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Forecasting manpower requirements in a manufacturing group

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FORECASTING MANPOWER REQUIREMENTS IN A MANUFACTURING GROUP

by

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ABSTRACT

This thesis introduces a computer-oriented system for forecasting Manpower Requirements in a manufacturing group. Included is a critical analysis of the system as it was applied in several actual manufacturing situations.

The first phase deals with the design and development of the system. In contrast to many previously developed systems in this area, it is designed to be functional at the actual production level. It is to be used by a first line supervisor, in liaison with the Industrial Engineer, to determine the number of employees required in a specific manufacturing group. The design consists of developing a mathematical model in detail for the manpower requirement calculations. This model is then computer-oriented to maximize speed and accuracy when used by management. The computerized model is then applied to actual industrial situations.

The second phase is concerned with a statistical analysis of the mathematical model and the associated manufacturing variables as they had been used to forecast Manpower Requirements in several manufacturing groups. This includes an appraisal of the relative importance of each of the manufacturing variables to the model. Also included is

an evaluation of the reliability and validity of the forecasting system. The statistical analysis also serves to suggest areas for future consideration.

Upon completion of the foregoing phases of development and industrial applications of the forecasting system, it appeared that the use of the system in those industrial applications was an effective method for planning and controlling the manufacturing groups. That is, the results of the industrial applications of the system for forecasting Manpower Requirements revealed that the system functioned well in providing to management, in advance, an accurate forecast of the values of manufacturing variables and the number of employees required to perform the manufacturing operations.

INTRODUCTION

The subject of this thesis - Forecasting Manpower Requirements - is one of the most basic responsibilities of management.

> The basic problem facing any enterprise tends to be one of allocating some scarce resources (men, machines or materials) to some desired outputs. On the level of production activities, this problem tends to be solved in industry by such methods as the graphical techniques developed by Henry Gantt.(1)

These techniques operate on a trial and error format and sometimes lead to erroneous conclusions. In all cases they are somewhat slow in feedback for managerial control.

Controlling the number of employees on any production operation greatly affects the manufacturing results from that operation. It has a significant bearing on the following: (1) whether the shop will meet schedules, (2) what level of efficiency will be attained, (3) the amount of inventory that will be on hand and (4) numerous other important manufacturing results. All results can be adversely affected if the required number of personnel cannot be accurately determined before a production operation begins.

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(1) Bowman and Fetter, Analysis for Production Management, Revised Ed. 1961, Richard D. Irwin, Inc., Honewood, Ill.

To function effectively in manpower control, it would be advantageous to examine a pertinent facet of the industrial complex in which the control is to be achieved.

> There are two basic types of production: (1) manufacture to stock and (2) job-order production. In manufacture to stock, production schedules based on sales estimates may be prepared in advance. In job-order production, production schedules must await confirmation of customer's order. Personnel schedules must be delayed, for workers cannot be hired to produce things for which orders have not been received. In the situation of manufacturing to stock, detailed personnel planning can begin upon receipt of the production schedule.(2)

In either case manpower control is important, and the delay imposed in a job-order production shop does not eliminate the need for planning manpower requirements. The situation encountered in the industrial experiment which follows was of the manufacture to stock type production shop. The production schedule based on sales forecasts was directed to the manufacturing organizations by the Production Control Department.

In developing an effective means to accomplish manpower control, it would be good to consider the essentials of effective control of employees. To control numbers of employees one must first establish objectives. There must be a target or objective in order to have purpose and direction to control.

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(2) MacNiece, E.H., Production, Forecasting, Planning and Control, 3rd Edition, Wiley, 1961.

What is the target or goal in the case of manpower control? From a manufacturing standpoint it would represent the number of employees who will produce no more or less than the required amount of product (1) when operating at an expected efficiency and quality level and (2) when process performance is consistent with expected capabilities. Inherent in the means for controlling employees is planning (in advance) what they are to produce and at what efficiency and quality level they are to produce it.

Essentially this is "Planning the Manpower to Match the Program". There are a definite number of hours in the program, and plans must be made in advance to meet these hours. Fewer hours would cause back schedules or premium labor payments for overtime. Too many hours may result in lowered efficiency, overproduction or buildup in inventory.

To determine the number of hours in the program one must first forecast all the manufacturing variables that will be encountered in meeting that program. For example, the levels of efficiency, shrinkage, repairs, etc. must be forecasted prior to determining manpower requirements. Even after forecasts are made for each variable, changes which affect the number of employees required occur often. Therefore, a system that is fast in updating the revisions

to the input variables without impairment to the accuracy of the output from that system should be used.

> Operational control systems are the most adapatble to computerization and represent the most advanced use of computers. Operational control systems have all the characteristics which make computer use possible; many interacting variables with a high degree of accuracy and a need to process the data rapidly so that proper corrective action may be taken, if necessary.(3)

Therefore, electronic computer methods may provide the desired accuracy, speed and detail when calculating Manpower Requirements for a production operation based on the most recent program and manufacturing data.

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(3) Konkel, Paul E., "Management Information Systems Can Be Computerized," Computer and Data Processing, June, 1964.

OBJECT OF THESIS

The ultimate purpose of this thesis is to develop and evaluate - through the analysis of several industrial applications - a computer-oriented system for forecasting Manpower Requirements in a manufacturing group.

More specifically, a mathematical model which will attempt to include most of the important factors that should be considered when calculating the number of employees required in a manufacturing group will be designed and developed. The factors, or manufacturing variables, associated with the model will be defined, and the relative importance of each manufacturing variable to the forecasting system will be considered. Accurate estimates of the values of the manufacturing variables are an important part in achieving realistic forecasts of Manpower Requirements. Therefore, considerable analyses will be made on each of the manufacturing variables used in the model.

The model and the associated manufacturing variables will be used to forecast Manpower Requirements on several production operations in the semi-conductor industry. These applications provide a basis for evaluating the

reliability and validity of the forecasting system. This evaluation will be made by comparing the number of employees used in each manufacturing group to the number of employees which had been forecasted as required for the same production operations.

PROCEDURES

Definition and Determination of Manufacturing Variables

In order to develop a method for forecasting Manpower Requirements on a production operation, one must first define all the manufacturing variables which are encountered in the performance of those operations. After defining the manufacturing variables, the actual value of each variable must be determined. Analyzing the historical data requires greater effort in getting the manufacturing variables set up for the first analysis of a production operation than is subsequently need to maintain the job on a continuing basis.

Following are the manufacturing variables that will be used later in a mathematical model developed for the calculation of Manpower Requirements. List 1 under each manufacturing variable defines its meaning. List 2 describes how the value of each manufacturing variable can be derived in an actual industrial situation.

<u>Program Requirements</u>

1. The types and quantities of product to be produced in the fiscal period. Quantities are adjusted for any back-schedules or anticipated changes in inventory levels.

2. The quantities required for each product in each period are obtained from staff departments, i.e. the Production Control or Merchandising Organizations. This manufacturing variable may vary more than any other variable. For each set of program requirements a manpower analysis should be made.

Good Stock Rate (BHrs/c)

1. Production hours required to manufacture one hundred good units to stock for each type of product.

2. Use labor standards or cost bulletin standards for the series of operations to be performed. Standards are to represent the amount of direct, productive effort required to produce each product at an operating efficiency of 100%.

Shrinkage Rate

1. The additional hours required due to shrinkage losses incurred during the manufacture of one hundred good units to stock.

2. Calculate the total Shrinkage Hours as a percentage of total Good Stock Hours for each type of product. This is done by analyzing past production records, then forecasting any changes where situations warrant.

Supplement Rate

1. The additional hours required for repairs, retest or reqork of any production unit to manufacture one hundred good units to stock.

2. Calculate the Total Supplement Hours as a percentage of total Good Stock Hours for each type of product. This is done by analyzing production records over past periods, then forecasting changes in those percentages where situations warrant.

Other Rate

1. The additional hours required for other miscellaneous work which may occur during the manufacture of 100 good units to stock.

2. Calculate the total Miscellaneous Hours as a percentage of Good Stock Hours for each type of product. This is done by analyzing past production records, then forecasting any changes in those percentages where situations warrant.

External Requirements

Layout-Machine Setter Allowance

1. The hours required for external, non-productive effort such as set-up, machine repairs, material handling, operator instruction, conference with supervisors, etc.

Process Checking Allowance

1. The hours required for external, non-productive effort such as process inspection and process testing performed at predetermined intervals during the manufacturing process.

Small Lot Allowance

1. The hours required for external, non-productive effort incurred when employee changes from job to job within a group of operations. This additional effort includes: a. Possible reduction in efficiency due to job changes within producing group. b. Recording quantities produced and hours spent on performance records.

Re: Foregoing External Allowances

2. Calculate the total hours required for each type of effort as a percentage of the total productive hours (Good Stock plus Junk plus Supplement). This is done by analyzing past production records, then forecasting any changes in those percentages where situations warrant.

Environmental Rate (SI-800)

1. The hours per working day required for maintaining proper housekeeping conditions.

2. Available as a labor standard or a cost bulletin standard.

Workdays in Period

1. The number of available working days in the fiscal period(s) for which Manpower Requirements are to be calculated.

2. Calculate the number of regular working days available in the period(s).

Daywork Rate

1. The percentage of the working day which is not included in the productive category.

2. Calculate the total hours for the production group which were charged to Daywork as a percentage of the total hours worked for the group. This is done by analyzing production records over past periods, then forecasting anticipated changes as situations warrant.

Absentee Rate

1. The percentage allowance for tardiness, sickness, personal, etc..

2. Calculate the total hours for the production group which were charged to Absent as a percentage of the total hours worked for the group. This is done by analyzing production records over past periods, then forecasting anticipated changes as situations warrant.

Efficiency

1. The actual or forecasted levels of efficiency on the operation(s) for which Manpower Requirements are to be calculated.

2. Available through the analysis of past production records on the operations.

Overtime (Sat. O.T.)

1. The percentage of additional production time available by expanding regular working hours.

2. Calculate the percentage by dividing additional hours available by regular hours available.

Development of the Mathematical Model

To forecast Manpower Requirements for a production operation one must determine (1) the total production hours required to perform that operation and (2) the hours available per employee for production effort in each period.

Both of these values can be determined by incorporating the manufacturing variables defined on the preceding pages into a mathematical equation. In this manner Manpower Requirements can be determined as follows:

A. Direct Requirements

$$\text{Base Employees} = \frac{(Q \times BHrs/c)(1.0+A+B+C)}{(D)(8(1.0-E-F)(G)(1.0+H)}$$

Where: Base Employees is the number of direct employees required. Numerator (above) is the total direct hours required.

Q is Production Quantity

BHrs/c is Good Stock Rate

A is Shrinkage Rate (%)

B is Supplement Rate (%)

C is Other Rate (%)

Denominator (above) is the total hours available per period per employee for direct production effort.

D is Workdays in Period

E is Daywork Rate (%)

F is Absentee Rate (%)

G is Efficiency (%)

H is Overtime (%)

B. External Requirements

Layout-Machine Setters = Base Employees x I

Process Checkers = Base Employees x J

Small Lot Requirements = Base Employees x K

Environmental Requirements = $\frac{D \times L}{D(8(1.0-E-F))(G)}$

Where: I is Layout-Machine Setter Allowance (%)

J is Process Checking Allowance (%)

K is Small Lot Allowance (%)

L is Environmental Rate (%)

C. Total Requirements

The foregoing equations for Direct Requirements and External Requirements can be combined into one mathematical calculation for Total Manpower Requirements as follows:

$$\text{Total Requirements} = \frac{(Q \times BHrs/c)(1.0+A+B+C)(1.0+I+J+K)+(D \times L)}{(D)\ (8(1.0-E-F))\ (G)\ (1.0+H)}$$

This mathematical model can be used in different types of industrial applications. That is, Manpower Requirements can be calculated for (1) a single production operation,

(2) a series of production operations within a production group, (3) an entire production group or (4) more than one production group. When the model is used for a single production operation, a capacity analysis is also obtained if there is one operator for each machine performing the operation under analysis.

The model is designed to be used for short term and long term Manpower planning. Different values will probably be used for the manufacturing variables due to anticipated improvements to manufacturing conditions over longer periods of time. For example, shrinkage losses should be reduced, efficiency levels should be increased, etc.

Detailed Example of the Mathematical Model

Following is a simplified manual application of the mathematical model to be used to determine Manpower Requirements.

Assume the following manufacturing data has been obtained through analysis of production records for one type of product in a manufacturing operation:

Manufacturing Variable	Value
Stock Rate	2.5 BHrs/c
Efficiency	105%
Shrinkage Rate	40%
Supplementary Rate	10%
Other Rate	0%
Layout-Machine Setter Allowance	10%
Process Checking Allowance	5%
Small-Lot Allowance	2%
Environmental Allowance	1 Hr./Working Day
Daywork Rate	10%
Absentee Rate	5%
Overtime Rate	0%

Further, assume the following program requirements are received from the Production Control Department:

432A Diode - 10,000 units to be stocked in December.

Example:

I. Calculate Direct Hours Required:

A. Good Stock Hours = 10,000 units x 2.5 BHrs/c = 250 Hrs.

B. Junk Hours = .40 x 250 = 100 Hrs.

C. Supplementary Hours = .10 x 250 = 25 Hrs.

D. Other Hours = 0 x 250 = 0 Hrs.

Total Productive Hours 375 Hrs.

II. Calculate External Hours Required:

A. Layout-Machine Setter Hours = .10 x 375 = 37.5 Hrs.

B. Process Checking Hours = .05 x 375 = 18.8 Hrs.

C. Small Lot Hours = .02 x 375 = 7.5 Hrs.

D. Environmental Hours = 1 Hr./day x 23 days = 23.0 Hrs.

III. Calculate Productive Hours Available per Employee:

A. Workdays in period = 23

B. Hours/Day Available for Production = 8(100%-DW%-Abs%)
= 8(100%-5%-10%)
= 6.8

C. Hours/period/employee = 23 x 6.8 = 156.4

IV. Calculate Manpower Requirements at 105% Efficiency:

A. Base Employees = $\frac{375 \text{ Hours}}{156.4 \times 1.05}$ = 2.28 Emp.

B. External Employees:

1. Layout-Machine Setters = $\frac{37.5}{156.4 \times 1.05}$ = .23 Emp.
2. Process Checkers = $\frac{18.8}{156.4 \times 1.05}$ = .11 Emp.
3. Small Lot = $\frac{7.5}{156.4 \times 1.05}$ = .05 Emp.
4. Environmental = $\frac{23.0}{156.4 \times 1.05}$ = .14 Emp.

Total Employees Required 2.81 Emp.

An alternate approach to calculate Total Employee Requirements, without a breakdown according to type of employee, can be used with the equation on page 15:

$$\text{Total Requirements} = \frac{(Q \times BHrs/c)(1.0+A+B+C)(1.0+I+J+K)+(D \times L)}{(D)\ (8(1.0-E-F))\ (G)\ (1.0+H)}$$

$$= \frac{(10000 \times 2.5/100)(1.0+40\%+10\%)(1.0+10\%+5\%+2\%)+(23 \times 1)}{(23)\ (8(1.0-10\%-5\%))(105\%(100\%+0\%)}$$

= 2.81 Employees

Development of Computerized System

To incorporate accuracy and speed in updating the manufacturing variables, the foregoing technique for calculating Manpower Requirements was converted into a computerized system. The initial steps in the design of the system were to determine (1) the amount of detail desired from the calculations and (2) the format of the computer printout of that detail. That is, a categorical breakdown of the Direct Manpower Requirements and the External Manpower Requirements for each product item in the manufacturing operation, plus Total Manpower Requirements for all product items in the manufacturing operation (Appendix A).

The next step in the design of the system was the development of the key-punched card fields (Appendix B). This card design provided the mechanical means by which all the manufacturing data was supplied to the computer. The card design was developed as shown in order to minimize the quantity of cards that must be key-punched as the input data varies. For example, if production quantities vary, only the cards in Deck 4 section of the input data deck must be changed. After the card field design was completed, forms were developed on which to write the manufacturing input data for transfer to key-punched cards (Appendix C).

A Computer Program was developed to (1) transfer the manufacturing data to the memory of the computer, (2) direct the computer to perform the required calculations and (3) direct the computer to print out the information in the desired format (Appendix D - Flow Chart of Computer Program) (Appendix E - Source Program Listing).

The Computer Program was developed using a problem-oriented programming language called Automath (Fortran II). The Program is used in conjunction with the Honeywell Automath 400 Compiler and the Automath 400 Monitor. The Program requires three magnetic tape drives, one for the Compiler and two to store the manufacturing input data prior to performing the calculations.

Before conducting a Manpower Requirements analysis in this computerized system, the keypunched cards containing all the manufacturing data must be ordered in a definite manner. This sequence of card orientation is important since the Computer Program was developed using a definite procedure for transferring the manufacturing data to magnetic tapes. In Appendix F is a schematic of the card sequence to be used.

Industrial Applications of System

The computer-oriented system was used to forecast Manpower Requirements in four manufacturing groups in the Western Electric Company. On the following page is the computer printout of the forecast for one manufacturing group. In Appendix A are the forecasts for all other manufacturing groups. Following each Forecasted Printout is another computer runoff of the Actual number of employees used in each manufacturing group in each fiscal period for which a Manpower Requirement forecast had been made. In the Actual printout all the values for the manufacturing variables were entered as they were actually encountered during the fiscal period.

Forecasts were made for more than one fiscal period in two manufacturing groups. Following are the names of each manufacturing group in the industrial applications and the fiscal period for which the forecast was made:

Group 25 - Thermistors	- October (10)
Group 5 - Glow Lamps	- October (10)
Group 5 - Glow Lamps	- November (11)
Group 71 - Alloy Transistors	- October (10)
Group 71 - Alloy Transistors	- November (11)
Group 6 - Miniatures and Carriers	- October (10)

MANPOWER REQUIREMENTS

PRODUCTION INFORMATION

CODE	CLAN	PERIOD	BHRS/C	---PERCENTAGES--- SHRG	SUPPL	OTHER
1A	204.	10	2.7884	34.00	3.00	0.00
1C	1681.	10	2.8659	34.00	3.00	0.00
1D	508.	10	2.6811	34.00	3.00	0.00
8A	12993.	10	2.2442	34.00	3.00	0.00
8C	7868.	10	2.0953	34.00	3.00	0.00
21A	884.	10	8.9840	34.00	3.00	0.00
37C	3787.	10	14.7450	34.00	3.00	0.00
24A	3169.	10	48.8000	34.00	3.00	0.00
24B	46.	10	48.8000	34.00	3.00	0.00
24C	3020.	10	50.2000	34.00	3.00	0.00
24D	607.	10	50.2000	34.00	3.00	0.00
25	THERMSTR	10				

NUMBER OF EMPLOYEES REQUIRED

	BASE	LC-MS	PRC-CHG	SM-LT	OTHER	TOT EXC SI800	SAT.ADJ
1A	0.05	0.00	0.00	0.00	0.00	0.06	0.05
1C	0.43	0.03	0.01	0.01	0.00	0.48	0.45
1D	0.12	0.01	0.00	0.00	0.00	0.14	0.13
8A	2.59	0.20	0.07	0.04	0.00	2.90	2.75
8C	1.47	0.11	0.04	0.02	0.00	1.64	1.55
21A	0.68	0.05	0.02	0.01	0.00	0.76	0.72
37C	4.96	0.38	0.13	0.07	0.00	5.55	5.26
24A	13.75	1.06	0.36	0.21	0.00	15.37	14.57
24B	0.20	0.02	0.01	0.00	0.00	0.22	0.21
24C	13.52	1.04	0.35	0.20	0.00	15.12	14.33
24D	2.71	0.21	0.07	0.04	0.00	3.03	2.87
	40.49	3.12	1.05	0.61	0.00	45.26	42.90
PLUS SI-800						1.36	1.36
TOTAL INCLUDING SI-800						46.62	44.26

DATA USED

EFFICIENCY 107.0 PERCENT DAYWORK 5.00 PERCENT ABSENT 5.00 PERCENT SATCT 5.50 PERCENT
LC-MS 7.70 PERCENT PRC-CHKG 2.60 PERCENT SMALL-LOT 1.50 PERCENT WORKING DAYS 20.
SI 800 10.44HOURS PER DAY

MANPOWER REQUIREMENTS

PRODUCTION INFORMATION

CODE	QUAN	PERIOD	HRS/C	---PERCENTAGES--- SHRG	SUPPL	OTHER
1A	460.	10	2.7884	31.60	2.58	0.00
1C	1869.	10	2.8659	31.60	2.58	0.00
1D	757.	10	2.6811	31.60	2.58	0.00
8A	13256.	10	2.2442	31.60	2.58	0.00
8C	7977.	10	2.0953	31.60	2.58	0.00
21A	1016.	10	8.6840	31.60	2.58	0.00
37C	3794.	10	14.7453	31.60	2.58	0.00
24A	3531.	10	48.8000	31.60	2.58	0.00
24B	60.	10	48.8000	31.60	2.58	0.00
24C	2625.	10	50.2000	31.60	2.58	0.00
24D	424.	10	50.2000	31.60	2.58	0.00
43A	167.	10	2.0774	31.60	2.58	0.00
025	END MNTH 10					

NUMBER OF EMPLOYEES REQUIRED

BASE	LC-MS	PRC-CHG	SM-LT	OTHER	TOT EXC SI800	SAT.ADJ
0.11	0.01	0.00	0.00	0.00	0.12	0.10
0.45	0.03	0.01	0.01	0.00	0.51	0.42
0.17	0.01	0.00	0.00	0.00	0.19	0.16
2.52	0.19	0.07	0.04	0.00	2.82	2.35
1.42	0.11	0.04	0.02	0.00	1.58	1.32
0.75	0.06	0.02	0.01	0.00	0.84	0.70
4.74	0.37	0.12	0.07	0.00	5.30	4.42
14.61	1.12	0.38	0.22	0.00	16.33	13.61
0.25	0.02	0.01	0.00	0.00	0.28	0.23
11.17	0.86	0.29	0.17	0.00	12.49	10.41
1.80	0.14	0.05	0.03	0.00	2.02	1.68
0.03	0.00	0.00	0.00	0.00	0.03	0.03
38.02	2.93	0.99	0.57	0.00	42.51	35.42
			PLUS	SI-800	1.32	1.32
			TOTAL	INCLUDING SI-800	43.83	36.74

DATA USED

EFFICIENCY 109.8 PERCENT DAYWORK 4.90 PERCENT ABSENT 5.00 PERCENT SATOT 20.00 PERCENT
LC-MS 7.70 PERCENT PRC-CHKG 2.00 PERCENT SMALL-LOT 1.50 PERCENT WORKING DAYS 20.
SI 800 10.44HOURS PER DAY

To conduct these forecasts, production records for each manufacturing group were analyzed in detail. Discussions were held with the production supervisors in each of the manufacturing groups. A considerable amount of data for the manufacturing variables was available through the Labor Standard system. Each product code listed on the computer printout represents an semi-conductor device manufactured to stock. Whenever possible the shrinkage and supplementary percentages were developed for each product code in the manufacturing group. If this was not feasible, as in most cases, an average percentage allowance was used for each product code in the manufacturing group. The manufacturing variable of absentee percentage was used as 5% in both the forecast and actual analysis. The value of this variable was not available for each manufacturing group in the industrial application. Therefore, an average percentage for all manufacturing groups was used. Any variation due to inaccuracy in forecasting absentee percentage can therefore not be evaluated in this experiment.

Referring to the printout further, the Base Employee category included personnel of the same labor code classification. That is, these personnel had the necessary skills to be transferred as required from one individual

production operation to another within the production group without impairing the average efficiency of the group.

The categories for the External Employees included personnel of different labor code classifications. In this manner, manpower requirements are obtained according to labor skills.

The forecasts were made approximately two months before the fiscal period in each case.

EVALUATION AND DISCUSSION

Manufacturing Variable Analysis

From examination of Appendix A one can realize that the forecasted Manpower Requirements are somewhat different than the Actual number of employees used in each manufacturing group. The following analysis examines the causes for the differences. To do this, the values for the manufacturing variables that were originally used to develop the Forecast (input of forecast) were compared with the values of the manufacturing variables as actually encountered in the manufacturing group (input of actual). Differences between the forecasted values and the actual values of the manufacturing variables existed in most of the manufacturing groups where the forecasting system had been applied (see Appendix A). Therefore, an appraisal of the relative importance to the overall forecasting system of each of the manufacturing variables was made. This appraisal was made by substituting separately the Actual value for each manufacturing variable into the forecasted manpower analysis, and using the original forecasted values for the other manufacturing variables in each of the manufacturing groups. In this manner, new "Forecasted Manpower Requirements" are recalculated based

on the new set of "Forecasted Manufacturing Variables". Appendix G contains the computer printouts of the new "Forecasted Manpower Requirements" for each substitution that was made for each manufacturing variable used in Group 25 - Thermistors.

For example, if the Actual Efficiency of 109.8% instead of the Forecasted Efficiency of 107.0% had been used when the forecast was originally developed in Group 25, the forecasted Total Manpower Requirements would have been 43.13 employees instead of 44.26. Thus, the 2.8% absolute difference between the forecasted and actual value for Efficiency had a 2.6% relative effect on the forecasted Total Manpower Requirements. Since this type of analysis was continued on all the manufacturing variables in all of the manufacturing groups where the forecasting system had been applied, the manufacturing variables which caused the largest difference between the forecasted Manpower Requirements and the Actual number of employees used in the manufacturing group were isolated (see Appendix G - Summary for each manufacturing group).

As a result of the preceding analysis of the input manufacturing data used to develop the forecasts for the manufacturing groups, it appears that the manufacturing

variable - Quantity - caused the largest inaccuracy to the forecasted Manpower Requirements. Inaccurate forecasting of this manufacturing variable caused an average inaccuracy of 8.6% to the Total Manpower Requirements (see Appendix H - Individual Factor Analysis).

That is, if all values for all the other manufacturing variables could have been forecasted exactly in all production groups, the forecasted Manpower Requirements would have differed from the Actual number of employees used in the manufacturing group by an average of 8.6% of the forecasted Manpower Requirements. The next largest difference between the forecasted requirements and the actual employees used in the manufacturing group was the result of inaccurate forecasting of the value of the manufacturing variable - Overtime (Sat O.T.). Inaccurate forecasting of the value of this manufacturing variable resulted in an average difference of 7.5% between the forecasted Manpower Requirements and the Actual number of employees used in the manufacturing group (see Appendix H).

The differences caused by both of these manufacturing variables - Quantity and Overtime - could be due to inadequate adjustments by the production supervision to the actual number of employees used in the manufacturing

group. That is, instead of increasing or decreasing the number of employees in the manufacturing group in accordance with the number of employees stated on the forecasted Manpower Requirement printout, the supervisor chose to overproduce or underproduce, or work more or less overtime. The differences between the forecasted data and the actual data caused by inaccurate forecasting of the values of these two manufacturing variables are sizeable and should be reduced if more accurate forecasting of Manpower Requirements is desired.

The author does not attempt to determine which is the correct number of employees for the manufacturing group - the Forecast or the Actual - in relation to good management of the manufacturing group. Instead, it is advised that the forecasted Manpower Requirements be updated continuously to reflect the most recent values of the manufacturing variables. In the preceding paragraph it was suggested that the supervision of the manufacturing groups may have made decisions not reflected in the forecasted Manpower Requirements (i.e. work more or less overtime than that forecasted). The author does not take issue with the fact that this may be the better action under certain circumstances, rather than hiring additional employees for a short duration. However, to

effectively utilize the proposed system for forecasting Manpower Requirements, the values of all the manufacturing variables should be updated to reflect both the capabilities of the manufacturing processed and supervisory judgement. Only in this manner will the forecasting procedure reflect the most accurate plans for the future manufacturing periods.

There is a residual or "interaction" effect listed on the summary sheet in Appendix H. This residual is obtained when the sum of the individual differences between the forecasted data and the actual data for each manufacturing variable is subtracted from the total difference between the Forecasted and Actual analysis where all the values of the manufacturing variables are as actually encountered in the manufacturing group. For example, in Group 25 - October, 1964 (see Appendix G - page 87) the sum of the individual differences between the forecasted data and the actual data was 7.92 employees, whereas the total difference between Forecasted data and Actual data encountered when using the forecasting system was 7.52 employees. This effect reveals that the inaccuracy of the overall forecasting system is not the sum of the inaccuracies of forecasting each manufacturing variable used in developing that forecast. If this were true,

higher inaccuracies would be encountered when forecasting Manpower Requirements using the system developed herein.

The foregoing analysis evaluated the importance of the accuracy of each manufacturing variable to the overall accuracy of the forecasting system using the data which was obtained when the system was used in several industrial applications. Following is an appraisal of the effect to the forecasted data of inaccuracies in the manufacturing variables in general. This effect will be evaluated in terms of the change in manpower requirements which would occur if an inaccurate value of a manufacturing variable is used in developing the forecast.

Repeated below is the basic equation for the calculation of Total Manpower Requirements on page 15:

$$\text{Total Requirements} = \frac{(QxBHrs/c)\ (1.0+A+B+C)\ (1.0+I+J+K)+(DxL)}{(D)\ (8(1.0-E-F))\ (G)\ (1.0+H)}$$

Note: The calculation for Environmental Hours (DxL) will be excluded in the subsequent analysis due to its small significance in the manufacturing group.

An examination of the preceding equation reveals that a 1% inaccuracy in the estimated value for any of the following manufacturing variables would produce a 1%

inaccuracy in the Total Manpower Requirements:

1. Q - Quantity
2. BHrs/c
3. D - Working Days
4. G - Efficiency
5. H - Overtime

The percentage inaccuracy to Total Manpower Requirements due to a 1% inaccuracy in forecasting any of the other manufacturing variables in the numerator of the preceding equation can be determined by dividing that particular manufacturing variable by the sum of all the manufacturing variables in the same term. For example, assume the following data applies to a manufacturing group:

A - Shrinkage percent = 50%

B - Supplement percent = 20%

C - Other percent = 10%

Therefore a 1% inaccuracy in forecasting the Shrinkage Percentage would result in a .28% inaccuracy to Total Manpower Requirements.

$$\frac{A}{1.0+A+B+C} = \frac{50\%}{100\%+50\%+20\%+10\%} = .28\%$$

Another example, assume the following data in a manufacturing group:

E - Daywork percent = 10%

F - Absent percent = 5%

Therefore a 1% inaccuracy in forecasting the Daywork Percentage would result in a .12% inaccuracy to Total Manpower Requirements.

$$\frac{E}{1.0-E-F} = \frac{10\%}{100\%-10\%-5\%} = .12\%$$

The foregoing procedure can be used to determine the relative importance of each manufacturing variable to the overall forecast in any manufacturing group. If this type of analysis is conducted before the forecast is made, one can determine which manufacturing variables demand the largest degree of accuracy in order to maximize the accuracy of the overall forecast.

Statistical Analysis of Forecasted vs. Actual Data

Following is a statistical analysis of the industrial applications of the system for forecasting Manpower Requirements. This analysis included a critical statistical review of the forecasted Manpower Requirements in each manufacturing group as compared to the Actual number of employees used in each production group. All analyses were conducted on three "populations" within each production group. They were as follows: (1) Base Employees, (2) Total Employees and (3) Base Employees per 1000 units of production. The reason for dividing the production group into these populations is that only certain manufacturing variables affect the "Base Employee population". Therefore, in the statistical analysis of the Base Employee population, one can isolate those variables independent of the other manufacturing variables (i.e. External Requirements), which will be analyzed when testing the population of Total Employees. The population of Base Employees per 1000 units of production was analyzed in order to separate any differences due to inaccuracy in forecasting production quantities. (This manufacturing variable was the source of largest difference between forecasted requirements and actual employees in the group as shown in the preceding Manufacturing Variable Analysis Section.)

The first step in the statistical investigation was to determine whether the variance of the forecasted Manpower Requirements and the variance of the Actual employees for each production group were sufficiently alike to warrant an assumption that they are independent estimates of the same population.(4) Thus, the significance of the difference between the variances was tested by the Variance Ratio Test (F-test). The Level of Significance used was 5%. The Null Hypothesis was - There is no significant difference between the variance of the forecasted Manpower Requirements and the variance of the Actual employees in the production group. The Alternative Hypothesis was that there is a significant difference between the variances.

The results of the F-test for each population within each production group are tabulated in Appendix I. Based on these results it appears that in most cases the Null Hypothesis cannot be rejected. That is, the variances of the forecasted data and the variances of the actual data in the industrial application of the forecasting system are alike to assume they are estimates of the same population variance.

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(4) Bowker, A.H., and Lieberman, G.J., "Engineering Statistics," Englewood Cliffs, N.J., Prentice-Hall, 1959.

Two of the three cases where there was a significant difference between the variance of the forecasted data and the variance of the actual data occurred when testing the populations - Base Employees/1000 units of production. Actually, this was a population added by the author to analyze more extensively the data collected from the industrial applications. The population in itself had no bearing on the accuracy of the forecasting system.

The next statistical investigation was conducted using the Student t-test.(5) This invesigation consisted of determining whether or not there was a significant difference between the Forecasted number of employees and the Actual number of employees used in each manufacturing group for the period of the forecast. The assumption stated in the Null Hypothesis was that there was no significant difference. This was tested against the Alternative Hypothesis, which was that there may be a difference between the forecasted and actual data due to the inability to accurately forecast the values of the manufacturing variables. This was a two-sided alternative hypothesis in that the Actual number of employees used in the manufacturing group could have been more or less than the Forecasted number of employees. The Level of Significance was 5%.

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(5) Davies, Owen L., "Design and Analysis of Industrial Experiments," Hafner Publishing Co., N.Y., 1956.

In most of the cases there was no significant difference between the mean value of the Forecasted data and the mean value of the Actual data when tested at the 5% level of significance. Therefore, in appraising the system for forecasting Manpower Requirements it is pertinent to determine at what level of significance there would have been a significant difference between the mean values. The results of that investigation are shown in the column - Approx. Prob. Level - in Appendix J. Also shown in that section are the tabulated results of the t-test for each population in each production group.

In 2 out of 18 cases there was a significant difference between the mean value of the Forecasted data and the mean value of the Actual data. In both cases the population "Base Employees/1000 units of production" was being tested using the t-test. It is important to remember that this is similar to the results obtained on page 37 where significant differences were encountered in the same population. This population was added by the author to gain a possible advantage in conducting the foregoing statistical analysis by removing the effects of the inaccuracy in forecasting the manufacturing variable of Quantity. At the time this population had been introduced, the manufacturing variable of Quantity was the cause of

the greatest variation between the Forecasted and Actual data. (see pages 28 - 29) However, it was discovered that with the removal of the effects of this manufacturing variable, Quantity, there would exist a greater difference between the Forecasted and Actual data.

The above point is particularly informative, and it appears further that the inaccurate forecasting of the manufacturing variable, Quantity, in the industrial applications of the forecasting system actually reduced the inaccuracies which might have been encountered in the use of the forecasting system. That is, Quantity seems to have "countered" some of the inaccuracies in forecasting the values of the other manufacturing variables, thereby lending greater validity to the overall forecasted data. For instance, on page 96 in Appendix G, if the effect of the manufacturing variable of Quantity was removed from the forecasted data, the difference between the forecasted and actual data would be 17.05 employees instead of the 11.69 employees actually encountered.

In Appendix K is a tabulated summary of the 95% confidence interval of the mean difference between the Forecasted and Actual numbers of employees used for each population in each production group. The upper and lower

limits of the confidence intervals are expressed in percentage variation to the forecasted data, as well as in terms of number of employees, in order to more usefully state the variation that could possibly exist, based on the experimental results, between the Forecasted and Actual numbers of employees. The data was developed using the Student's t-distribution. When using small samples, as in this analysis, this distribution should be used to calculate the confidence interval instead of the Normal Distribution.(6)

Examination of the tabulated results of the foregoing analysis revealed that in most cases the spread of the confidence interval of the mean difference exceeds that which may be tolerable in forecasting Manpower Requirements. A confidence interval of 10% variation between the forecast and actual data may be realistic; but, as shown in Appendix K, this percentage was exceeded in every population. Therefore, based on the results of this analysis of the individual manufacturing groups only, it appears the forecasting system developed herein will fail sometimes to accurately predict the associated manufacturing variables and therefore incorrectly forecast the number of employees required. This is an interesting

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(6) Davies, Owen L., op.cit., p. 35

observation when considering the previous analysis on page 38 which showed there was no statistical difference at the 5% level of significance between the forecasted data and the actual data. However, due to the data obtained from the industrial applications, the spread of the 95% confidence interval of the mean difference for each manufacturing group is larger than that which would guarantee an accurate forecasting system in all applications.

Now that a statistical investigation was conducted on each population within each production group and the results stated, the next area of investigation was to combine and analyze all the date for the four manufacturing groups in the industrial experiment. In Appendix L are the results of the t-test, the confidence interval calculations and the level at which there would be a significant difference in the means for the combined data.

The results of this analysis are particularly informative when compared to the previous results obtained when analyzing each manufacturing group separately. That is, none of the populations analyzed by the t-test here revealed a significant difference between the mean value

of the forecasted data and the mean value of the actual data. This result is similar to the result of the t-test in the separate manufacturing groups. However, when the data for all the manufacturing groups is combined, the 95% confidence interval of the mean difference of the forecasted and actual data is considerably narrower. In almost every case (see Appendix L) the range, within which 95% of the differences between the Forecasted data and the Actual data occur, is narrow enough, in the opinion of the author, to warrant the use of the system for manpower planning purposes. That is, the Actual number of employees in the manufacturing group does not deviate more than 10% from the forecasted Manpower Requirements in 95 out of 100 cases. It is further emphasized that 10% is the outer limit of this confidence interval, and in most cases the accuracy is considerably better than this level implies.

The results of another statistical examination of the data collected in the industrial applications of the forecasting system are tabulated in Appendix M. The percentages in column "E(%)" are expressed as a percentage variation of the forecasted Manpower Requirements. Column "E(emp.)" in the table can be defined as follows: there is a 5% chance that the true

difference between the Forecasted data and the Actual data is as great as this number. An alternate statement of similar context can be stated as follows: there is 95% confidence that the true difference between the Forecasted data and the Actual data is less than this value.

As in calculating the confidence intervals, it appears from the above analysis that only the combined data for all the manufacturing groups gives the degree of confidence in all cases that is desired when forecasting Manpower Requirements. This is not to say that forecasts for the individual manufacturing groups are completely invalid, instead this analysis tells us that in some cases the difference between the forecasted data another actual data will exceed the desired level of accuracy.

SUMMARY AND CONCLUSIONS

The industrial applications of the system for forecasting Manpower Requirements developed herein have demonstrated that:

1. The manufacturing variables of Quantity and Overtime had the largest effect on the inaccuracy of the forecasting system. The forecasted values for these variables differed from that which was actually encountered by an average of 8.6% for Quantity and 7.5% for Overtime. The inability to accurately estimate the values of these manufacturing caused the same relative inaccuracy, i.e. 8.6% and 7.5% respectively, to the forecasted Manpower Requirements in the industrial applications. These rather large percentage differences between the forecasted Manpower Requirements and the Actual number of employees used in the manufacturing group may have been due to the fact that the estimated values of the manufacturing variables used in the industrial applications were made two months in advance of the actual production operations. If updating of the values of all the manufacturing variables to reflect most recent capabilities and managerial judgment is incorporated

into the forecasting system, the accuracy of the system should be somewhat increased. Management will have a realistic picture, in advance, of what to expect during the performance of the productions operations only if the values of the manufacturing variables reflect the most accurate estimates available.

2. Even though the values of the manufacturing variables were not updated in the industrial applications, there was still no statistically significant difference between the forecasted Manpower Requirements and the Actual number of employees used in the manufacturing group for the period of the forecast. It appeared that in using this forecasting system in the industrial applications, the estimates of the values of the variables were accurate enough to obtain a valid forecast of the Manpower Requirements. Therefore, the industrial applications of the forecasting system were useful to management because the forecasted data reflected a realistic picture of what to expect during the performance of the production operations.

3. A residual or "interaction" effect was encountered when analyzing the data obtained from the industrial applications of the forecasting system. This effect revealed that the inaccuracy of the overall forecasting system was less than the sum of the inaccuracies in forecasting the values of the manufacturing variables used in developing the forecast. Therefore, it appeared that the effects to the forecasting system of inaccurate forecasting of the values of the manufacturing variables were not independent. In fact, the accuracy of the forecasting procedure was improved when all the manufacturing variables are combined into one mathematical model.

For example, the inaccurate forecasting of the values of the manufacturing variable of Quantity did not hinder the accuracy of the forecasting procedure in the industrial applications. In fact, the inability to forecast exactly the production quantities "countered" some of the inaccuracies which existed in forecasting the values of the other manufacturing variables, thereby lending greater validity to the overall forecasting system.

4.

a. Due to the large spread on the 95% confidence interval of the difference between the forecasted data and the actual data in the individual manufacturing groups, there seems to be less certainty in the forecasting system than Item 2 might imply. That is, the possible difference which could be encountered between the Forecasted data and the Actual data in the individual manufacturing groups is considerably larger than the 10% variation which was assumed by the author as a reasonable level of accuracy.

b. The 95% confidence interval of the difference between the Forecasted data and the Actual data obtained when analyzing all the manufacturing groups combined was considerably narrower than the confidence interval in part a. above. Therefore, the forecasting data developed through the use of this system should produce a reasonable level of accuracy more often in larger or combined manufacturing groups than in smaller or individual manufacturing groups.

5.

a. The computerized system has considerable flexibility in most of the manufacturing input data that can be used when forecasting Manpower Requirements. For example, individual shrinkage and supplementary allowances can be used for each production item in the manufacturing group. However, the system has less flexibility in the manufacturing variables of efficiency and overtime. That is, the same level of production efficiency and overtime is applied to all the production items in the manufacturing group in the existing system. These restrictions could be removed if necessary through a redesign of the input data deck and a revision to the computer program.

b. The system can be used for forecasting Manpower Requirements for a maximum of twelve manufacturing periods. This limitation did not cause any problems in the industrial applications conducted herein. However, if greater scope is desired a redesign of the computerized system would be required.

The design and industrial applications of the system for forecasting Manpower Requirements revealed several general observations:

1. To produce accurate forcasts under this system, management is compelled to analyze in detail, and consider in relation to each other, many of the manufacturing variables pertinent to the manufacturing operations.

2. Sound estimates of the values of the manufacturing variables used in the forecasting system can provide valuable information for managerial control. That is, changes can be made before the production operations begin, thereby improving the manufacturing process or reducing the number of employees required. For example, a forecast might specify a 20% level of Overtime required to meet a production schedule. Through analysis of and improvement to the other manufacturing variables (i.e. Efficiency, Shrinkage, etc.) the 20% Overtime might be avoided or reduced somewhat.

3. Computerization of this system for forecasting Manpower Requirements provided the speed and accuracy which is required to update the values of the manufacturing variables used to develop the forecasts. It appears this system would be too cumbersome to function manually.

FUTURE CONSIDERATIONS

An investigation of the effects to forecasting Manpower Requirements of the interaction of the manufacturing variables in an industrial setting might be conducted. For example, what is the effect of a large increase in effeciency on the shrinkage losses in a manufacturing group? Sound analysis and conclusions to questions such as this would improve the forecasting procedure.

In the industrial applications conducted in this thesis, the values of the manufacturing variables were derived to a large extent through the labor standard system. To increase the versatility of the forecasting procedure, an investigation should be made to determine the applicability of the cost standard system, or any other equivalent system.

The effects of the manufacturing variable of absenteeism were not evaluated in the industrial applications. Further investigation might be conducted on this manufacturing variable, thereby determining its importance in manpower planning.

This same technique for determining manpower requirements might be applied to analyzing an individual operation

requirements within a production group. If greater scope is desired, total manpower requirements might be analyzed by combining the analysis to include more than one production group.

APPENDIX A

FORECAST AND ACTUAL COMPUTER PRINTOUTS

MANPOWER REQUIREMENTS

PRODUCTION INFORMATION

CODE	QLAN	PERIOD	BHRS/C	---PERCENTAGES--- SHRG	SUPPL	OTHER
313C	6579.	10	4.5300	14.00	0.50	1.50
313CA	3000.	10	4.5300	14.00	0.50	1.50
313CC	6796.	10	4.5300	14.00	0.50	1.50
346C	10047.	10	4.8200	14.00	0.50	1.50
353A	3523.	10	4.8200	14.00	0.50	1.50
430B	2997.	10	9.2600	14.00	0.50	1.50
358A	2000.	10	9.2100	14.00	0.50	1.50
359A	554.	10	7.9600	14.00	0.50	1.50
425A	10596.	10	7.3600	14.00	0.50	1.50
413B	2300.	10	7.1200	14.00	0.50	1.50
423C	800.	10	7.3600	14.00	0.50	1.50
427A	1848.	10	9.6700	14.00	0.50	1.50
432B	444.	10	7.9800	14.00	0.50	1.50
460A	4700.	10	7.9500	14.00	0.50	1.50
5	GLCW LPS	10				

NUMBER OF EMPLOYEES REQUIRED

BASE	LO-MS	PRO-CHG	SM-LT	OTHER	TOT EXC SI800	SAT.ADJ
2.29	0.27	0.06	0.01	0.03	2.65	2.65
1.05	0.12	0.03	0.00	0.01	1.21	1.21
2.37	0.28	0.06	0.01	0.03	2.74	2.74
3.73	0.44	0.09	0.01	0.05	4.31	4.31
1.31	0.15	0.03	0.00	0.02	1.51	1.51
1.21	0.14	0.03	0.00	0.02	1.40	1.40
1.42	0.17	0.03	0.00	0.02	1.64	1.64
0.34	0.04	0.01	0.00	0.00	0.39	0.39
6.00	0.70	0.14	0.02	0.08	6.94	6.94
1.26	0.15	0.03	0.00	0.02	1.46	1.46
0.45	0.05	0.01	0.00	0.01	0.52	0.52
1.38	0.16	0.03	0.00	0.02	1.59	1.59
0.27	0.03	0.01	0.00	0.00	0.32	0.32
2.88	0.34	0.07	0.01	0.04	3.33	3.33
25.95	3.04	0.62	0.08	0.34	30.02	30.02
			PLUS SI-800		0.86	0.86
			TOTAL INCLUDING SI-800		30.88	30.88

DATA USED

EFFICIENCY 100.0 PERCENT DAYWORK 2.00 PERCENT ABSENT 5.00 PERCENT SATOT 0.00 PERCENT
LC-MS 11.70 PERCENT PRO-CHKG 2.40 PERCENT SMALL-LOT 0.30 PERCENT WORKING DAYS 20.
SI 800 6.38 HOURS PER DAY

MANPOWER REQUIREMENTS

PRODUCTION INFORMATION

CODE	CLAN	PERIOD	BHRS/C	---PERCENTAGES--- SHRG	SUPPL	OTHER
313C	6704.	10	4.5300	12.33	0.45	1.50
313CA	2980.	10	4.5300	12.33	0.45	1.50
313CC	6942.	10	4.5300	12.33	0.45	1.50
346C	8531.	10	4.8200	12.33	0.45	1.50
353A	3589.	10	4.8200	12.33	0.45	1.50
430B	5867.	10	5.2600	12.33	0.45	1.50
358A	2393.	10	9.2100	12.33	0.45	1.50
359A	892.	10	7.9600	12.33	0.45	1.50
425A	10625.	10	7.3600	12.33	0.45	1.50
413B	2417.	10	7.1200	12.33	0.45	1.50
423C	1082.	10	7.3600	12.33	0.45	1.50
427A	1848.	10	9.6700	12.33	0.45	1.50
432B	396.	10	7.9800	12.33	0.45	1.50
460A	5023.	10	7.9500	12.33	0.45	1.50
05B	END MNTH	10				

NUMBER OF EMPLOYEES REQUIRED

BASE	LC-MS	PRC-CHG	SM-LT	OTHER	TOT EXC SI800	SAT.ADJ
2.13	0.31	0.05	0.01	0.03	2.53	2.38
0.95	0.14	0.02	0.00	0.01	1.12	1.06
2.20	0.32	0.05	0.01	0.03	2.62	2.47
2.88	0.42	0.07	0.01	0.04	3.42	3.22
1.21	0.18	0.03	0.00	0.02	1.44	1.36
2.16	0.32	0.05	0.01	0.03	2.57	2.42
1.54	0.23	0.04	0.00	0.02	1.83	1.73
0.50	0.07	0.01	0.00	0.01	0.59	0.56
5.48	0.81	0.13	0.02	0.07	6.51	6.13
1.21	0.18	0.03	0.00	0.02	1.43	1.35
0.56	0.08	0.01	0.00	0.01	0.66	0.62
1.25	0.18	0.03	0.00	0.02	1.49	1.40
0.22	0.03	0.01	0.00	0.00	0.26	0.25
2.80	0.41	0.07	0.01	0.04	3.32	3.13
25.09	3.69	0.60	0.08	0.33	29.79	28.08
			PLLS	SI-800	0.91	0.91
			TOTAL	INCLUDING SI-800	30.70	28.99

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DATA USED

EFFICIENCY 107.0 PERCENT DAYWORK 1.00 PERCENT ABSENT 5.00 PERCENT SATCT 6.10 PERCENT
LC-MS 14.70 PERCENT PRC-CHKG 2.40 PERCENT SMALL-LOT 0.30 PERCENT WORKING DAYS 20.
SI 800 7.31HOURS PER DAY

MANPOWER REQUIREMENTS

PRODUCTION INFORMATION

CODE	CLAN	PERIOD	BHRS/C	---PERCENTAGES--- SHRG	SUPPL	OTHER
313C	6810.	11	4.5300	14.00	0.50	1.50
313CA	4000.	11	4.5300	14.00	0.50	1.50
313CC	4080.	11	4.5300	14.00	0.50	1.50
346C	11240.	11	4.8200	14.00	0.50	1.50
353A	3910.	11	4.8200	14.00	0.50	1.50
430B	4870.	11	5.2600	14.00	0.50	1.50
358A	2060.	11	9.2100	14.00	0.50	1.50
359A	38.	11	7.9600	14.00	0.50	1.50
425A	14500.	11	7.3600	14.00	0.50	1.50
413B	2000.	11	7.1200	14.00	0.50	1.50
423C	800.	11	7.3600	14.00	0.50	1.50
427A	653.	11	9.6700	14.00	0.50	1.50
432B	155.	11	7.9800	14.00	0.50	1.50
460A	4700.	11	7.9500	14.00	0.50	1.50
5	GLCW LPS	11				

NUMBER OF EMPLOYEES REQUIRED

BASE	LO-MS	PRC-CHG	SM-LT	OTHER	TOT EXC SI800	SAT.ADJ
2.37	0.28	0.06	0.01	0.03	2.75	2.75
1.39	0.16	0.03	0.00	0.02	1.61	1.61
1.42	0.17	0.03	0.00	0.02	1.65	1.65
4.17	0.49	0.10	0.01	0.05	4.82	4.82
1.45	0.17	0.03	0.00	0.02	1.68	1.68
1.97	0.23	0.05	0.01	0.03	2.28	2.28
1.46	0.17	0.04	0.00	0.02	1.69	1.69
0.02	0.00	0.00	0.00	0.00	0.03	0.03
8.21	0.96	0.20	0.02	0.11	9.50	9.50
1.10	0.13	0.03	0.00	0.01	1.27	1.27
0.45	0.05	0.01	0.00	0.01	0.52	0.52
0.49	0.06	0.01	0.00	0.01	0.56	0.56
0.10	0.01	0.00	0.00	0.00	0.11	0.11
2.88	0.34	0.07	0.01	0.04	3.33	3.33
27.48	3.22	0.66	0.08	0.36	31.80	31.80
			PLUS SI-800		0.86	0.86
			TOTAL INCLUDING SI-800		32.66	32.66

DATA USED

EFFICIENCY 100.0 PERCENT DAYWORK 2.00 PERCENT ABSENT 5.00 PERCENT SATOT 0.00 PERCENT
LO-MS 11.70 PERCENT PRC-CHKG 2.40 PERCENT SMALL-LOT 0.30 PERCENT WORKING DAYS 20.
SI 800 6.38HOURS PER DAY

MANPOWER REQUIREMENTS

PRODUCTION INFORMATION

CODE	CLAN	PERIOD	BHRS/C	---PERCENTAGES--- SHRG	SUPPL	OTHER
313C	7636.	11	4.5300	12.00	1.75	1.50
313CA	4154.	11	4.5300	12.00	1.75	1.50
313CC	5845.	11	4.5300	12.00	1.75	1.50
346C	11387.	11	4.8200	12.00	1.75	1.50
353A	3715.	11	4.8200	12.00	1.75	1.50
430B	5009.	11	5.2600	12.00	1.75	1.50
358A	1786.	11	9.2100	12.00	1.75	1.50
359A	28.	11	7.9600	12.00	1.75	1.50
425A	7539.	11	7.3600	12.00	1.75	1.50
413B	1793.	11	7.1200	12.00	1.75	1.50
423C	241.	11	7.3600	12.00	1.75	1.50
427A	2960.	11	9.6700	12.00	1.75	1.50
432B	263.	11	7.9800	12.00	1.75	1.50
460A	4261.	11	7.9500	12.00	1.75	1.50
050	END MNTH	11				

NUMBER OF EMPLOYEES REQUIRED

BASE	LO-MS	PRC-CHG	SM-LT	OTHER	TOT EXC SI800	SAT.ADJ
2.47	0.34	0.06	0.01	0.03	2.91	2.88
1.34	0.19	0.03	0.00	0.02	1.58	1.57
1.89	0.26	0.05	0.01	0.02	2.23	2.20
3.92	0.54	0.09	0.01	0.05	4.61	4.57
1.28	0.18	0.03	0.00	0.02	1.51	1.49
1.88	0.26	0.05	0.01	0.02	2.22	2.19
1.17	0.16	0.03	0.00	0.02	1.38	1.37
0.02	0.00	0.00	0.00	0.00	0.02	0.02
3.96	0.55	0.10	0.01	0.05	4.67	4.62
0.91	0.13	0.02	0.00	0.01	1.07	1.06
0.13	0.02	0.00	0.00	0.00	0.15	0.15
2.04	0.28	0.05	0.01	0.03	2.41	2.38
0.15	0.02	0.00	0.00	0.00	0.18	0.17
2.42	0.33	0.06	0.01	0.03	2.85	2.82
23.57	3.25	0.57	0.07	0.31	27.77	27.50
			PLUS SI-800		0.92	0.92
			TOTAL INCLUDING SI-800		28.69	28.41

DATA LSEC

EFFICIENCY 106.1 PERCENT DAYWORK 1.10 PERCENT ABSENT 5.00 PERCENT SATOT 1.00 PERCENT
LC-MS 13.80 PERCENT PRC-CHKG 2.40 PERCENT SMALL-LOT 0.30 PERCENT WORKING DAYS 20.
SI 800 7.31 HOURS PER DAY

MANPOWER REQUIREMENTS

PRODUCTION INFORMATION

CODE	CLAN	PERIOD	BHRS/C	---PERCENTAGES--- SHRG	SUPPL	OTHER
35A	4000.	10	4.1618	60.00	50.00	3.64
37A	0.	10	9.4253	120.00	15.00	3.64
F-35023	0.	10	0.8457	60.00	50.00	3.64
8B	22000.	10	1.4051	170.00	40.00	3.64
9A	3500.	10	8.8394	200.00	50.00	3.64
9B	200.	10	8.5528	120.00	15.00	3.64
9C	12500.	10	8.5528	120.00	15.00	3.64
12A	0.	10	0.8457	60.00	50.00	3.64
12B	36000.	10	0.8457	60.00	50.00	3.64
12D	40000.	10	0.8457	60.00	50.00	3.64
12E	4800.	10	1.3631	60.00	50.00	3.64
12F	74000.	10	1.0160	60.00	50.00	3.64
12G	49000.	10	0.8457	60.00	50.00	3.64
12H	115000.	10	0.8457	60.00	50.00	3.64
12K	0.	10	1.3631	60.00	50.00	3.64
12L	8000.	10	1.1511	60.00	50.00	3.64
12M	6700.	10	0.8457	60.00	50.00	3.64
12N	5000.	10	0.8457	60.00	50.00	3.64
17A	200.	10	5.9200	15.00	0.00	3.64
17B	4500.	10	5.9200	15.00	0.00	3.64
28A	0.	10	47.7400	120.00	15.00	3.64
30A	600.	10	2.5375	170.00	40.00	3.64
30B	0.	10	2.0201	170.00	40.00	3.64
30C	0.	10	2.0201	170.00	40.00	3.64
36A	150.	10	1.2745	170.00	40.00	3.64
31A	1200.	10	1.9712	60.00	50.00	3.64
31B	0.	10	1.4538	60.00	50.00	3.64
31C	150.	10	1.4538	60.00	50.00	3.64
071	ALLYXTRA	10				

NUMBER OF EMPLOYEES REQUIRED

BASE	LO-MS	PRO-CHG	SM-LT	OTHER	TOT EXC SI800	SAT.ADJ
2.22	0.29	0.16	0.00	0.04	2.71	2.51
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.08	0.81	0.44	0.00	0.07	7.39	6.85
6.87	0.91	0.49	0.01	0.07	8.35	7.73
0.25	0.03	0.02	0.00	0.00	0.31	0.29
15.93	2.11	1.15	0.01	0.25	19.44	18.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.05	0.54	0.29	0.00	0.07	4.96	4.59
4.50	0.60	0.32	0.00	0.08	5.51	5.10
0.87	0.12	0.06	0.00	0.02	1.06	0.99
10.01	1.33	0.72	0.01	0.17	12.24	11.33
5.52	0.73	0.40	0.00	0.10	6.75	6.25
12.95	1.72	0.93	0.01	0.22	15.83	14.66
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.23	0.16	0.09	0.00	0.02	1.50	1.39
0.75	0.10	0.05	0.00	0.01	0.92	0.85
0.56	0.07	0.04	0.00	0.01	0.69	0.64
0.09	0.01	0.01	0.00	0.00	0.11	0.10
1.94	0.26	0.14	0.00	0.06	2.40	2.22
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.30	0.04	0.02	0.00	0.00	0.36	0.34
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.04	0.00	0.00	0.00	0.00	0.05	0.04
0.31	0.04	0.02	0.00	0.01	0.39	0.36
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.03	0.00	0.00	0.00	0.00	0.04	0.03
74.50	9.87	5.36	0.06	1.21	90.99	84.25
		PLUS SI-800			3.69	3.69
		TOTAL INCLUDING SI-800			94.68	87.94

DATA USED

EFFICIENCY 106.0 PERCENT DAYWORK 2.00 PERCENT ABSENT 5.00 PERCENT SATOT 8.00 PERCENT
LO-MS 13.25 PERCENT PRO-CHKG 7.19 PERCENT SMALL-LOT 0.08 PERCENT WORKING DAYS 20.
SI 800 29.10 HOURS PER DAY

MANPOWER REQUIREMENTS

PRODUCTION INFORMATION

CODE	CLAN	PERIOD	BHRS/C	---PERCENTAGES--- SHRG	SUPPL	OTHER
35A	3683.	10	4.1618	58.40	46.10	3.64
37A	53.	10	9.4253	105.40	1.70	3.64
F-35023	1820.	10	0.8457	58.40	46.10	3.64
8B	17635.	10	1.4059	265.60	25.60	3.64
9A	4088.	10	8.8394	53.90	30.80	3.64
9B	201.	10	8.5528	105.40	1.70	3.64
9D	12918.	10	8.5528	105.40	1.70	3.64
12A	0.	10	0.8457	58.40	46.10	3.64
12B	36171.	10	0.8457	58.40	46.10	3.64
12D	67761.	10	0.8457	58.40	46.10	3.64
12E	11894.	10	1.3631	58.40	46.10	3.64
12F	62083.	10	1.0160	58.40	46.10	3.64
12G	71625.	10	0.8457	58.40	46.10	3.64
12H	139551.	10	0.8457	58.40	46.10	3.64
12K	3.	10	1.3631	58.40	46.10	3.64
12L	17534.	10	1.1511	58.40	46.10	3.64
12M	9300.	10	0.8457	58.40	46.10	3.64
12N	30.	10	0.8457	58.40	46.10	3.64
17A	497.	10	5.9200	451.40	0.80	3.64
17B	1289.	10	5.9200	451.40	0.80	3.64
28A	0.	10	47.4000	451.40	0.80	3.64
30A	824.	10	2.5375	265.60	25.60	3.64
30B	0.	10	2.0201	265.60	25.60	3.64
30C	92.	10	2.0201	265.60	25.60	3.64
36A	700.	10	1.2745	265.60	25.60	3.64
31A	0.	10	1.9712	58.40	46.10	3.64
31B	0.	10	1.4538	58.40	46.10	3.64
31C	125.	10	1.4538	58.40	46.10	3.64
071	END MNTH	10				

NUMBER OF EMPLOYEES REQUIRED

BASE	LO-MS	PRO-CHG	SM-LT	OTHER	TOT EXC SI800	SAT.ADJ
2.05	0.23	0.15	0.00	0.04	2.46	2.05
0.07	0.01	0.00	0.00	0.00	0.08	0.07
0.21	0.02	0.01	0.00	0.00	0.25	0.21
6.34	0.71	0.45	0.01	0.06	7.56	6.30
4.36	0.49	0.31	0.00	0.09	5.25	4.37
0.23	0.03	0.02	0.00	0.00	0.28	0.23
14.95	1.67	1.07	0.01	0.26	17.96	14.96
0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.09	0.46	0.29	0.00	0.07	4.91	4.09
7.66	0.85	0.55	0.01	0.14	9.20	7.67
2.17	0.24	0.15	0.00	0.04	2.60	2.17
8.43	0.94	0.60	0.01	0.15	10.13	8.44
8.09	0.90	0.58	0.01	0.14	9.72	8.10
15.77	1.76	1.13	0.01	0.28	18.94	15.79
0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.70	0.30	0.19	0.00	0.05	3.24	2.70
1.05	0.12	0.08	0.00	0.02	1.26	1.05
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.06	0.12	0.08	0.00	0.01	1.26	1.05
2.75	0.31	0.20	0.00	0.02	3.28	2.73
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.53	0.06	0.04	0.00	0.00	0.64	0.53
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.05	0.01	0.00	0.00	0.00	0.06	0.05
0.23	0.03	0.02	0.00	0.00	0.27	0.23
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02	0.00	0.00	0.00	0.00	0.03	0.02
82.80	9.22	5.91	0.07	1.38	99.38	82.82
		PLUS	SI-800		3.72	3.72
		TOTAL	INCLUDING	SI-800	103.10	86.53

DATA USED

EFFICIENCY 102.2 PERCENT DAYWORK 1.40 PERCENT ABSENT 5.00 PERCENT SATOT 20.00 PERCENT
LC-MS 11.14 PERCENT PRO-CHKG 7.14 PERCENT SMALL-LOT 0.08 PERCENT WORKING DAYS 20.
SI 800 28.44HOURS PER DAY

MANPOWER REQUIREMENTS

PRODUCTION INFORMATION

CODE	QUAN	PERIOD	BHRS/C	---PERCENTAGES--- SHRG	SUPPL	OTHER
35A	4000.	11	4.1618	60.00	50.00	3.64
37A	0.	11	9.4253	120.00	15.00	3.64
F-35023	0.	11	0.8457	60.00	50.00	3.64
8B	22000.	11	1.4051	170.00	40.00	3.64
9A	3500.	11	8.8394	200.00	50.00	3.64
9B	200.	11	8.5528	120.00	15.00	3.64
9C	12500.	11	8.5528	120.00	15.00	3.64
12A	0.	11	0.8457	60.00	50.00	3.64
12B	36000.	11	0.8457	60.00	50.00	3.64
12C	40000.	11	0.8457	60.00	50.00	3.64
12E	4800.	11	1.3631	60.00	50.00	3.64
12F	74000.	11	1.0160	60.00	50.00	3.64
12G	50000.	11	0.8457	60.00	50.00	3.64
12H	115000.	11	0.8457	60.00	50.00	3.64
12K	0.	11	1.3631	60.00	50.00	3.64
12L	8000.	11	1.1511	60.00	50.00	3.64
12M	6700.	11	0.8457	60.00	50.00	3.64
12N	5500.	11	0.8457	60.00	50.00	3.64
17A	200.	11	5.9200	15.00	0.00	3.64
17B	4500.	11	5.9200	15.00	0.00	3.64
28A	0.	11	47.7400	120.00	15.00	3.64
30A	600.	11	2.5375	170.00	40.00	3.64
30B	0.	11	2.0201	170.00	40.00	3.64
30C	0.	11	2.0201	170.00	40.00	3.64
36A	150.	11	1.2745	170.00	40.00	3.64
31A	1200.	11	1.9712	60.00	50.00	3.64
31B	0.	11	1.4538	60.00	50.00	3.64
31C	150.	11	1.4538	60.00	50.00	3.64
071	ALLYXTRA	11				

NUMBER OF EMPLOYEES REQUIRED

BASE	LC-MS	PRC-CHG	SM-LT	OTHER	TOT EXC SI800	SAT.ADJ
2.22	0.29	0.16	0.00	0.04	2.71	2.51
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.08	0.81	0.44	0.00	0.07	7.39	6.85
6.87	0.91	0.49	0.01	0.07	8.35	7.73
0.25	0.03	0.02	0.00	0.00	0.31	0.29
15.93	2.11	1.15	0.01	0.25	19.44	18.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.05	0.54	0.29	0.00	0.07	4.96	4.59
4.50	0.60	0.32	0.00	0.08	5.51	5.10
0.87	0.12	0.06	0.00	0.02	1.06	0.99
10.01	1.33	0.72	0.01	0.17	12.24	11.33
5.63	0.75	0.40	0.00	0.10	6.88	6.37
12.95	1.72	0.93	0.01	0.22	15.83	14.66
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.23	0.16	0.09	0.00	0.02	1.50	1.39
0.75	0.10	0.05	0.00	0.01	0.92	0.85
0.62	0.08	0.04	0.00	0.01	0.76	0.70
0.09	0.01	0.01	0.00	0.00	0.11	0.10
1.94	0.26	0.14	0.00	0.06	2.40	2.22
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.30	0.04	0.02	0.00	0.00	0.36	0.34
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.04	0.00	0.00	0.00	0.00	0.05	0.04
0.31	0.04	0.02	0.00	0.01	0.39	0.36
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.03	0.00	0.00	0.00	0.00	0.04	0.03
74.67	9.89	5.37	0.06	1.21	91.20	84.44
		PLUS SI-800			3.69	3.69
		TOTAL INCLUDING SI-800			94.89	88.13

DATA USED

EFFICIENCY 106.0 PERCENT DAYWORK 2.00 PERCENT ABSENT 5.00 PERCENT SATCT 8.00 PERCENT
LC-MS 13.25 PERCENT PRC-CHKG 7.19 PERCENT SMALL-LOT 0.08 PERCENT WORKING DAYS 20.
SI 800 29.10HOURS PER DAY

MANPOWER REQUIREMENTS

PRODUCTION INFORMATION

CODE	QUAN	PERIOD	8HRS/C	---PERCENTAGES--- SHRG	SUPPL	OTHER
35A	3844.	11	3.2978	80.98	75.96	3.64
37A	164.	11	9.4253	88.57	2.76	3.64
F-35023	5010.	11	0.8169	80.98	75.96	3.64
8B	23383.	11	1.2527	247.95	122.80	3.64
9A	1922.	11	9.4600	81.41	0.52	3.64
9B	221.	11	8.3600	88.57	2.76	3.64
9C	15802.	11	8.3600	88.57	2.76	3.64
12A	0.	11	0.8169	80.98	75.96	3.64
12B	14734.	11	0.8169	80.98	75.96	3.64
12D	82135.	11	0.8169	80.98	75.96	3.64
12E	20475.	11	1.2466	80.98	75.96	3.64
12F	45953.	11	0.9584	80.98	75.96	3.64
12G	14791.	11	0.8169	80.98	75.96	3.64
12H	150889.	11	0.8169	80.98	75.96	3.64
12K	474.	11	1.2466	80.98	75.96	3.64
12L	18559.	11	1.0427	80.98	75.96	3.64
12M	16440.	11	0.8169	80.98	75.96	3.64
12N	8304.	11	0.8169	80.98	75.96	3.64
17A	0.	11	5.9200	51.67	1.92	3.64
17B	7432.	11	5.8830	51.67	1.92	3.64
28A	0.	11	47.7400	51.67	1.92	3.64
30A	354.	11	2.2974	247.95	122.80	3.64
30B	0.	11	1.8677	247.95	122.80	3.64
30C	0.	11	1.8677	247.95	122.80	3.64
36A	8.	11	1.6942	247.95	122.80	3.64
31A	425.	11	1.8547	80.98	75.96	3.64
31B	0.	11	1.4250	80.98	75.96	3.64
31C	0.	11	1.4250	80.98	75.96	3.64
35B	295.	11	0.8169	80.98	75.96	3.64
071	END MNTH	11				

NUMBER OF EMPLOYEES REQUIRED

BASE	LO-MS	PRC-CHG	SM-LT	OTHER	TOT EXC SI800	SAT.ADJ
2.07	0.28	0.13	0.00	0.03	2.51	2.09
0.19	0.03	0.01	0.00	0.00	0.23	0.19
0.67	0.09	0.04	0.00	0.01	0.81	0.68
8.78	1.17	0.55	0.01	0.07	10.57	8.81
2.11	0.28	0.13	0.00	0.04	2.56	2.14
0.23	0.03	0.01	0.00	0.00	0.27	0.23
16.09	2.14	1.02	0.01	0.31	19.56	16.30
0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.97	0.26	0.12	0.00	0.03	2.38	1.99
10.97	1.46	0.69	0.01	0.16	13.29	11.07
4.17	0.55	0.26	0.00	0.06	5.06	4.21
7.20	0.96	0.45	0.01	0.10	8.72	7.27
1.98	0.26	0.12	0.00	0.03	2.39	1.99
20.16	2.68	1.27	0.02	0.29	24.41	20.34
0.10	0.01	0.01	0.00	0.00	0.12	0.10
3.17	0.42	0.20	0.00	0.04	3.83	3.19
2.20	0.29	0.14	0.00	0.03	2.66	2.22
1.11	0.15	0.07	0.00	0.02	1.34	1.12
0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.27	0.57	0.27	0.00	0.10	5.22	4.35
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.24	0.03	0.02	0.00	0.00	0.29	0.24
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.13	0.02	0.01	0.00	0.00	0.16	0.13
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.04	0.01	0.00	0.00	0.00	0.05	0.04
87.84	11.67	5.54	0.07	1.32	106.45	88.71
		PLUS SI-800			3.62	3.62
		TOTAL INCLUDING SI-800			110.06	92.32

DATA USED

EFFICIENCY 104.9 PERCENT DAYWORK 1.40 PERCENT ABSENT 5.00 PERCENT SATOT 20.00 PERCENT
LO-MS 13.29 PERCENT PRC-CHKG 6.31 PERCENT SMALL-LOT 0.08 PERCENT WORKING DAYS 20.
SI 800 28.40HOURS PER DAY

MANPOWER REQUIREMENTS

PRODUCTION INFORMATION

CODE	CLAN	PERIOD	BHRS/C	---PERCENTAGES--- SHRG	SUPPL	OTHER
396A	10000.	10	8.8700	29.00	3.00	3.70
401A	0.	10	7.1100	29.00	3.00	3.70
407B	3000.	10	9.9900	29.00	3.00	3.70
407A	31500.	10	8.7200	29.00	3.00	3.70
408A	85000.	10	7.1100	29.00	3.00	3.70
412A	800.	10	19.4400	29.00	3.00	3.70
404A	9000.	10	12.6200	29.00	3.00	3.70
5847	4000.	10	12.6200	29.00	3.00	3.70
417A	3700.	10	11.0800	29.00	3.00	3.70
5842	300.	10	11.0800	29.00	3.00	3.70
435A	1600.	10	17.1700	29.00	3.00	3.70
373A	710.	10	19.8400	29.00	3.00	3.70
374A	895.	10	19.7700	29.00	3.00	3.70
381A	55.	10	38.9700	29.00	3.00	3.70
384A	2300.	10	37.1100	29.00	3.00	3.70
386A	880.	10	35.7900	29.00	3.00	3.70
387A	135.	10	36.2700	29.00	3.00	3.70
418A	0.	10	25.8200	29.00	3.00	3.70
429A	6200.	10	27.5300	29.00	3.00	3.70
436A	1200.	10	40.7900	29.00	3.00	3.70
437A	2755.	10	35.9500	29.00	3.00	3.70
448A	240.	10	39.0500	29.00	3.00	3.70
454A	0.	10	39.4100	29.00	3.00	3.70
448B	50.	10	39.0500	29.00	3.00	3.70
55788	1000.	10	11.0800	29.00	3.00	3.70
6	MIN-CARR	10				

NUMBER OF EMPLOYEES REQUIRED

BASE	LO-MS	PRO-CHG	SM-LT	OTHER	TOT EXC SI800	SAT.ADJ
7.98	0.58	0.34	0.04	0.22	9.16	9.16
0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.70	0.20	0.11	0.01	0.08	3.10	3.10
24.71	1.80	1.04	0.12	0.69	28.37	28.37
54.37	3.97	2.28	0.27	1.52	62.42	62.42
1.40	0.10	0.06	0.01	0.04	1.61	1.61
10.22	0.75	0.43	0.05	0.29	11.73	11.73
4.54	0.33	0.19	0.02	0.13	5.21	5.21
3.69	0.27	0.15	0.02	0.10	4.23	4.23
0.30	0.02	0.01	0.00	0.01	0.34	0.34
2.47	0.18	0.10	0.01	0.07	2.84	2.84
1.27	0.09	0.05	0.01	0.04	1.45	1.45
1.59	0.12	0.07	0.01	0.04	1.83	1.83
0.19	0.01	0.01	0.00	0.01	0.22	0.22
7.68	0.56	0.32	0.04	0.22	8.82	8.82
2.83	0.21	0.12	0.01	0.08	3.25	3.25
0.44	0.03	0.02	0.00	0.01	0.51	0.51
0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.36	1.12	0.64	0.08	0.43	17.63	17.63
4.40	0.32	0.18	0.02	0.12	5.06	5.06
8.91	0.65	0.37	0.04	0.25	10.23	10.23
0.84	0.06	0.04	0.00	0.02	0.97	0.97
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.18	0.01	0.01	0.00	0.00	0.20	0.20
1.00	0.07	0.04	0.00	0.03	1.14	1.14
157.07	11.47	6.60	0.79	4.40	180.32	180.32
			PLUS SI-800		3.72	3.72
			TOTAL INCLUDING SI-800		184.04	184.04

DATA USED

EFFICIENCY 100.0 PERCENT DAYWORK 3.30 PERCENT ABSENT 5.00 PERCENT SATOT 0.00 PERCENT
LO-MS 7.30 PERCENT PRO-CHKG 4.20 PERCENT SMALL-LOT 0.50 PERCENT WORKING DAYS 20.
SI 800 27.27 HOURS PER DAY

MANPOWER REQUIREMENTS

PRODUCTION INFORMATION

CODE	CLAM	PERIOD	BHRS/C	---PERCENTAGES--- SHRG	SUPPL	OTHER
396A	11961.	10	8.8700	27.70	1.82	3.70
401A	0.	10	7.1100	27.70	1.82	3.70
407B	3968.	10	9.9900	27.70	1.82	3.70
407A	24383.	10	8.7200	27.70	1.82	3.70
408A	99134.	10	7.1100	27.70	1.82	3.70
412A	408.	10	19.4400	27.70	1.82	3.70
404A	8043.	10	10.0500	27.70	1.82	3.70
5847	5283.	10	10.0500	27.70	1.82	3.70
417A	0.	10	11.0800	27.70	1.82	3.70
5842	26.	10	8.7800	27.70	1.82	3.70
435A	1142.	10	14.6000	27.70	1.82	3.70
373A	377.	10	19.8400	27.70	1.82	3.70
374A	352.	10	19.7700	27.70	1.82	3.70
381A	98.	10	38.9700	27.70	1.82	3.70
364A	1343.	10	37.1100	27.70	1.82	3.70
386A	462.	10	35.7900	27.70	1.82	3.70
387A	135.	10	36.2700	27.70	1.82	3.70
418A	2231.	10	23.2000	27.70	1.82	3.70
429A	6355.	10	27.5300	27.70	1.82	3.70
436A	631.	10	40.7900	27.70	1.82	3.70
437A	3043.	10	35.9500	27.70	1.82	3.70
448A	0.	10	39.0500	27.70	1.82	3.70
454A	0.	10	39.4100	27.70	1.82	3.70
448B	0.	10	39.0500	27.70	1.82	3.70
55788	27750.	10	8.5000	27.70	1.82	3.70
CC6	AFTER	10				

NUMBER OF EMPLOYEES REQUIRED

BASE	LC-MS	PRC-CHG	SM-LT	OTHER	TOT.EXC SI800	SAT.ADJ
8.67	0.63	0.36	0.04	0.25	9.96	9.96
0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.24	0.24	0.14	0.02	0.09	3.72	3.72
17.37	1.27	0.73	0.09	0.50	19.95	19.95
57.59	4.20	2.42	0.29	1.65	66.14	66.14
0.65	0.05	0.03	0.00	0.02	0.74	0.74
6.60	0.48	0.28	0.03	0.19	7.59	7.59
4.34	0.32	0.18	0.02	0.12	4.98	4.98
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02	0.00	0.00	0.00	0.00	0.02	0.02
1.36	0.10	0.06	0.01	0.04	1.56	1.56
0.61	0.04	0.03	0.00	0.02	0.70	0.70
0.57	0.04	0.02	0.00	0.02	0.65	0.65
0.31	0.02	0.01	0.00	0.01	0.36	0.36
4.07	0.30	0.17	0.02	0.12	4.68	4.68
1.35	0.10	0.06	0.01	0.04	1.55	1.55
0.40	0.03	0.02	0.00	0.01	0.46	0.46
4.23	0.31	0.18	0.02	0.12	4.86	4.86
14.29	1.04	0.60	0.07	0.41	16.42	16.42
2.10	0.15	0.09	0.01	0.06	2.42	2.42
8.94	0.65	0.38	0.04	0.26	10.27	10.27
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00
19.27	1.41	0.81	0.10	0.55	22.13	22.13
155.98	11.39	6.55	0.78	4.46	179.16	179.16
			PLUS SI-800		2.99	2.99
			TOTAL INCLUDING SI-800		182.15	182.15

DATA USED

EFFICIENCY 107.0 PERCENT DAYWORK 2.40 PERCENT ABSENT 5.00 PERCENT SATOT 0.00 PERCENT
LC-MS 7.30 PERCENT PRC-CHKG 4.20 PERCENT SMALL-LOT 0.50 PERCENT WORKING DAYS 20.
SI 800 23.70HOURS PER DAY

APPENDIX B

CARD FIELD DESIGN

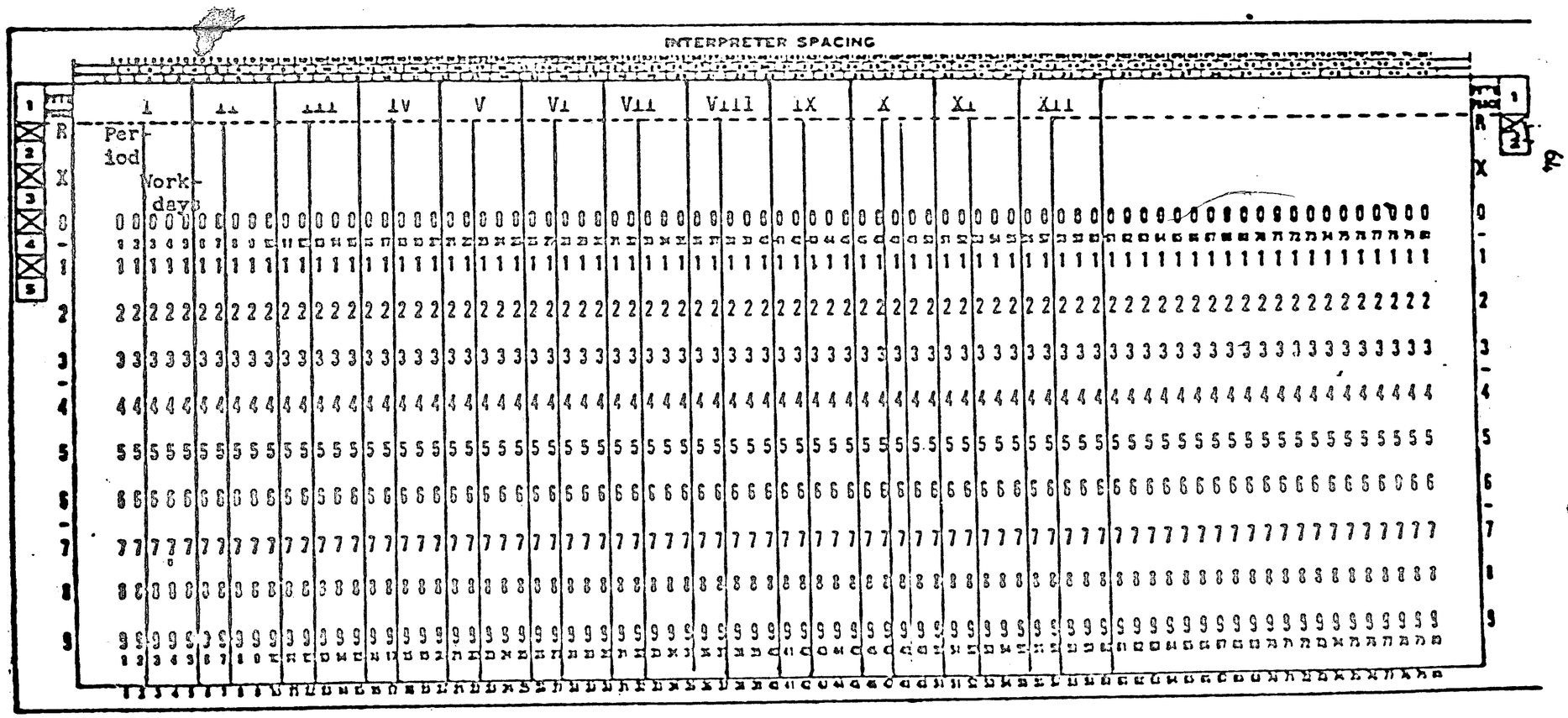
Data Processing Card Form Design

JOB NAME: JOB NUMBER: CARD CODE:

DECK NO. 1 Periods and Working Days

(Applicable to all Product Codes in manufacturing Group)

Period designation by Month's number - i.e. 6 for July
or Period designation by Month's abreviation-i.e. Jy for July
or 4Q for Fourth Quarter

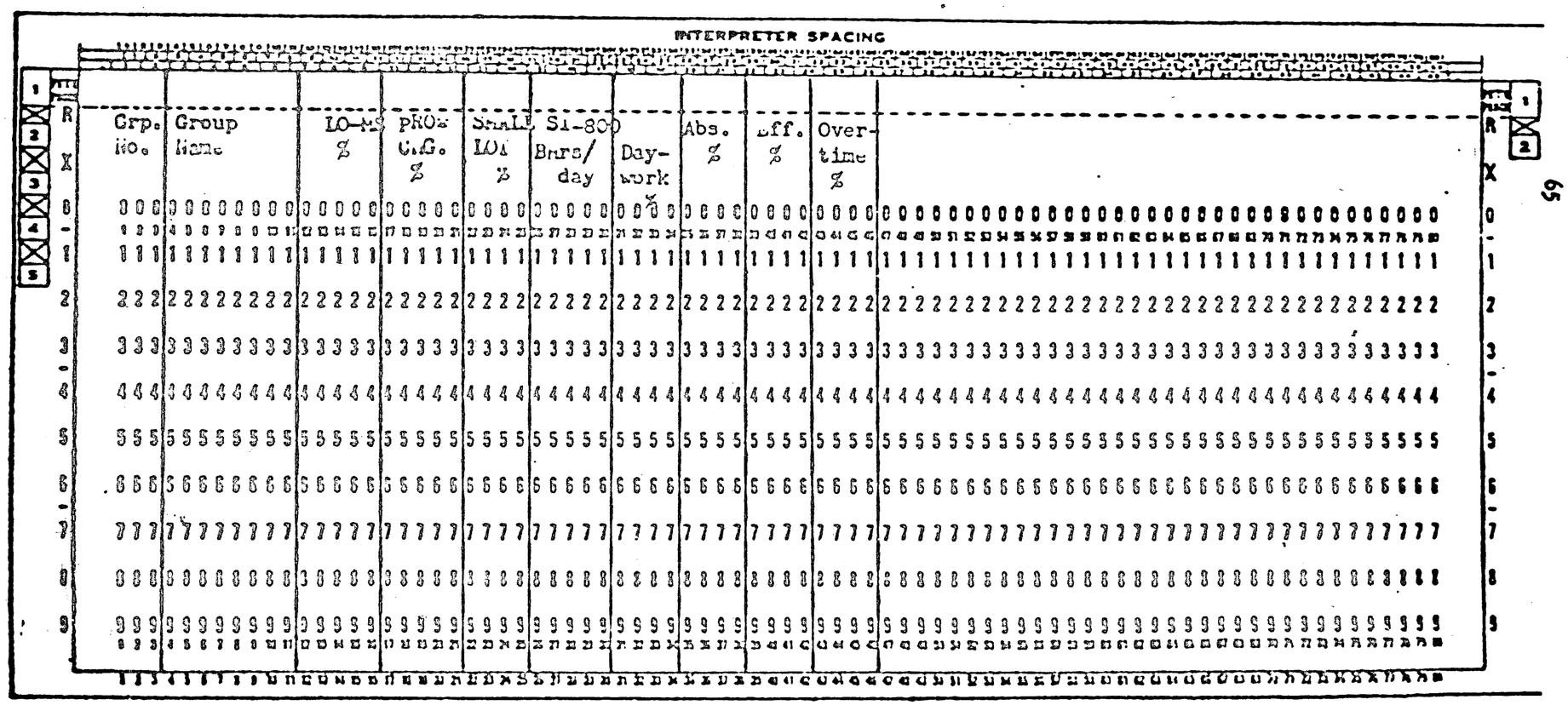


Data Processing Card Form Design

JOB NAME: JOB NUMBER: CARD CODE:

DeCa NO. 2 Group Information Card

One key-punched card for the Manufacturing Group with information applicable to all product codes in the Group.

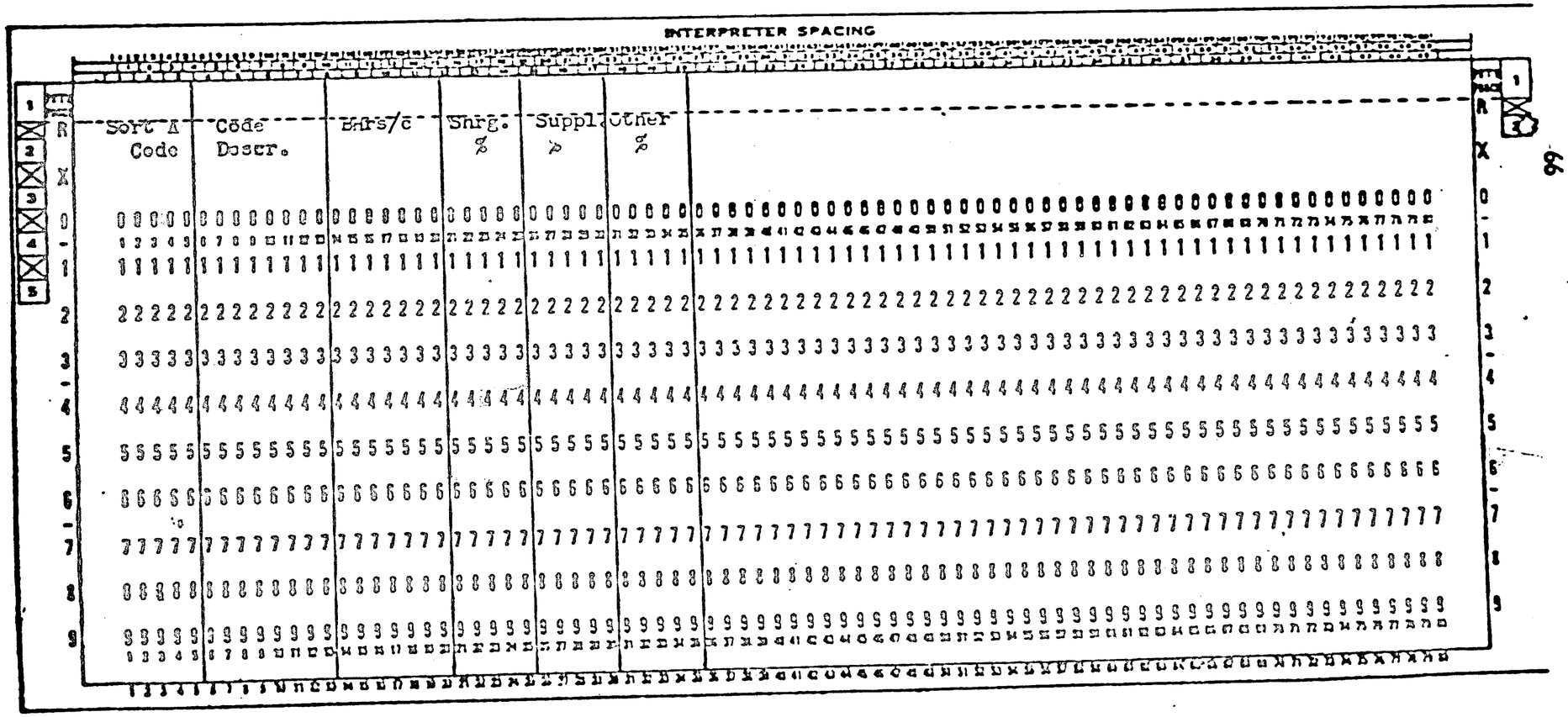


Data Processing Card Form Design

JOB NAME: JOB NUMBER: CARD CODE:

DATA NO. 3 Product Code Information

Cards with data for the manufacturing Variables for each product code in the manufacturing Group

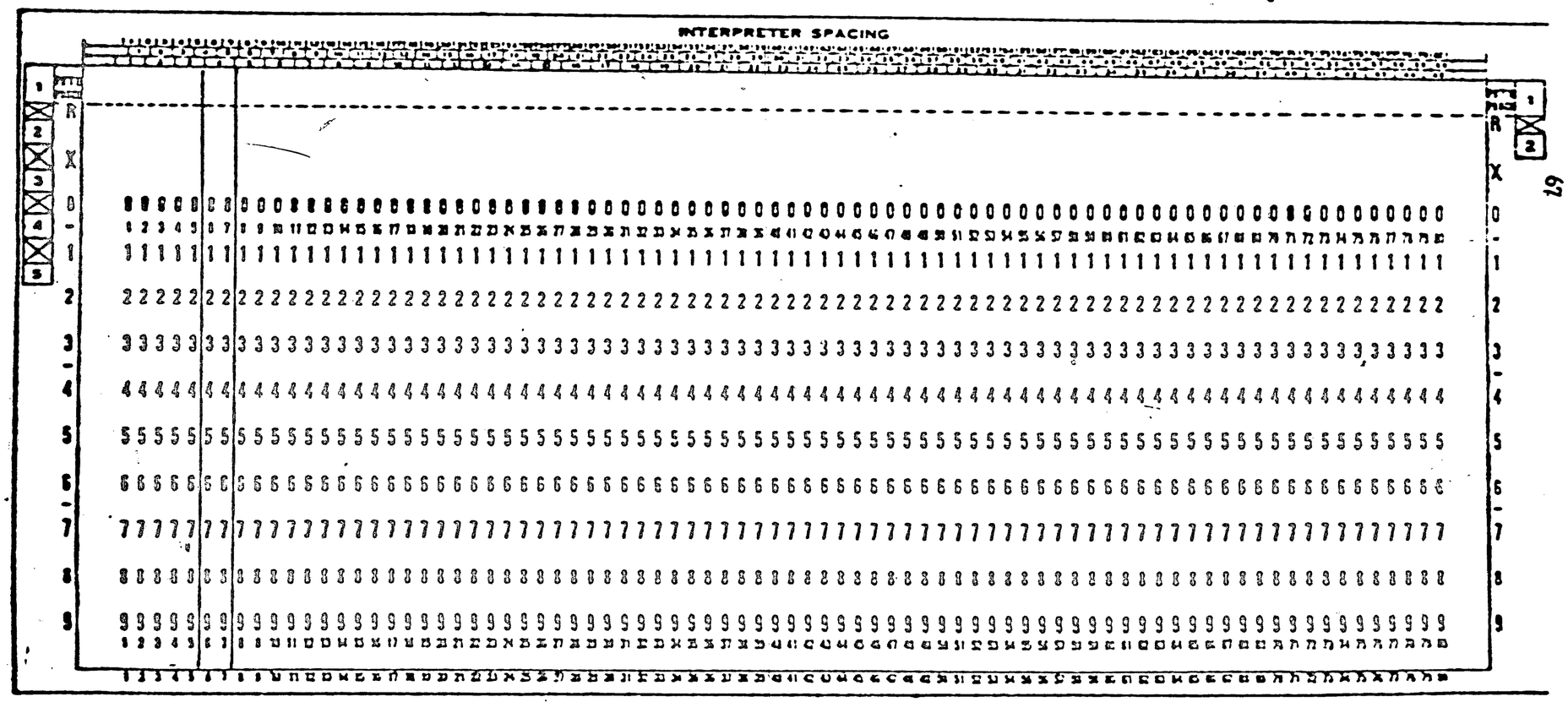


Data Processing Card Form Design

JOB NAME: JOB NUMBER: CARD CODE:

Control Card for back of Deck 3

Contains number of Periods being Forecasted (max. 12)



Data Processing Card Form Design

JOB NAME: JOB NUMBER: CARD CODE:

DCR .O. 4 Product Code Quantity Information

Cards for each Product Code in the Manufacturing Group with Quantity to be produced in each Period.

INTERPRETER SPACING

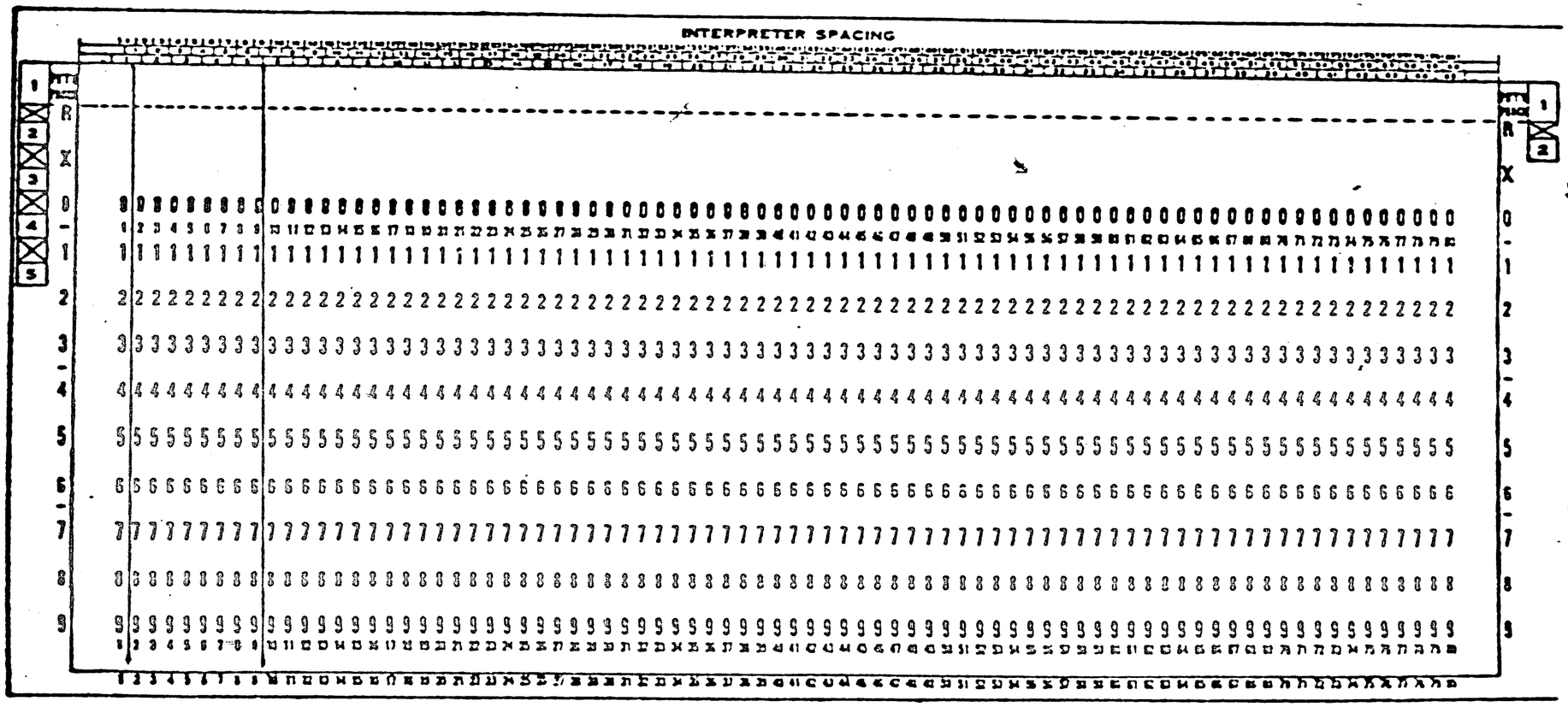
Sort No.	Quan.	Quan.	Quan.	Quan.	Quan.	Quan.	Quan.	Quan.	Quan.	Quan.	Quan.	Quan.	Quan.	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9	9	9	9	9	9	9

Data Processing Card Form Design

JOB NAME: JOB NUMBER: CARD CODE:

FIRST CARD

80 Back-up Input Data Deck



APPENDIX C

FORM DESIGN

Group No.___ Descrip._____

Engineer_____ Date _____

Period	Work Days	Period	Work Days	Period	Work Days	Period	Work Days	Period	Work Days	Period	Work Days	Period	Work Days	Period	Work Days	Period	Work Days	Period	Work Days	Period	Work Days	Period	Work Days
1	5		3		5		8		13		18		23		28		33		38		43		48

Gr. No.	Group Name	LOMS %	Pro-Chk %	Small Lot %	S1-800 BHRS Day	Day-Work %	Absent %	Eff. %	Sat.OT %
3	11	16	21	25	30	34	38	42	46

Group No. ____ Descrip. __________

Engineer ________________ Date __________

Sort Code	Code Descrip.	BHRS / C	Shrg. %	Supp. %	Other	

Gr. No.___ Descrip.___

Engineer___ Date___

No. of pages	
7	

Group No.__ Descrip.______

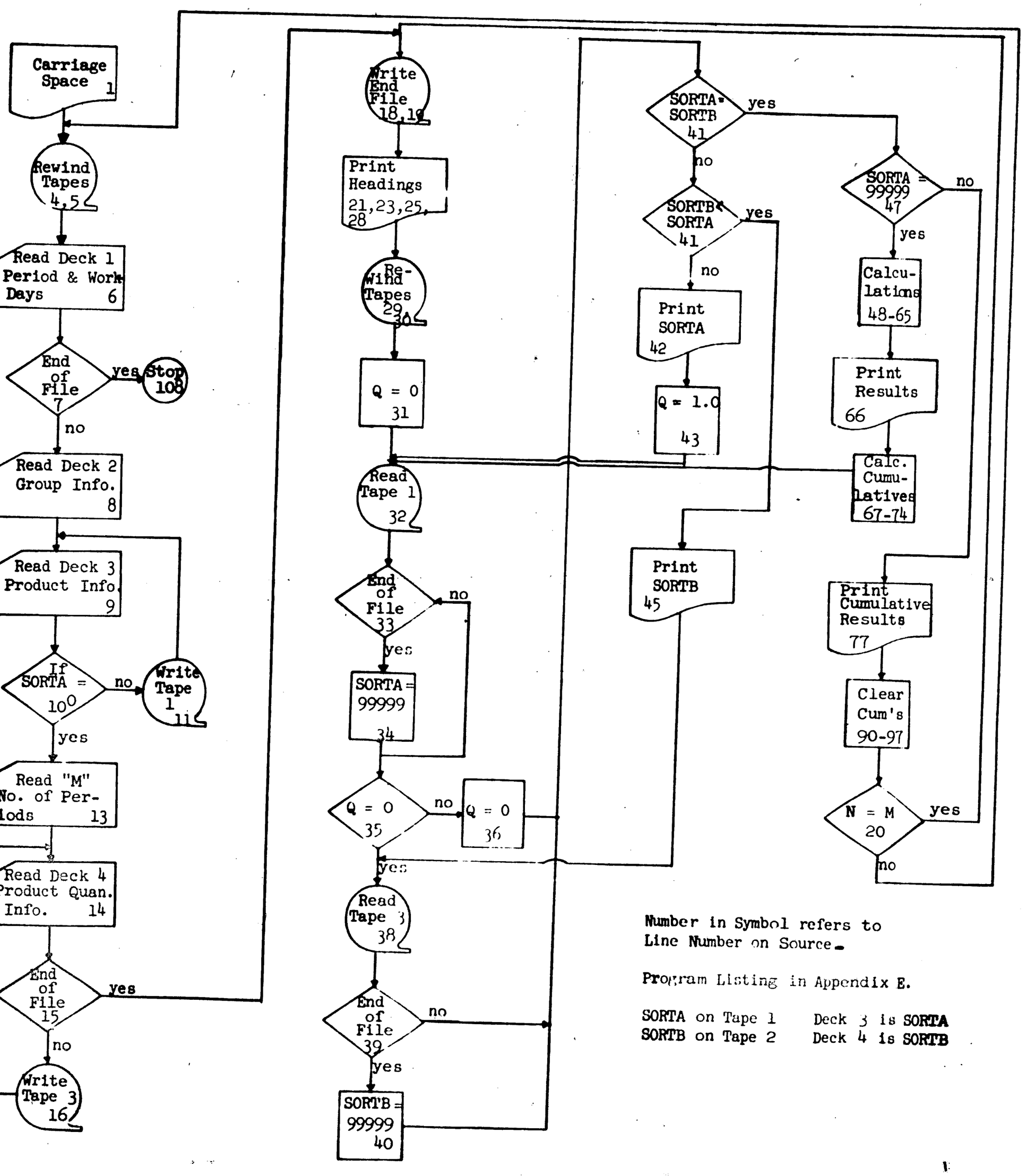
Engineer__________ Date______

Sort Code	Quant. Per. 1	Per. 2	Per. 3	Per. 4	Per. 5	Per. 6	Per. 7	Per. 8	Per. 9	Per. 10	Per. 11	Per. 12	
8	6 11	17	23	29	35	41	47	53	57	65	71	77	

APPENDIX D

FLOW CHART OF COMPUTER PROGRAM

PROGRAM FLOW CHART



Number in Symbol refers to Line Number on Source.

Program Listing in Appendix E.

SORTA on Tape 1 Deck 3 is SORTA
SORTB on Tape 2 Deck 4 is SORTB

APPENDIX E

SOURCE PROGRAM LISTING

*** SOURCE PROGRAM LISTING ***

```
      TITLEDWD
C     D.W.DIETRICH,DEPT. 5430) X-2414
C     MANPOWER REQUIREMENTS
      DIMENSION NPER(12),WD(12)
      DIMENSION GUAN(12)
      PRINT 200                                                    1
  200 FORMAT(1H1)                                                  2
   11 CONTINUE                                                     3
      REWIND 3                                                     4
      REWIND 1                                                     5
      READ 10,(NPER(N),WD(N),N=1,12)                               6
      IF END OF FILE 160,12                                        7
   12 READ 15,IGRPNO,GRPNAM,XLOMS,PROCHG,SMLT,SI,DW,ABSENT,EFF,SATOT  8
   16 READ 20,SCRTA,ICODE,BHRS,SHRG,SUPPL,OTHER                    9
      IF(SORTA-C) 25,25,18                                         10
   18 WRITE TAPE 1,SCRTA,ICODE,BHRS,SHRG,SUPPL,OTHER               11
      GO TO 16                                                     12
   25 READ 30,M                                                    13
   32 READ 35,SCRTB,(GUAN(N),N=1,M)                                14
      IF END OF FILE 45,40                                         15
   40 WRITE TAPE 3,SCRTB,GUAN                                      16
      GO TO 32                                                     17
   45 END FILE 1                                                   18
```

```
      END FILE 3                                                        19
      DO 150 N=1,2                                                      20
      PRINT 104                                                         21
  104 FORMAT(1HC,45B,21HMANPOWER REQUIREMENTS)                          22
      PRINT 151                                                         23
  151 FORMAT(1H0,11B,10HPRODUCTION,1B,11HINFORMATION,33B,6HNUMBER,1B,   24
     X2HOF,1B,9HEMPLOYEES,1B,8HREQUIRED)
      PRINT 152                                                         25
  152 FORMAT(1H ,30B,3H---,11HPERCENTAGES,3H---)                        26
      PRINT 100                                                         27
  100 FORMAT(1H0,1B,4HCODE,4B,4HQUAN,3B,6HPERIOD,1B,6HHRS/C,1B,         28
     X4HSHRG,2B,5HSUPPL,1B,5HOTHER,12B,4HBASE,3B,5HLC-MS,2B,
     X7HPRO-CHG,1B,5HSM-LT,2B,5HOTHER,2B,
     X13HTOT EXC SI80C,1B,7HSAT.ADJ)
      REWIND 3                                                          29
      REWIND 1                                                          30
      C=0.0                                                             31
   47 READ TAPE 1,SORTA,ICODE,BHRS,SHRG,SUPPL,OTHER                     32
      IF END OF FILE 48,50                                              33
   48 SORTA=99999.                                                      34
   50 IF(C=0.0) 55,55,56                                                35
   56 C=0.0                                                             36
      GO TO 60                                                          37
   55 READ TAPE 3,SORTB,QUAN                                            38
      IF END OF FILE 58,60                                              39
   58 SORTB=99999.                                                      40
   60 IF(SORTB-SORTA) 68,70,65                                          41
   65 PRINT 66,SORTA                                                    42
      C=1.0                                                             43
```

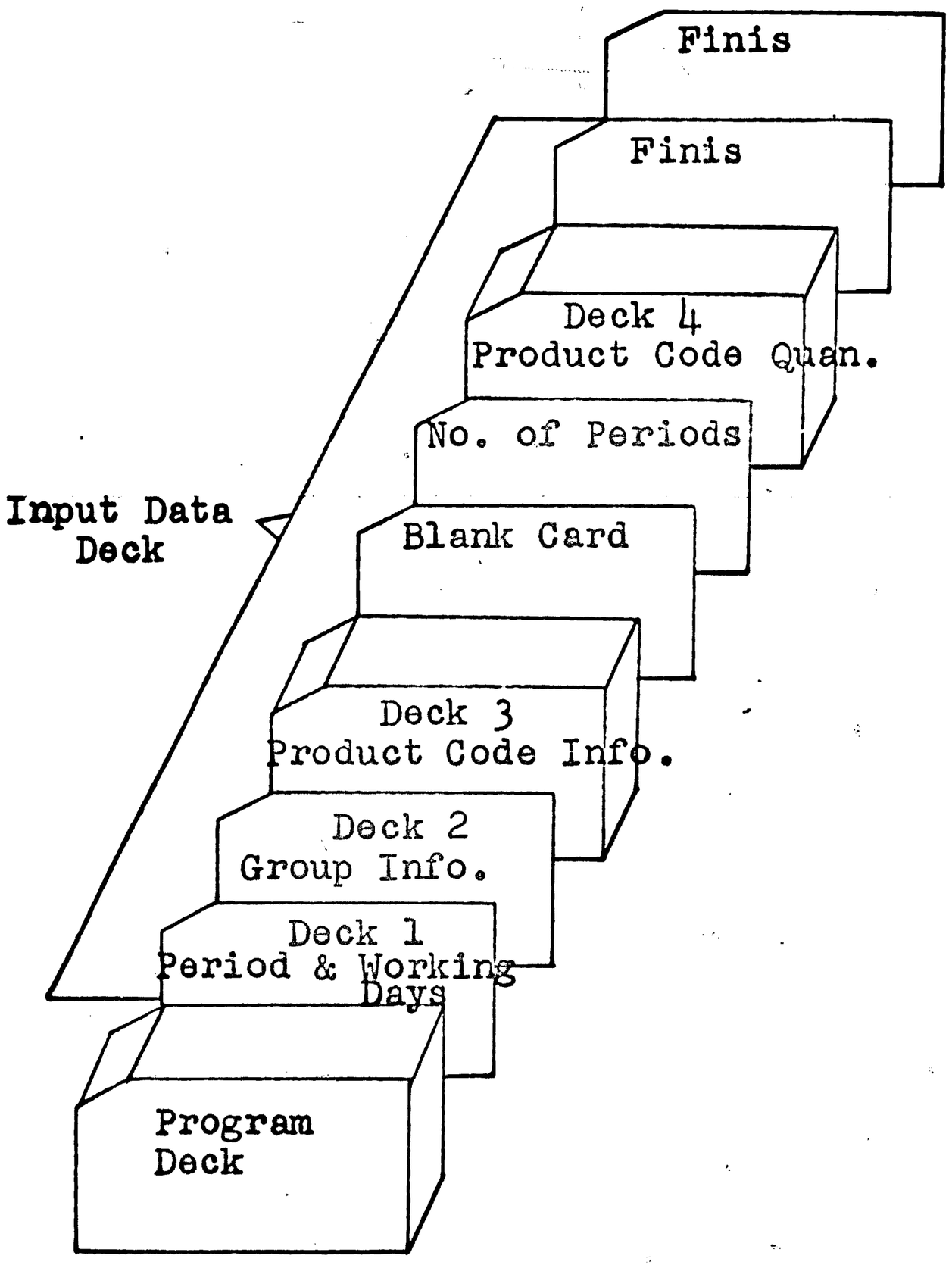
```
      GO TO 47                                                          44
   68 PRINT 69,SCRTB                                                    45
      GO TO 99                                                          46
   70 IF(SCRTA-99999.)80,95,95                                          47
   80 W1=(GLAN(N)*BHRS)/100.0                                           48
      W2=(W1*SHRG)/100.0                                                49
      W3=(W1*SUPPL)/100.0                                               50
      W4=W1+W2+W3                                                       51
      W5=(W4*XLCHS)/100.0                                               52
      W6=(W4*PRCCHG)/100.0                                              53
      W7=(W4*SALTI)/100.0                                               54
      W8=(W1*OTHER)/100.0                                               55
      W9=WD(N)*SI                                                       56
      X=(8.0*(100.0-ABSENT-DW))/100.0                                   57
      V=WD(N)*X                                                         58
      Y1=(W4/V)/EFF                                                     59
      Y2=(W5/V)/EFF                                                     60
      Y3=(W6/V)/EFF                                                     61
      Y4=(W7/V)/EFF                                                     62
      Y5=(W8/V)/EFF                                                     63
      Z7=Y1+Y2+Y3+Y4+Y5                                                 64
      U=(Z7/(100.0+SATCT))*100.0                                        65
      PRINT 85,ICODE,GUAN(N),NPER(N),BHRS,SHRG,SUPPL,OTHER,Y1,          66
     XY2,Y3,Y4,Y5,Z7,U
      Y1TOT=Y1TOT+Y1                                                    67
      Y2TOT=Y2TOT+Y2                                                    68
      Y3TOT=Y3TOT+Y3                                                    69
      Y4TOT=Y4TOT+Y4                                                    70
```

```
      Y5TOT=Y5TOT+Y5                                                    71
      Y6TOT=(W9/V)/EFF                                                  72
      ZTOT=ZTOT+Z7                                                      73
      UTOT=UTOT+U                                                       74
      AEFF=EFF*100.0                                                    75
      GO TO 47                                                          76
   95 PRINT 98,IGRPNO,GRPNAM,NPER(N),Y1TOT,Y2TOT,Y3TOT,Y4TOT,Y5TOT,     77
     XZTOT,UTOT
      VTOT=ZTOT+Y6TOT                                                   78
      WTOT=UTOT+Y6TOT                                                   79
      PRINT 99,Y6TOT,Y6TOT                                              80
   99 FORMAT(1H ,76B,4HPLUS,3B,6HSI-800,9B,F6.2,6B,F6.2)                81
      PRINT 105                                                         82
  105 FORMAT(1H ,99B,5H-----,7B,5H-----)                                83
      PRINT 101,VTOT,WTOT                                               84
  101 FORMAT(1HO,68B,5HTOTAL,2B,9HINCLUDING,2B,6HSI-800,7B,F7.2,5B,     85
     XF7.2)
      PRINT 102                                                         86
  102 FORMAT(1HO,5B,4HDATA,2B,4HUSED)                                   87
      PRINT 103,AEFF,DW,ABSENT,SATOT,XLOMS,PROCHG,SMLT,WD(N),SI         88
  103 FORMAT(1H ,6B,10HEFFICIENCY,F6.1,1B,7HPERCENT,6B,7HDAYSWRK,       89
     XF6.2,3B,7HPERCENT,6B,6HABSENT,3B,F6.2,1B,7HPERCENT,6B,5HSATOT,
     XF6.2,1B,7HPERCENT/1H ,6B,5HLO-MS,5B,F7.2,1B,7HPERCENT,5B
     X8HPRO-CHG,F6.2,2B,7HPERCENT,6B, 9HSMALL-LOT,F7.2,2B,
     X7HPERCENT,6B,7HWORKING,1B,4HDAYS,1B,F5.0/1H1,6B,6HSI 800,6B,
     XF7.2,5HHOURS,1B,3HPER,1B,3HDAY)
      Y1TOT=0                                                           90
      Y2TOT=0                                                           91
      Y3TOT=0                                                           92
      Y4TOT=0                                                           93
      Y5TOT=0                                                           94
```

```
      Y6TOT=0                                                          95
      ZTOT=0                                                           96
  150 UTOT=0                                                           97
      GO TO 11                                                         98
   10 FORMAT(12(A2,F3.0))                                              99
   15 FORMAT(I3,A8,F5.2,F5.2,F4.2,F5.2,F4.2,F4.2,F4.3,F4.2)            100
   20 FORMAT(F5.0,A8,F7.4,F5.2,F5.2,F5.2)                              101
   30 FORMAT(58,I2)                                                    102
   35 FORMAT(F5.0,12F6.0)                                              103
   66 FORMAT(1H ,1B,F7.0)                                              104
   69 FORMAT(1H ,1B,F7.0)                                              105
   85 FORMAT(1H ,A8,1B,F8.3,1B,A2,   F9.4,   F7.2,   F7.2,            106
     XF6.2,9B,F7.2,1B,F6.2,2B,F6.2,2B,F6.2,1B,F6.2,4B,F7.2,4B,
     XF7.2)
   98 FORMAT(1HC,I4,4B,A8,1B,A4,35B,F7.2,1B,F6.2,2B,F6.2,2B,F6.2,      107
     X1B,F6.2,1B,3B,F7.2,5B,F7.2)
  100 STOP                                                             108
      END                                                              109
```

APPENDIX F

ORDERING OF INPUT DATA DECK



APPENDIX G

COMPUTER PRINTOUTS FOR INDIVIDUAL FACTOR ANALYSIS IN ONE PRODUCTION GROUP (Group 25)

SUMMARY FOR INDIVIDUAL FACTOR ANALYSIS FOR EACH PRODUCTION GROUP

MANPOWER REQUIREMENTS

PRODUCTION INFORMATION

CODE	CLAN	PERIOD	SHRS/C	---PERCENTAGES--- SHRG	SUPPL	OTHER
1A	204.	10	2.7884	34.00	3.00	0.00
1C	1681.	10	2.8659	34.00	3.00	0.00
1D	508.	10	2.6811	34.00	3.00	0.00
8A	12993.	10	2.2442	34.00	3.00	0.00
8C	7869.	10	2.0953	34.00	3.00	0.00
21A	884.	10	8.6840	34.00	3.00	0.00
37C	3787.	10	14.7450	34.00	3.00	0.00
24A	3169.	10	48.8000	34.00	3.00	0.00
24B	46.	10	48.8000	34.00	3.00	0.00
24C	3029.	10	50.2000	34.00	3.00	0.00
24D	607.	10	50.2000	34.00	3.00	0.00
025	EFFICIEN	10				

NUMBER OF EMPLOYEES REQUIRED

BASE	LO-MS	PRO-CHG	SM-LT	OTHER	TOT EXC SI800	SAT.ADJ
0.05	0.00	0.00	0.00	0.00	0.06	0.05
0.42	0.03	0.01	0.01	0.00	0.47	0.44
0.12	0.01	0.00	0.00	0.00	0.13	0.13
2.53	0.19	0.07	0.04	0.00	2.82	2.68
1.43	0.11	0.04	0.02	0.00	1.60	1.51
0.67	0.05	0.02	0.01	0.00	0.74	0.70
4.84	0.37	0.13	0.07	0.00	5.41	5.13
13.40	1.03	0.35	0.20	0.00	14.98	14.20
0.19	0.01	0.01	0.00	0.00	0.22	0.21
13.18	1.01	0.34	0.20	0.00	14.73	13.96
2.64	0.20	0.07	0.04	0.00	2.95	2.80
39.45	3.04	1.03	0.59	0.00	44.11	41.81
		PLUS	SI-800		1.32	1.32
	TOTAL	INCLUDING	SI-800		45.43	43.13

DATA USED

EFFICIENCY	109.8 PERCENT	DAYWORK	5.00 PERCENT	ABSENT	5.00 PERCENT	SATOT	5.50 PERCENT
LC-MS	7.70 PERCENT	PRC-CHKG	2.60 PERCENT	SMALL-LOT	1.50 PERCENT	WORKING DAYS	20.
SI 800	10.44 HOURS PER DAY						

MANPOWER REQUIREMENTS

PRODUCTION INFORMATION

CODE	CLAN	PERIOD	BHRS/C	---PERCENTAGES--- SHRG	SUPPL	OTHER
1A	204.	10	2.7884	34.00	3.00	0.00
1C	1681.	10	2.8659	34.00	3.00	0.00
1D	508.	10	2.6811	34.00	3.00	0.00
8A	12993.	10	2.2442	34.00	3.00	0.00
8C	7868.	10	2.0953	34.00	3.00	0.00
21A	884.	10	8.6840	34.00	3.00	0.00
37C	3787.	10	14.7450	34.00	3.00	0.00
24A	3169.	10	48.8000	34.00	3.00	0.00
24B	46.	10	48.8000	34.00	3.00	0.00
24C	3029.	10	50.2000	34.00	3.00	0.00
24D	607.	10	50.2000	34.00	3.00	0.00
025	DAYWORK	10				

NUMBER OF EMPLOYEES REQUIRED

BASE	LO-MS	PRO-CHG	SM-LT	OTHER	TOT EXC SI800	SAT.ADJ
0.05	0.00	0.00	0.00	0.00	0.06	0.05
0.43	0.03	0.01	0.01	0.00	0.48	0.45
0.12	0.01	0.00	0.00	0.00	0.14	0.13
2.59	0.20	0.07	0.04	0.00	2.90	2.74
1.46	0.11	0.04	0.02	0.00	1.64	1.55
0.68	0.05	0.02	0.01	0.00	0.76	0.72
4.96	0.38	0.13	0.07	0.00	5.54	5.26
13.74	1.06	0.36	0.21	0.00	15.36	14.56
0.20	0.02	0.01	0.00	0.00	0.22	0.21
13.51	1.04	0.35	0.20	0.00	15.10	14.31
2.71	0.21	0.07	0.04	0.00	3.03	2.87
40.44	3.11	1.05	0.61	0.00	45.21	42.86
		PLUS	SI-800		1.35	1.35
		TOTAL	INCLUDING	SI-800	46.57	44.21

DATA USED

EFFICIENCY	107.0 PERCENT	DAYWORK	4.90	PERCENT	ABSENT	5.00 PERCENT	SATOT 5.50 PERCENT
LC-MS	7.70 PERCENT	PRC-CHKG	2.60	PERCENT	SMALL-LOT	1.50 PERCENT	WORKING DAYS 20.
SI 800	10.44HOURS PER DAY						

MANPOWER REQUIREMENTS

PRODUCTION INFORMATION

CODE	CLAN	PERIOD	BHRS/C	---PERCENTAGES--- SHRG	SUPPL	OTHER
1A	204.	10	2.7884	34.00	3.00	0.00
1C	1681.	10	2.8659	34.00	3.00	0.00
1D	508.	10	2.6811	34.00	3.00	0.00
8A	12993.	10	2.2442	34.00	3.00	0.00
8C	7868.	10	2.0953	34.00	3.00	0.00
21A	884.	10	8.6840	34.00	3.00	0.00
37C	3787.	10	14.7450	34.00	3.00	0.00
24A	3169.	10	48.8000	34.00	3.00	0.00
24B	46.	10	48.8000	34.00	3.00	0.00
24C	3029.	10	50.2000	34.00	3.00	0.00
24D	607.	10	50.2000	34.00	3.00	0.00
025	SAT CT	10				

NUMBER OF EMPLOYEES REQUIRED

BASE	LO-MS	PRC-CHG	SM-LT	OTHER	TOT EXC SI800	SAT.ADJ
0.05	0.00	0.00	0.00	0.00	0.06	0.05
0.43	0.03	0.01	0.01	0.00	0.48	0.40
0.12	0.01	0.00	0.00	0.00	0.14	0.11
2.59	0.20	0.07	0.04	0.00	2.90	2.42
1.47	0.11	0.04	0.02	0.00	1.64	1.37
0.68	0.05	0.02	0.01	0.00	0.76	0.64
4.96	0.38	0.13	0.07	0.00	5.55	4.63
13.75	1.06	0.36	0.21	0.00	15.37	12.81
0.20	0.02	0.01	0.00	0.00	0.22	0.19
13.52	1.04	0.35	0.20	0.00	15.12	12.60
2.71	0.21	0.07	0.04	0.00	3.03	2.52
40.49	3.12	1.05	0.61	0.00	45.26	37.72
		PLUS	SI-800		1.36	1.36
		TOTAL	INCLUDING	SI-800	46.62	39.07

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DATA USED

EFFICIENCY 107.0 PERCENT DAYWORK 5.00 PERCENT ABSENT 5.00 PERCENT SATOT 20.00 PERCENT
LC-MS 7.70 PERCENT PRC-CHKG 2.60 PERCENT SMALL-LCT 1.50 PERCENT WORKING DAYS 20.
SI 800 10.44HOURS PER DAY

MANPOWER REQUIREMENTS

PRODUCTION INFORMATION

CODE	CLAN	PERIOD	BHRS/C	---PERCENTAGES--- SHRG	SUPPL	OTHER
1A	204.	10	2.7884	31.60	3.00	0.00
1C	1681.	10	2.8659	31.60	3.00	0.00
1D	508.	10	2.6811	31.60	3.00	0.00
8A	12993.	10	2.2442	31.60	3.00	0.00
8C	7868.	10	2.0953	31.60	3.00	0.00
21A	884.	10	8.6840	31.60	3.00	0.00
37C	3787.	10	14.7450	31.60	3.00	0.00
24A	3169.	10	48.8000	31.60	3.00	0.00
24B	46.	10	48.8000	31.60	3.00	0.00
24C	3029.	10	50.2000	31.60	3.00	0.00
24D	607.	10	50.2000	31.60	3.00	0.00
025	SHRG.	10				

NUMBER OF EMPLOYEES REQUIRED

BASE	LO-MS	PRO-CHG	SM-LT	OTHER	TOT EXC SI800	SAT.ADJ
0.05	0.00	0.00	0.00	0.00	0.06	0.05
0.42	0.03	0.01	0.01	0.00	0.47	0.45
0.12	0.01	0.00	0.00	0.00	0.13	0.13
2.55	0.20	0.07	0.04	0.00	2.85	2.70
1.44	0.11	0.04	0.02	0.00	1.61	1.53
0.67	0.05	0.02	0.01	0.00	0.75	0.71
4.88	0.38	0.13	0.07	0.00	5.45	5.17
13.51	1.04	0.35	0.20	0.00	15.10	14.32
0.20	0.02	0.01	0.00	0.00	0.22	0.21
13.28	1.02	0.35	0.20	0.00	14.85	14.08
2.66	0.20	0.07	0.04	0.00	2.98	2.82
39.78	3.06	1.03	0.60	0.00	44.47	42.15
		PLUS	SI-800		1.36	1.36
		TOTAL	INCLUDING	SI-800	45.82	43.51

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DATA USED

EFFICIENCY 107.0 PERCENT DAYWORK 5.00 PERCENT ABSENT 5.00 PERCENT SATOT 5.50 PERCENT
LC-MS 7.70 PERCENT PRO-CHKG 2.60 PERCENT SMALL-LOT 1.50 PERCENT WORKING DAYS 20.
SI 800 10.44 HOURS PER DAY

MANPOWER REQUIREMENTS

PRODUCTION INFORMATION

CODE	CLAN	PERIOD	BHRS/C	---PERCENTAGES--- SHRG	SUPPL	OTHER
1A	204.	10	2.7884	34.00	2.58	0.00
1C	1681.	10	2.8659	34.00	2.58	0.00
1D	508.	10	2.6811	34.00	2.58	0.00
8A	12993.	10	2.2442	34.00	2.58	0.00
8C	7868.	10	2.0953	34.00	2.58	0.00
21A	884.	10	9.6840	34.00	2.58	0.00
37C	3787.	10	14.7450	34.00	2.58	0.00
24A	3169.	10	48.8000	34.00	2.58	0.00
24B	46.	10	48.8000	34.00	2.58	0.00
24C	3029.	10	50.2000	34.00	2.58	0.00
24D	607.	10	50.2000	34.00	2.58	0.00
C25	SUPPL.	10				

NUMBER OF EMPLOYEES REQUIRED

	BASE	LO-MS	PRO-CHG	SM-LT	OTHER	TOT EXC SI800	SAT.ADJ
1A	0.05	0.00	0.00	0.00	0.00	0.06	0.05
1C	0.43	0.03	0.01	0.01	0.00	0.48	0.45
1D	0.12	0.01	0.00	0.00	0.00	0.13	0.13
8A	2.58	0.20	0.07	0.04	0.00	2.89	2.74
8C	1.46	0.11	0.04	0.02	0.00	1.63	1.55
21A	0.68	0.05	0.02	0.01	0.00	0.76	0.72
37C	4.95	0.38	0.13	0.07	0.00	5.53	5.25
24A	13.71	1.06	0.36	0.21	0.00	15.33	14.53
24B	0.20	0.02	0.01	0.00	0.00	0.22	0.21
24C	13.48	1.04	0.35	0.20	0.00	15.07	14.28
24D	2.70	0.21	0.07	0.04	0.00	3.02	2.86
C25	40.36	3.11	1.05	0.61	0.00	45.12	42.77
			PLUS SI-800			1.36	1.36
			TOTAL INCLUDING SI-800			46.48	44.13

DATA USED

EFFICIENCY	107.0 PERCENT	DAYWORK	5.00 PERCENT	ABSENT	5.00 PERCENT	SATOT 5.50 PERCENT
LC-MS	7.70 PERCENT	PRO-CHKG	2.60 PERCENT	SMALL-LCT	1.50 PERCENT	WORKING DAYS 20.
SI 800	10.44HOURS PER DAY					

MANPOWER REQUIREMENTS

PRODUCTION INFORMATION

CODE	CLAN	PERIOD	BHRS/C	---PERCENTAGES--- SHRG	SUPPL	OTHER
1A	460.	10	2.7884	34.00	3.00	0.00
1C	1869.	10	2.8659	34.00	3.00	0.00
1D	757.	10	2.6811	34.00	3.00	0.00
8A	13256.	10	2.2442	34.00	3.00	0.00
8C	7977.	10	2.0953	34.00	3.00	0.00
21A	1016.	10	8.6840	34.00	3.00	0.00
37C	3794.	10	14.7450	34.00	3.00	0.00
24A	3531.	10	48.8000	34.00	3.00	0.00
24B	60.	10	48.8000	34.00	3.00	0.00
24C	2625.	10	50.2000	34.00	3.00	0.00
24D	424.	10	50.2000	34.00	3.00	0.00
025	CLANTITY	10				

NUMBER OF EMPLOYEES REQUIRED

BASE	LO-MS	PRO-CHG	SM-LT	OTHER	TOT EXC SI800	SAT.ADJ
0.11	0.01	0.00	0.00	0.00	0.13	0.12
0.48	0.04	0.01	0.01	0.00	0.53	0.50
0.18	0.01	0.00	0.00	0.00	0.20	0.19
2.65	0.20	0.07	0.04	0.00	2.96	2.80
1.49	0.11	0.04	0.02	0.00	1.66	1.57
0.78	0.06	0.02	0.01	0.00	0.88	0.83
4.97	0.38	0.13	0.07	0.00	5.56	5.27
15.32	1.18	0.40	0.23	0.00	17.13	16.24
0.26	0.02	0.01	0.00	0.00	0.29	0.28
11.72	0.90	0.30	0.18	0.00	13.10	12.42
1.89	0.15	0.05	0.03	0.00	2.12	2.01
39.85	3.07	1.04	0.60	0.00	44.55	42.23
		PLUS	SI-800		1.36	1.36
		TOTAL	INCLUDING	SI-800	45.91	43.59

06

DATA USED

EFFICIENCY 107.0 PERCENT DAYWORK 5.00 PERCENT ABSENT 5.00 PERCENT SATOT 5.50 PERCENT
LO-MS 7.70 PERCENT PRO-CHKG 2.60 PERCENT SMALL-LOT 1.50 PERCENT WORKING DAYS 20.
SI 800 10.44 HOURS PER DAY

Summary

Group 25 - October, 1964

Factor	Forecast	Actual	Effect on Total Employees
Efficiency	107.0%	109.8%	+1.13
Daywork	5.0%	4.9%	+ .05
Sat. O.T.	5.5%	20.0%	+5.19
Shrinkage	34.0%	31.6%	+ .75
Supplementary	3.0%	2.58%	+ .13
Quantity	(see runoffs)		+ .67
			+7.92

Total Forecast - 44.26

Total Actual - 36.74

+ 7.52

Summary

Group 5 - October, 1964

Factor	Forecast	Actual	Effect on Total Employees
Efficiency	100.0%	107.0%	+2.02
Daywork	2.0%	1.0%	+ .32
Sat. O.T.	0.0%	6.1%	+1.72
Shrinkage	14.0%	12.33%	+ .43
Supplementary	.5%	.45%	+ .01
Quantity	(see runoffs)		-1.94
LO-MS	11.7%	14.7%	- .78
SI-800	6.38	7.31	- .12
			+1.66

Total Forecast - 30.88

Total Actual - 28.99

+ 1.89

Summary

Group 5 - November, 1964

Factor	Forecast	Actual	Effect on Total Employees
Efficiency	100.0%	106.1%	+1.88
Daywork	2.0%	1.1%	+ .32
Sat. O.T.	0.0%	1.0%	+ .32
Shrinkage	14.0%	12.0%	+ .55
Supplementary	.5%	1.75%	- .34
Quantity	(see runoffs)		+2.43
LO-MS	11.7%	13.8%	- .57
SI-800	6.38	7.31	- .12
			+4.47

Total Forecast - 32.66

Total Actual - 28.41
+ 4.25

Summary

Group 71 - October, 1964

Factor	Forecast	Actual	Effect on Total Employees
Efficiency	106.0%	102.2%	-3.27
Daywork	2.0%	1.4%	+ .56
Sat. O.T.	8.0%	20.0%	+8.42
Shrinkage	(see runoffs)		-6.11
Supplementary	(see runoffs)		+2.65
Quantity	(see runoffs)		-9.74
LO-MS	13.25%	11.14%	+1.45
SI-800	29.1	28.44	+ .08
			-5.96

Total Forecast - 87.94

Total Actual - 86.53

+ 1.41

Summary

Group 71 - November, 1964

Factor	Forecast	Actual	Effect on Total Employees
Efficiency	106.0%	104.9%	- .93
Daywork	2.0%	1.40%	+ .56
Sat. O.T.	8.0%	20.0%	+8.44
LO-MS	13.25	13.29%	- .03
Pro-Chg.	7.19%	6.31%	+ .61
SI-800	29.1	28.4	+ .09
Shrinkage	(see runoffs)		-2.30
Supplementary	(see runoffs)		-5.88
Quantity	(see runoffs)		-8.65
			-8.09

Total Forecast - 88.13

Total Actual - 92.32

- 4.19

Summary

Group 6 - October, 1964

Factor	Forecast	Actual	Effect on Total Employees	
Efficiency	100.0%	107.0%	+12.02	
Daywork	3.3%	2.4%	+ 1.77	
Shrinkage	29.0%	27.7%	+ 1.71	+17.05
Supplementary	3.0%	1.82%	+ 1.55	
Quantity	(see runoffs)		-28.74	
			-11.69	

Total Forecast - 184.04

Total Actual - 188.15

- 4.11

INDIVIDUAL FACTOR ANALYSIS

Grp. No.	Period	EFFICIENCY Fore-Cast %	Act. %	Diff. %	Effect on Total Empl. %	DAYWORK Fore-Cast %	Act. %	Diff. %	Effect on Total Empl. %	SAT. C.T. Fore-Cast %	Act. %	Diff. %	Effect on Total Empl. %	SHRINKAGE Fore-Cast %	Act. %	Diff. %	Effect on Total Empl. %	SUPPLEMENTS Fore-Cast %	Act. %	Diff. %	Effect on Total Empl. %	QUANTITY Fore-Cast %	Act. %	Diff. %	Effect on Total Empl. %
5	October, 1964	100.0	107.0	7.0	+6.8	2.0	1.0	1.0	+1.1	0.0	6.1	6.1	5.6	14.0	12.3	1.7	+1.4	.50	.45	.05	+.03	(See Runoffs)			-6.3
5	November, 1964	100.0	106.1	6.1	+5.8	2.0	1.1	.9	+.98	0.0	1.0	1.0	+.98	14.0	12.0	2.0	+1.7	.50	1.75	1.20	-1.04	(See Runoffs)			+7.4
71	October, 1964	106.0	102.2	3.8	-3.7	2.0	1.4	.6	+.64	8.0	20.0	12.0	+9.6	(See Runoffs)			-7.0	(See Runoffs)			+3.0	(See Runoffs)			-11.1
71	November, 1964	106.0	104.9	1.1	-1.1	2.0	1.4	.6	+.64	8.0	20.0	12.0	+9.6	(See Runoffs)			-2.6	(See Runoffs)			-6.7	(See Runoffs)			-9.8
6	October, 1964	100.0	107.0	7.0	+6.5	3.3	2.4	.9	+.96	-	-	-	-	29.0	27.7	1.3	+.93	3.0	1.82	1.18	+.84	(See Runoffs)			-15.6
25	October, 1964	107.0	109.8	2.8	+2.6	5.0	4.9	.1	+.11	5.5	20.0	14.5	+11.7	34.0	31.6	2.4	+1.7	3.0	2.58	.42	+.29	(See Runoffs)			+1.5
	Average				4.4 (3)				.74 (7)				7.5 (2)				2.6 (4)				2.0 (5)				3.6 (1)

Grp. No.	Period	LO-MS Fore-Cast %	Act. %	Diff. %	Effect %	SI-800 Fore-Cast %	Act. %	Diff. %	Effect %	"Interaction" Effect %	Sum of Effect %
5	October, 1964	11.7	14.7	3.0	-2.5	6.38	7.31	.93	-.39	-.75	+6.1
5	November, 1964	11.7	13.8	2.1	-1.7	6.38	7.31	.93	-.37	-.67	+13
71	October, 1964	13.25	11.14	2.1	+1.7	29.1	28.44	.66	+.09	+8.4	+1.6
71	November, 1964	13.25	13.29	.04	-.03	29.1	28.44	.66	.09	+4.43	-4.8
6	October, 1964	-	-	-	-	-	-	-	-	+4.1	-2.2
25	October, 1964	-	-	-	-	-	-	-	-	-.9	+17
	Average				1.5 (6)				.24 (8)	3.2	

APPENDIX I

Group	Period	Population	Standard Deviation Forecasted	Actual	F value Calculated	Table	Remarks
25	October	Base Emp.	4.78	4.58	1.08	2.90	Not significant
25	October	Total Emp.	5.10	4.22	1.47	2.90	Not significant
25	October	Base/1000	1.92	1.82	1.12	2.90	Not significant
5	October	Base Emp.	1.49	.968	2.36	2.50	Not significant
5	October	Total Emp.	1.73	1.45	1.42	2.50	Not significant
5	October	Base/1000	.134	.125	1.15	2.50	Not significant
5	Nov.	Base Emp.	2.05	1.09	3.51	2.50	Significant
5	Nov.	Total Emp.	2.36	1.51	2.45	2.50	Not significant
5	Nov.	Base/1000	.137	.139	1.04	2.50	Not significant
71	October	Base Emp.	4.16	4.30	1.08	1.90	Not significant
71	October	Total Emp.	4.72	4.34	1.19	1.90	Not significant
71	October	Base/1000	.390	.606	2.41	1.90	Significant
71	Nov.	Base Emp.	3.92	4.92	1.57	1.80	Not significant
71	Nov.	Total Emp.	4.14	5.02	1.46	1.80	Not significant
71	Nov.	Base/1000	.490	.324	2.34	2.18	Significant
6	October	Base Emp.	11.3	11.8	1.09	1.98	Not significant
6	October	Total Emp.	13.0	13.5	1.07	1.98	Not significant
6	October	Base/1000	1.04	.920	1.26	2.17	Not significant

APPENDIX J

Group	Period	Population	Mean Value Forecasted	Actual	t value Calculated	Table	Remarks	d.f.	Approx. Prob. Level
25	October	Base Emp.	3.38	3.17	.940	2.20	Not significant	11	40%
25	October	Total Emp.	3.57	2.95	1.99	2.20	Not significant	11	8%
25	October	Base/1000	1.73	1.67	1.31	2.20	Not significant	11	20%
5	October	Base Emp.	1.85	1.80	.571	2.16	Not significant	13	60%
5	October	Total Emp.	2.15	2.00	.546	2.16	Not significant	13	60%
5	October	Base/1000	.513	.466	19.6	2.16	Significant	13	.1%
5	Nov.	Base Emp.	1.96	1.68	.838	2.16	Not significant	13	40%
5	Nov.	Total Emp.	2.27	1.96	.814	2.16	Not significant	13	45%
5	Nov.	Base/1000	.507	.480	1.32	2.16	Not significant	13	20%
71	October	Base Emp.	2.66	2.95	1.34	2.05	Not significant	27	20%
71	October	Total Emp.	3.01	2.95	.203	2.05	Not significant	27	85%
71	October	Base/1000	.315	.450	1.06	2.09	Not significant	19	30%
71	Nov.	Base Emp.	2.57	3.00	1.01	2.05	Not significant	27	30%
71	Nov.	Total Emp.	2.90	3.05	.324	2.05	Not significant	28	75%
71	Nov.	Base/1000	.430	.410	.420	2.09	Not significant	19	70%
6	October	Base Emp.	6.30	6.23	.045	2.06	Not significant	24	90%
6	October	Total Emp.	7.21	7.16	.049	2.06	Not significant	24	90%
6	October	Base/1000	1.94	1.71	9.80	2.10	Significant	18	.1%

APPENDIX K

DATA FOR INDIVIDUAL MANUFACTURING GROUPS

Group	Period	Population	Mean Difference	Upper Limit Emp.	Upper Limit %	Lower Limit Emp.	Lower Limit %
25	October	Base Emp.	-.21	.280	8.0%	- .70	-21.0%
25	October	Total Emp.	-.62	.064	1.8%	-1.31	-37.0%
25	October	Base/1000	-.065	.039	2.3%	- .169	- 9.8%
5	October	Base Emp.	-.06	.167	9.0%	- .287	-15.5%
5	October	Total Emp.	-.14	.136	6.3%	- .416	-19.3%
5	October	Base/1000	-.049	-.0436	-8.5%	- .0544	-10.6%
5	Nov.	Base Emp.	-.280	.440	22.5%	-1.00	-51.0%
5	Nov.	Total Emp.	-.310	.510	26.0%	-1.13	-57.7%
5	Nov.	Base/1000	-.220	.014	2.8%	- .058	-11.4%
71	October	Base Emp.	.300	.760	29.0%	- .16	- 6.0%
71	October	Total Emp.	-.050	.460	15.0%	- .56	-18.0%
71	October	Base/1000	.140	.410	129.0%	- .13	-45.0%
71	Nov.	Base Emp.	.470	1.43	56.0%	- .49	-19.0%
71	Nov.	Total Emp.	.150	1.10	38.0%	- .80	-28.0%
71	Nov.	Base/1000	-.020	.080	19.0%	- .13	-29.0%
6	October	Base Emp.	-.040	1.78	28.0%	-1.86	-30.0%
6	October	Total Emp.	-.050	2.05	28.0%	-2.15	-30.0%
6	October	Base/1000	-.230	- .181	- 9.3%	- .279	-14.0%

Note: Minus sign means Forecast was greater than Actual in the Mean Difference Column.

APPENDIX L

Combined Data For All Manufacturing Groups

Population	Mean Value Fore.	Actual	t-test Calc.	Table	Probability Level at Sign.Diff.
Base Employees	3.12	3.14	.125	1.98	10%
Total Empl.	3.52	3.35	.697	1.98	50%
Base/1000units	.905	.865	1.32	1.99	80%

Population	Mean Difference	Confidence Interval (95%) Upper	%	Lower	%
Base Employees	.02	.334	11%	-.296	-10%
Total Empl.	-.17	.313	9%	-.653	-19%
Base/1000units	-.04	.021	2%	-.101	-11%

APPENDIX M

DATA FOR INDIVIDUAL AND COMBINED MANUFACTURING GROUPS

Group	Period	Population	Mean Difference	E(emp.)	E(%)
25	Oct.	Base Emp.	.210	.613	18%
25	Oct.	Total Emp.	.621	1.25	35%
25	Oct.	Base/1000	.0646	.19	11%
5	Oct.	Base Emp.	.060	.246	13%
5	Oct.	Total Emp.	.140	.250	12%
5	Oct.	Base/1000	-	-	-
5	Nov.	Base Emp.	.280	.870	44%
5	Nov.	Total Emp.	.310	.990	44%
5	Nov.	Base/1000	.022	.052	10%
71	Oct.	Base Emp.	.300	.680	26%
71	Oct.	Total Emp.	.050	.470	16%
71	Oct.	Base/1000	.136	.360	92%
71	Nov.	Base Emp.	.470	1.27	49%
71	Nov.	Total Emp.	.150	.94	32%
71	Nov.	Base/1000	.021	.107	25%
6	Oct.	Base Emp.	.040	1.58	25%
6	Oct.	Total Emp.	.050	1.81	25%
6	Oct.	Base/1000	-	-	-
ALL GROUPS		Base Emp.	.020	.286	9%
ALL GROUPS		Total Emp.	.170	.575	16%
ALL GROUPS		Base/1000	.040	.0905	10%

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