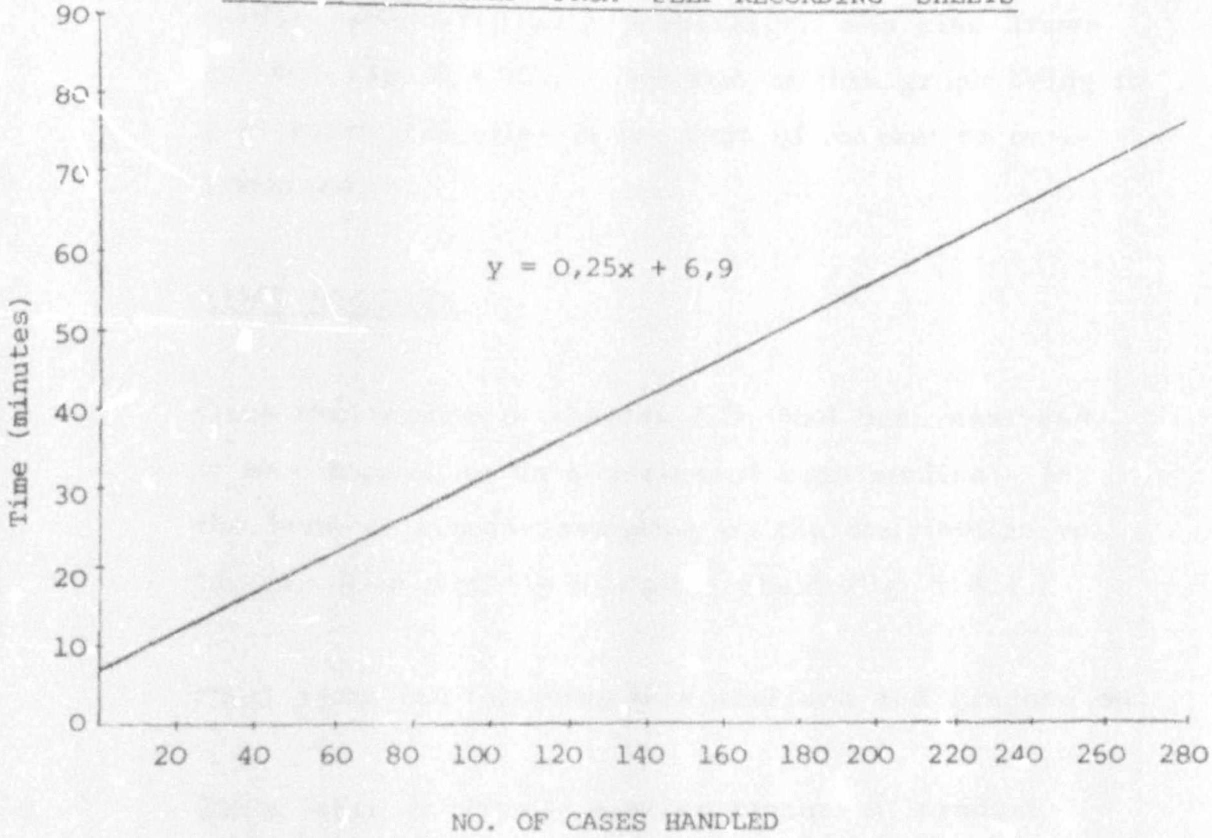
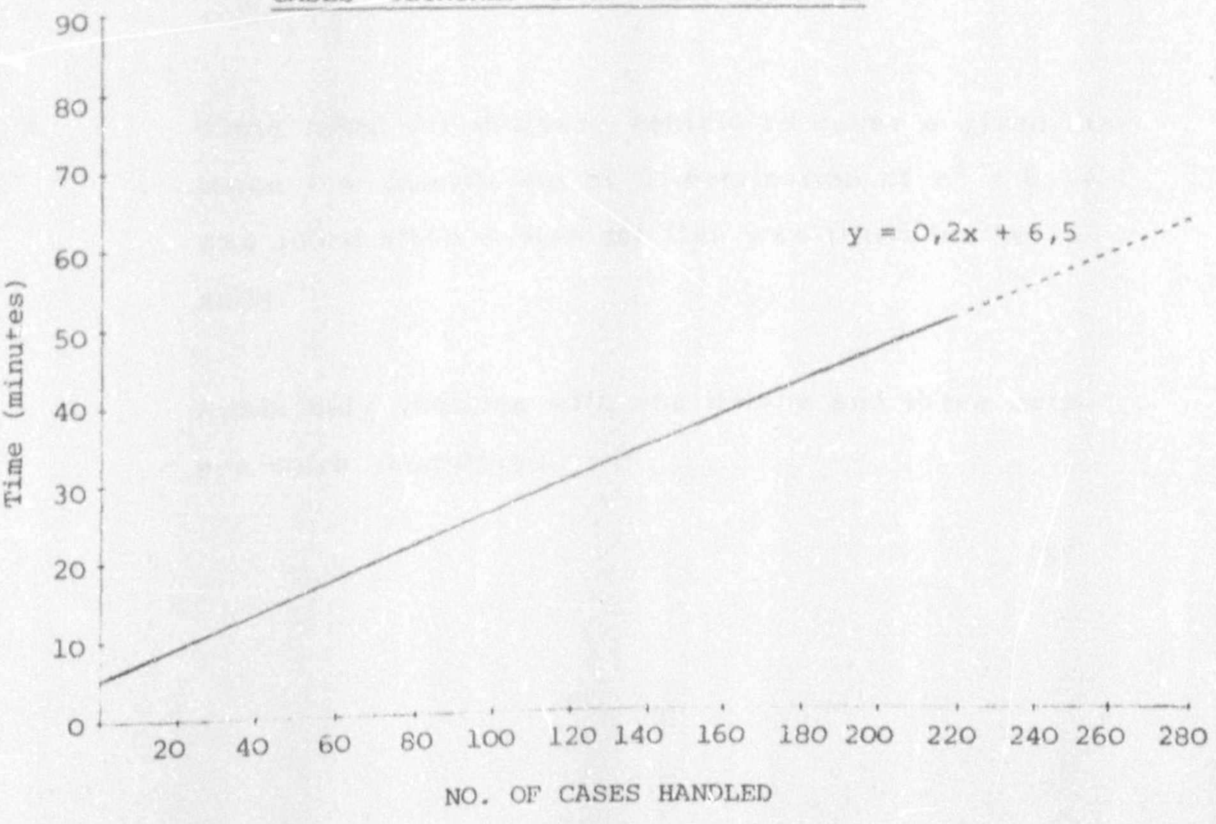


FIG : 5.3.3

GRAPH OF TIME TAKEN TO DELIVER A GIVEN NO. OF CASES OBTAINED FROM TIME STUDIES



Using the same data a graph of the number of cases dropped versus the cumulative number of outlets visited considered as a percentage, was also drawn up (see Fig: 2. 4. 1.). The aim of this graph being to give some indication of the type of market to be examined.

5. 4. TIME STUDIES

5. 4. 1. Once the results in chapter 5. 3. had been analysed, it was decided to do a series of time studies - in the form of activity sampling on the distribution vehicles. (See Activity Sampling Sheet Fig: 5. 4. 1.).

Once again the following was analysed and graphed out.

5. 4. 2. Time taken to deliver a given amount of product (see Fig: 5. 3. 3.) - a co-efficient of determination of $r^2 = 0,94$ was found, (see appendix 1 for worked example) when a straight line was fitted to the results.

5. 4. 3. Time taken for delivery vehicle to cover a given distance - a co-efficient of determination of $r^2 = 0,94$ was found when a straight line was fitted to the results.

Again only vehicles with one driver and three helpers were considered.

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FIG. 5.4.1

ACTIVITY SAMPLING SHEET

D	1	2	3	4	D	1	2	3	4	D	1	2	3	4

GENERAL INFORMATION

	START	STOP	DURATION
SPEEDO			
TIME			

NAME OF STORE

N/R FULLS	RET. FULLS	RET. EMPTY

CODES

C = UNLOAD FROM VEHICLE
D = FULLS INTO STORE
G = EMPTIES FROM STORE
H = EMPTIES ONTO VEHICLE
L = SORT EMPTIES
O = PARK
P = INSTRUCTIONS
Q = ARRANGE VEHICLE
E = IDLE
IE = ENFORCED IDLE
A = PAPERWORK AND PROCEDURE (DRIVER ONLY)

Appendix 1 shows the results obtained and how they were analysed.

Besides this, the details of the activity sampling sheets were also analysed - these results are shown in Fig: 5.4.4.

Discussion of results:

As can be seen, the linear regression line fits the data very closely ($r^2 = 0,94$). An even closer co-efficient of determination ($r^2 = 0,948$) could be found by fitting a power curve to the data. This is to be expected as when the number of cases involved increases, the idle time incurred by the helpers decreases (see Fig: 5.4.5.) and the graph flattens out. However, for practical purposes, the straight line fits the graph well enough to consider the delivery times as a linear function.

Travelling Time vs Distance Travelled (see Fig: 5.6.2)

Here the linear regression line fits the data very closely - co-efficient of determination $r^2 = 0,94$.

As in Fig: 5.3.2., the origin of the graph is not zero as it still takes time to move the truck to a new outlet even if the distance is very small.

The time from the base of the vertical time axis to the origin of the graph is thus a constant time involved in each delivery or distance travelled.

FIG: 5. 4. 4.

	Small Drops mean 40 cases 2 helpers	Large Drops mean 100 cases 3 helpers
% of Time Spent:		
Unloading	10	14
Fulls to Store	10	15
Empties from Store	7	12
Empties onto vehicle	6	9
Sorting Empties	10	12
Giving Instructions	3	2
Arranging Truck	6	14
Idle	35	14
Administration	13	8

FIG : 5.4.5

INCREASE IN IDLE TIME
WITH NO. OF CASES DROPPED

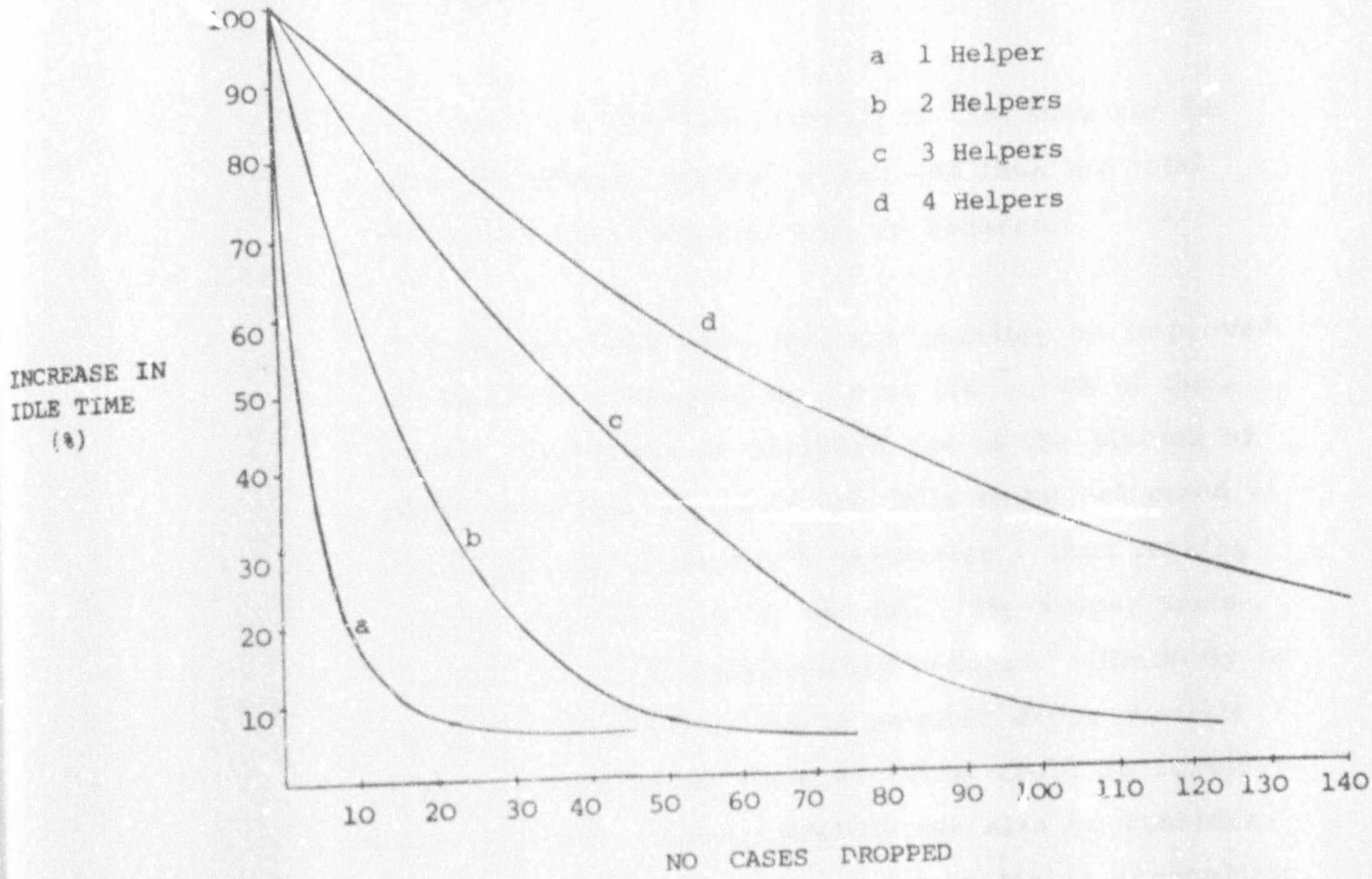


FIG : 5.4.5

INCREASE IN IDLE TIME

WITH NO. OF CASES DROPPED

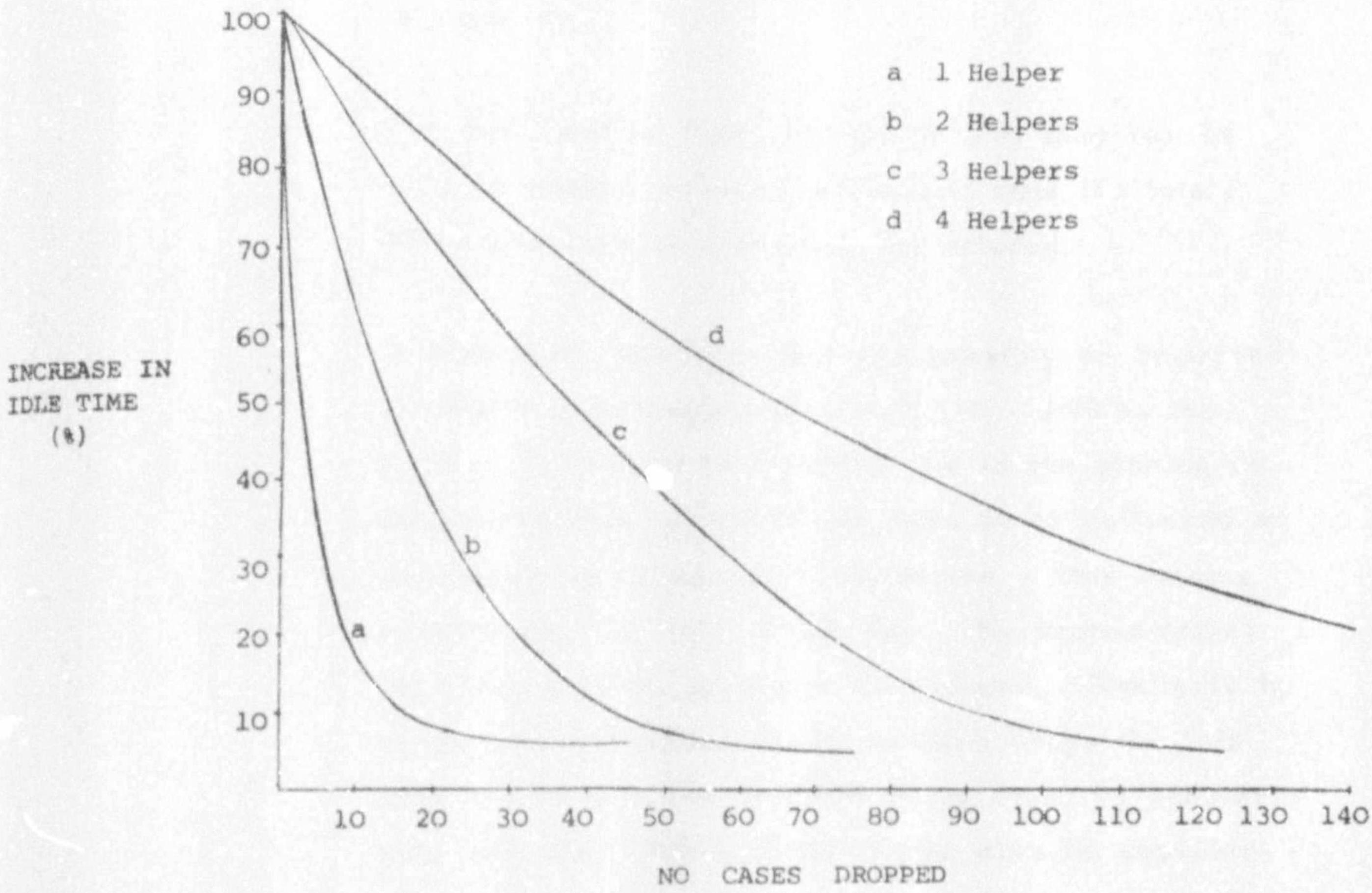


Fig: 5.4.4. - Table of Average Activity Times

This table shows how the time involved in each drop is made up.

The main use of these results is that they can be used to identify problem areas and thus the total amount of time involved can be reduced.

In this case, the item that can possibly be improved the most is arranging the truck (10 - 14% of the time). This time is incurred due to the placing of empty products on top of the fulls to be delivered at the beginning of the day's deliveries - thus making access difficult later in the day. By proper training this could be considerably reduced. Similarly by correct labour allocation to smaller drops the idle time involved in the smaller drops could be considerably reduced. Administration can also be considerably reduced (see chapter 5.9.) by taking appropriate steps.

Fig: 5.4.5. - Idle Time vs Size of Drop

Here we can see how the idle time decreases with the increase in the size of the drop. By plotting out similar graphs for different labour complements, the change in idle times with drop size can easily be seen.

Fig 5.4.5. can be used as a labour warning guide for each delivery. It also shows that using a constant labour complement for each truck no matter what the size of the drop, is not a good idea, as this leads to over-staffing on the small drops and under-staffing on the large drops (see chapter 5.8).

5.5. COMPARISON OF RESULTS:

The next step was to analyse the results found from the self recording sheets (chapter 5.3.) and the time studies (chapter 5.4.).

Fig: 5.5.1. shows graphs 5.3.2. and 5.3.3. on the same axies

As can be seen there is a large difference in the time involved in each drop when one compares the times found on the self recording sheets and the time found from the activity sampling, the average difference ranging from 18% to 24%.

The differences expressed by this graph must be time available to us that can easily be saved.

By saving the times shown, massive improvements (between 18% and 24%) can be made to our distribution system.

5.5.1. Reasons for the differences.

The main reason for these differences seems to be one of control. During the time that the activity

FIG : 5.5.1

GRAPH SHOWING POSSIBLE SAVINGS WHEN COMPARING TIMES SHOWN BY SELF-RECORDING SHEETS AND TIMES SHOWN BY ACTIVITY SAMPLING

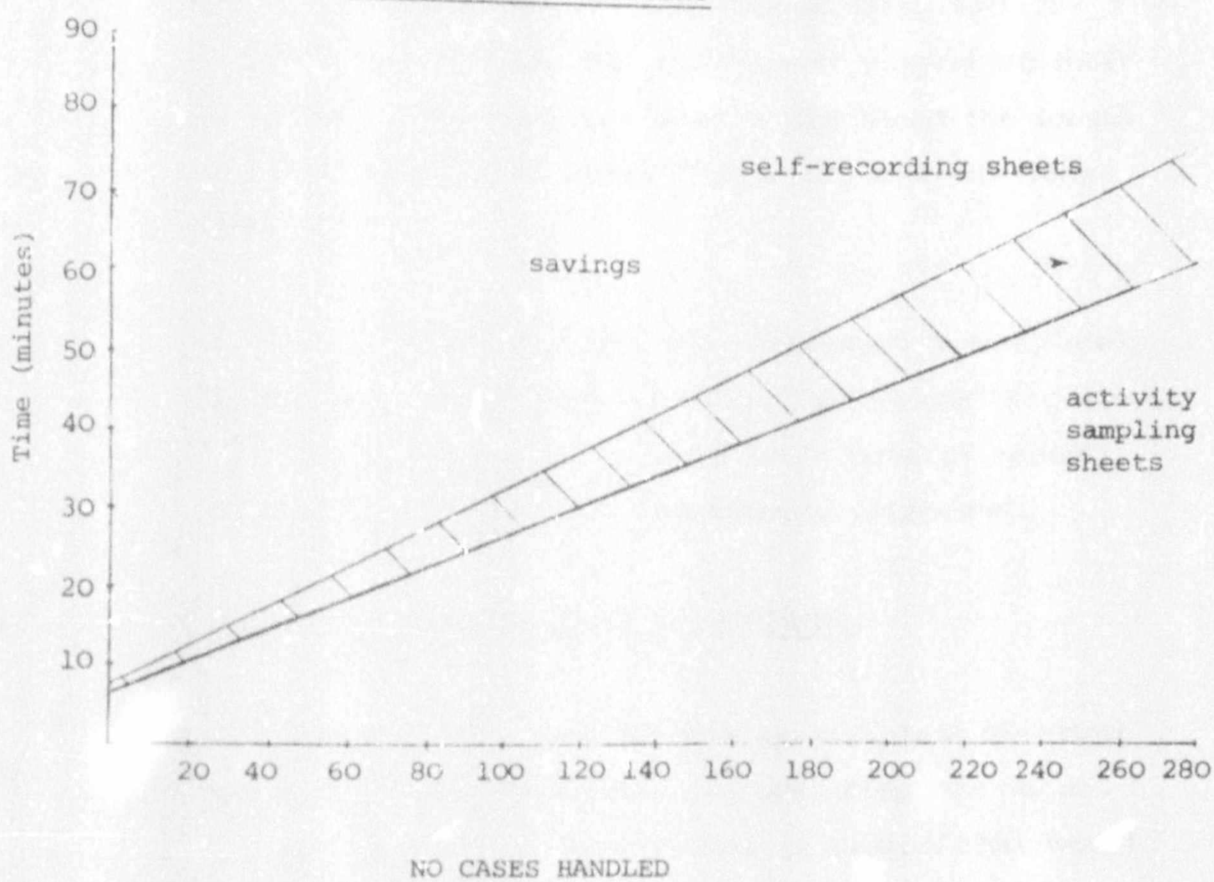
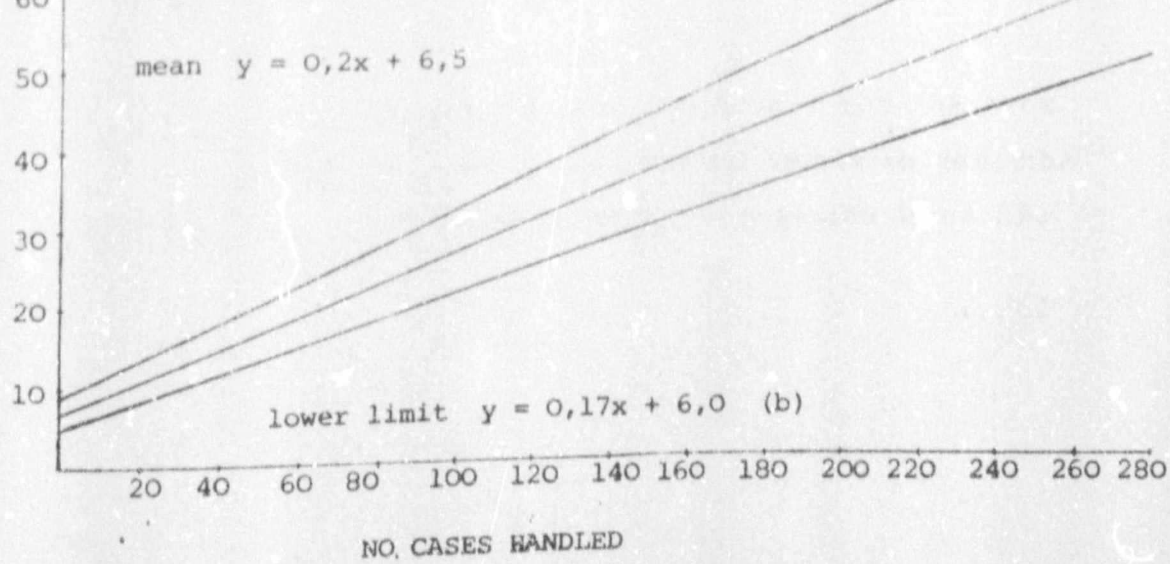


FIG : 5.6.1

NO. OF CASES HANDLED CONTROL CHART - 2 STANDARD DEVIATIONS



sampling was done, the drivers (and their helpers) were under continuous observation and control. However, while they were filling in their self recording sheets there was no form of control on their activities. No questions were asked about the length of their deliveries, where they went, and how long they took.

The Distribution Manager thus developed a completely unrealistic set of "rule of thumb" standards to control his driver - i.e. he only set a time of return by previous history and experienced judgement.

5.6. A SYSTEM OF DELIVERY CONTROL:

Now that a major problem and area of cost and time saving had been identified, the next step was to develop a simple practical system of control that would force the distribution personnel to work at maximum efficiency (rate).

5.6.1. Drop Size Control Chart:

The drop size control chart (Fig: 5.6.1.) shows a control chart developed from graph 5.3.3. (see appendix 1).

The linear regression line which best fits the time study data is used as the central means to describe the data. Two further linear regression lines are also plotted on either side of the mean (lines a and b on Fig: 5.6.1.). These regression lines describe the best fit lines two standard deviations from the mean. The area between lines a and b thus describe two control lines. Ninety-five per cent of all deliveries should now lie between these control lines.

Fig: 5.6.1. can now be used as a control chart.

Should any drop be outside these control limits, it could be deemed out of control and action could then be taken.

5.6.2. Distance Time Control Charts:

A similar control chart showing 2 standard deviations from the mean is shown by Fig: 5.6.2.

5.6.3. Total time for a day's deliveries:

The mean total time taken for a day's delivery can be found by adding the individual mean times taken for each drop and the individual mean times taken to travel each distance.

This total time can thus be set as a target return time for each truck on its day's deliveries.

In order not to make the model too difficult to implement, the individual variations from the mean of each

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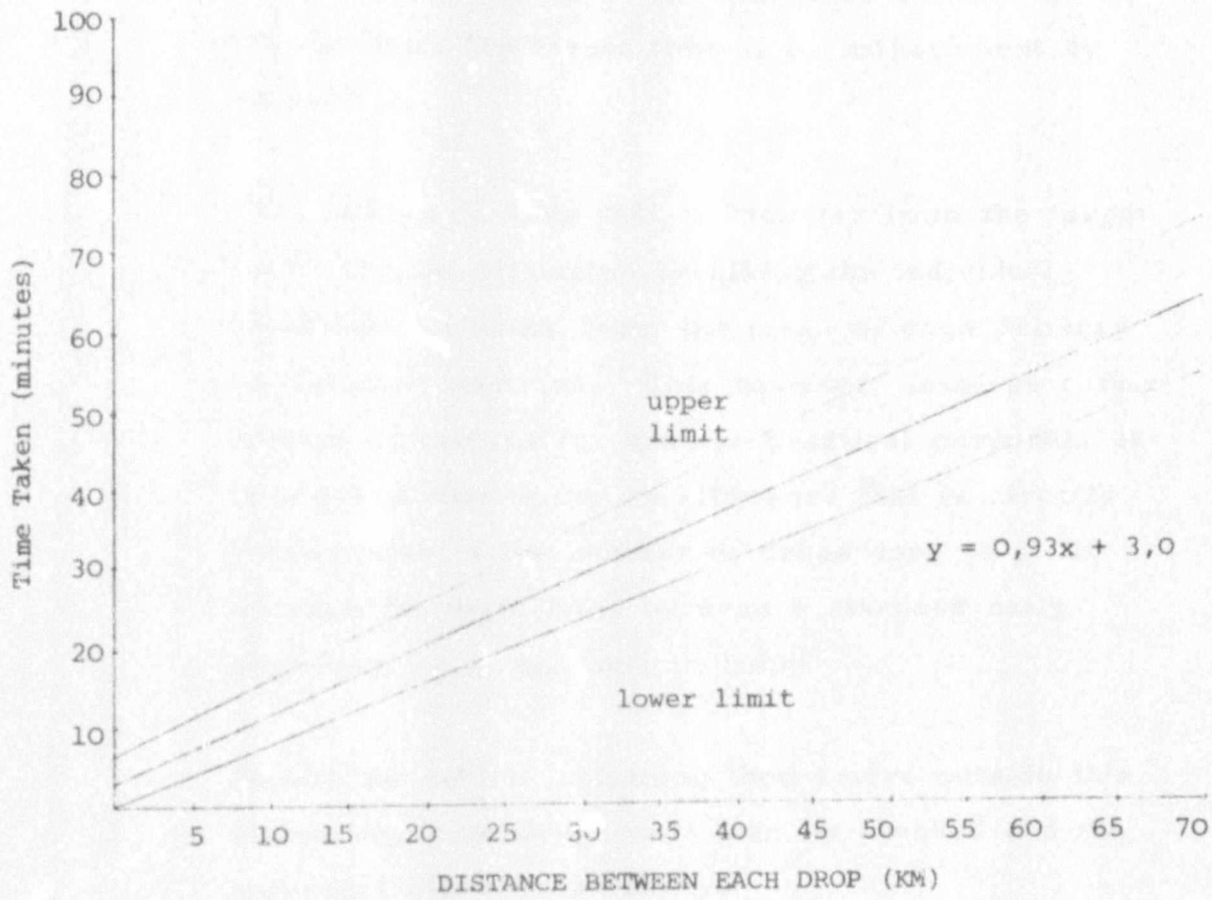
FIG : 5.6.2

DISTANCE TIME CONTROL CHART



drop need not be considered unless the distribution's vehicle arrives back at the depots at a time that is too far from the target time (i.e. management by exception).

This amount of time that is "too far from the target time" can be calculated by taking the individual allowable variances from the mean of each delivery or distance travelled. This however, involves a fair amount of arithmetic, and for practical purposes, it is much easier to set an allowance that is directly proportional to the number of drops done (e.g. 10 minutes for each drop) or even a standard daily allowance (e.g. one half an hour).

Should the vehicle returning then arrive outside this allowance, each drop could then be checked and the individual allowances checked.

5.6.4. Control Chart Follow Up:

The control chart should not be considered as a static guide, but should be modified regularly until it is found to perfectly suit a specific distribution centre's requirements. Modifications might be needed due to seasonal changes in the market, product changes, route variations, etc. and it will thus be necessary to continuously up-date all information.

5.6.5. Practical Implementation:

The actual recording of the day's activities could be done on a simple sheet of paper by the driver, such as on the self recording sheet (Fig: 5.3.1.) or by some sort of automatic recording device fixed to the vehicle.

The only parameters that need to be recorded by the vehicle's driver are:

5.6.5.1. Time start from depot
5.6.5.2. Time arrive at each outlet
5.6.5.3. Distance travelled between each stop
5.6.5.4. Number of cases handled (from invoice)
5.6.5.5. Time leave each outlet
5.6.5.6. Time arrive back at depot.

5.6.6. Other Control Measures:

The following are some further control measures which may be instituted to keep track of the operation of the vehicles.

5.6.6.1. Outlets should be asked to monitor drivers.
5.6.6.2. Drivers should be asked to monitor outlets.
5.6.6.3. Spot checks should be done on vehicles after they have left the factory
5.6.6.4 Preseller/Sales Managers should make a point of observing trucks on their routes.

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5.6.6.5. Allowances should always be made for random day to day occurrences.

5.6.6.6. Standards must be continuously reviewed and adjusted accordingly.

5.6.6.7. Drivers should always be able to phone through to headquarters if there are problems.

5.6.6.8. Drivers should be strictly instructed as to what cases/empties/products are acceptable and may be taken on board the truck.

5.6.6.9. In dense town areas 2 or more administrative persons may be used on one truck - thus allowing them to go to different outlets at the same time.

This leads to the idea of establishing a mobile depot in town i.e. truck parks - horse is separated from semi-trailer and distribution is then done from the semi-trailer.

5.7. MINIMISING DISTANCES:

By using the developed control model a system has been developed to minimise the labour idle time.

No attempt has however been made to minimise distances involved.

5.7.1. Efficiency Investigations.

The author approached this problem by setting up a table of distances between each outlet in a specific

Table 5.7.1

TABLE OF DISTANCES

		Distance To						
		A	B	C	D	E	F	G
Distance From	A	-	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}
	B	X_{21}	-	X_{23}	X_{24}	X_{25}	X_{26}	X_{27}
	C	X_{31}	X_{32}	-	X_{34}	X_{35}	X_{36}	X_{37}
	D	X_{41}	X_{42}	X_{43}	-	X_{45}	X_{46}	X_{47}
	E	X_{51}	X_{52}	X_{53}	X_{54}	-	X_{56}	X_{57}
	F	X_{61}	X_{62}	X_{63}	X_{64}	X_{65}	-	X_{67}
	G	X_{71}	X_{72}	X_{73}	X_{74}	X_{75}	X_{76}	-

TABLE 5.7.2.

Route	Actual Distance	Theoretical minimum distance	Savings (%)
1	105	114	- 9,0
2	72	70	3,0
3	261	254	3,0
4	38	38	0,0
5	14	14	0,0
6	21	20	5,0
7	8	10	- 25,0
8	18	18	0,0
9	15	12	20,0
10	64	60	6,0
11	27	28	4,0
12	23	20	13,0
Total	666	658	1,2

area (see table 5.7.1.).

The travelling salesman algorithm (ref. 11) was then used to find the minimum route between the points to be serviced.

The actual distance incurred by the truck servicing the outlets described in table 5.7.1. was then taken from the odometer and compared to the theoretical minimum obtained from the travelling salesman algorithm analysis.

Twelve different routes were analysed by this method, incurring an average of fourteen drops on each route.

5.7.2. Results obtained.

Table 5.7.2. shows a table of the actual distances travelled by each vehicle compared to the theoretical minimum from the travelling salesman algorithm.

As can be seen by table 5.7.2. the attempt to reduce the distances travelled was not very successful.

In two cases it was even possible for the drivers to find a route that was less than the theoretical minimum (the author feels that this is due to shortcuts unknown to his table of minimum routes).