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JOB SHOP PRODUCTION PLANNING & CONTROL - CASE STUDY
(AECI Modderfontein - Central Workshops)

Aharon Franco

A Dissertation Submitted to the Faculty of Engineering
University of the Witwatersrand, Johannesburg
for the Degree of Master of Science

Johannesburg 1982

DECLARATION

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

AHARON FRANCO

30th day of JUNE 1982

ABSTRACT

A scheduling approach for job-shop or made-to-order production has been studied extensively over the last 20 years in connection with computerized systems for Production Planning & Control.

The purpose of the major part of this text is to "sell" the idea of a Real Queue approach for ordinary jobs computerized scheduling systems, and a Manual Planning system for emergency and short jobs, by means of capacity allocated to this purpose.

Most of the systems employed to-day by various production companies, are "packages" sold to them by large Computerized Data Processing companies and were tailored to suit them, based on the available modular software systems. with no significant differences between one or the other. Whereas, the computer used in production planning improved control over orders, reduced the clerical work concerned and provided quick and efficient tools for decision making, less success was achieved in production management regarding meeting of definite promised delivery dates, as a result of emergency and short jobs entering the system and requiring immediate production processing. This can be attributed to the people using the system, but to a large extent, it is attributable to the approach of scheduling in most cases. Nevertheless, attempts were made to construct suitable programmes, but only by a few companies, employing in-house programmers and systems personnel for their own purposes.

As competition between manufacturers is extremely high at present, the meeting of promised delivery dates for all kinds of jobs is becoming more and more important. This requires having confident scheduling and determining of delivery dates systems, which can be constructed only after carrying out a careful and in-depth study of the system concerned.

The study given here, reflects the various stages taken when tackling a problem like this. It has been carried out in three major stages: Overall study of all management aspects of the workshops, the existing planning system and the experiments in implementation of another approach to scheduling.

The study used quantative methods, data, tables and graphs, illustrating the various stages of the project and the text consists of 5 parts:

PART A : Overall Management Study

PART B : "CAPOSS" - The existing planning & scheduling system

PART C : Implementation and experiments for determining the best solution for the system

PART D : Final Results and Comparisons

PART E : Production Planning & Control - Literature Survey

The text was written in this way, to enable students, system analysts, Industrial Engineers and Production Management personnel to use the various parts of the text for their individual practice and purposes, when dealing with production planning systems in general,and job shop production planning systems in particular.

Part A

C O N T E N T S

PREFACE

1. INTRODUCTION

2. SUMMARY AND CONCLUSIONS

3. RECOMMENDATIONS

4. FINDINGS

   4.1. Management

   4.2. Organisation

   4.3. Key Objective

   4.4. Production Planning & Control

   4.5. Estimating

   5.6. Labour, Recruitment and Training

APPENDICES

1. Extracts from previous CWS investigations

2. List of pertinent Information/Findings/Recommendations over last 2 years

3. Proposed organization structure of planning & control

   3a Planning & Control responsible to Manager Industrial Engineering

   3b Planning & Control Section responsible to Workshops Manager

4. Key performance areas

5. Proposed organization structure of Planning & Control Section (Functional only)

6. Proposed individual incentive bonus schemes for CWS artisans

Part B

C O N T E N T S

PREFACE

		PAGE
1.	Introduction to CAPOSS	1
2.	Purpose and objectives of scheduling	2
	2.1 General	
	2.2 Solution	
3.	Planning a Job	5
	3.1 General	
	3.2 Scheduling techniques	
4.	Prerequisites	10
	4.1 Description of Data	
	4.2 Work centres	
	4.3 Shop Calendar	
5.	Features of CAPOSS	13
	5.1 Operation splitting	
	5.2 Lot splitting	
	5.3 Overlapping	
	5.4 Related facilities	
	5.5 Operation Grouping	
	5.6 Alternate Possibilities	
	5.7 Overtime	
	5.8 Statistics	
	5.9 Priorities and Loading Procedures	
	5.10 Urgent Orders and changes	
	5.11 Pull early procedure	
	5.12 Costing	
	5.13 Materials	
6.	Input	17
	6.1 User input	
	6.2 Main content of Rout card	
	6.3 Specification of work centres	
	6.4 Parameters	
7.	System output	19
	7.1 Printed output	
	7.2 Output files	
8.	Transactions and Feedback	30
	8.1 Transactions	
	8.2 Feedback	
9.	Processing Description	32

APPENDICES

1. Description of Data

2. Workshops CAPOSS Calendar

3. Route Card Input

4. Printed Output

5. a. Input coding note for additions
   b. Input coding note for cancellations and change

6. Processing Description

7. Programming System

Part C

CONTENTS

		Page
INTRODUCTION		1
1.	JOB SHOP PRODUCTION PLANNING & CONTROL - GENERAL	2
2.	SYSTEM ANALYSIS	
2.1.	Recognition and formulation of the problem	2
2.2.	Organization of the project	3
2.3.	Definition of system objectives	3
2.4.	System design	4
2.5.	Modification of the system in order to rectify the situation	7
2.6.	Operation	13
3.	DETERMINATION OF WORK CENTRE CAPACITY	15
4.	PLANNING SECTION	
4.1.	Organization structure	16
4.2.	Key performance areas	16
5.	LONG TERM JOBS	
5.1.	General	18
5.2.	Action taken	18
6.	PLACING OUTSIDE ORDERS	
6.1.	General	20
6.2.	Placing outside material/manufacturing orders - Overall solution	21
6.3.	Order inspection of expediting	21
6.4.	Backlog	22
6.5.	Alternative suppliers	22
7.	QUALITY ASSURANCE	
7.1.	Procedures	23
7.2.	Spoiled Work	23
7.3.	Rejected Work	23
8.	FLOOR MANAGEMENT : PROCEDURES, REGULATIONS & TRAINING	
8.1.	General	25
8.2.	Daily Work List	25
8.3.	Standard times for jobs	27
8.4.	Training & Motivation	28

2/...

		Page
9.	ESTIMATING	
	9.1. General	30
	9.2. Liaison with shop floor	30
	9.3. Feedback	30
	9.4. Specifications and drawings	30
	9.5. Liaison with the planning sect on	31
10.	BONUS SCHEME	
	10.1. Background	32
	10.2. New bonus scheme	32
	10.3. Summary	35
11.	COSTING	36

APPENDICES

1	:	Emergency Jobs Loading into the System
2	.	Emergency Jobs
3a	:	Planning & Control Section Delivery Dates - State
3b	:	Planning & Control Section Hours Loaded per Work Centre - State
4	:	Changes in CFDs due to the new scheduling approach
5	:	Amendment List to the Stores System Delivery Dates & Lead Times
6	:	Factory Made Spare (Isando)- Capacity requirements (Extracts from memorandum)
7a	:	Backlog & Incoming Work
7b	:	Monthly Work Centre Capacities
8	:	Planning & Control - Organization Structure
9	:	Planning & Control - Key Performance Areas
10	:	Jobs Residence Time
11	:	Approved list of Suppliers and Manufacturing Delivery Time
12	:	Report 46 - Listing of outstanding orders
13	:	Quality Assurance Procedure Standard
14	:	Spoiled Work
15	:	Illustration - Times Schedule
16a	:	Engineering Work Order
16b	:	Engineering Work Order - Check List
16c	:	Engineering Work Order - Continuation Sheet
17a	:	Estimator Planner - FMS job request procedure
17b	:	Estimator Planner - Plant job request procedure
18	:	Engineering Time Card
19	:	Bonus Scheme - Recommended operation card

Part D

C O N T E N T S

		Page
INTRODUCTION		1
1.	PROJECT SUMMARY AND CONCLUSIONS	2
2.	ORDINARY JOBS	
2.1.	Turnaround Time	4
2.1.1.	Analysis	4
2.2.	Delivery Dates	4
2.2.1.	General	4
2.2.2.	Adjustment of Due Dates	5
2.2.2.1.	Introduction	5
2.2.2.2.	Distribution Function	6
7 2.2.2.3.	Analysis	7
2.3.	Conclusion	8
2.4.	Additional note from the Author	8
3.	CAPOSS - TURNAROUND TIME ANALYSIS (MONTHLY REPORT)	9
3.1.	Results based on DUE DATES	9
3.2.	Results based on FCFD	10
4.	EMERGENCY JOBS - TURNAROUND TIME	
4.1.	September-October Results	12
4.2.	Comparison between final results and previous months' results	12
4.3.	Discussion	13
5.	LONG TERM JOBS	
5.1.	Results	15
5.2.	Summary	15
6.	OUTSIDE ORDERS	16
7.	QUANTITY OF SERVICE	
7.1.	Results	17
7.2.	Analysis	17
8.	OPERATING RESULTS (COSTS)	19

2/...

		Page
9.	INDUSTRIAL ENGINEERING	
	9.1. Estimating	20
	9.2. Incentive Scheme Revision	20
	9.3. Computer System Support	20
10.	MANPOWER & TRAINING	
	10.1. Recruitment and Contract Labour	21
	10.2. Training	21
11.	ITEMS OUTSTANDING	23
	11.1. Carpenters Shop	23
	11.2. Other tasks	23
12.	MINUTES FROM DISCUSSION OF THE FINAL REPORT WITHIN THE COMPANY	24

APPENDICES

1	-	Central Workshop	:	Deviation from jobs required delivery date
2	-	Exactum	:	Deviation from jobs required delivery date
3	-	Outside Orders	:	Deviation from jobs required delivery date
4			:	Changes of CFDs due to the new perception
5	-	Central Workshop	:	Residence time of jobs in the System
6a	-	Central Workshop	:	Number of jobs per input, output and order file January - September 1981
6b	-	Central Workshop	:	Number of hours per input, output and order file January - September 1981

Part E

C O N T E N T S

		Page
	PREFACE	
1.	PRODUCTION PLANNING AND CONTROL - GENERAL INTRODUCTION	1
	1.1 Definitions 1.2 Tasks of Production Planning and Control	
2.	PRODUCTION PLANNING AND CONTROL DEPARTMENT FUNCTION AND POSITION WITHIN THE ORGANISATION	2
3.	INTERNAL DIVISION OF PRODUCTION PLANNING AND CONTROL FUNCTION	4
4.	CONTROL SYSTEM	6
5.	PRODUCTION PLANNING	8
	5.1 Long Term Planning 5.2 Short Term Planning	
6.	TECHNIQUES USED IN PRODUCTION PLANNING AND CONTROL	9
	6.1 GANTT Chart 6.2 Introduction to computer use	
7.	COMPUTER USES FOR PRODUCTION PLANNING AND CONTROL	11
	7.1 General 7.2 Basic techniques used in computers for Production Planning and Control	
8.	ADVANTAGES ON USING COMPUTER FOR PRODUCTION PLANNING AND CONTROL	13
9.	COMPUTER PROGRAMMES FOR PRODUCTION PLANNING AND CONTROL	14
10.	SYSTEMS VIEW FOR PLANNING AND CONTROL	17
	10.1 General 10.2 Planning 10.3 Control 10.4 Planning and control summary	
11.	MANAGEMENT INFORMATION SYSTEMS	20
	11.1 Systems view to M/S 11.2 Building a M/S	
12.	PRODUCTION PLANNING AND CONTROL INTEGRATED	25
	12.1 Toward better control 12.2 Need for flexibility 12.3 Long term capacity planning 12.4 Master scheduling 12.5 Short term scheduling 12.6 Control and Progress 12.7 Scheduling approaches 12.8 The Integrated System	
13.	OTHER VIEWS ON PRODUCTION PLANNING AND CONTROL	29
	13.1 General 13.2 Pre-production planning 13.3 Production control 13.4 Dispatching and follow up	
14.	QUEUES	36
	14.1 The investigation of queueing systems 14.2 The modification of queueing systems 14.3 Few notes on some simple queues	

PREFACE

This text, which is my dissertation for the degree of Master of Science in Engineering, studies the correct perception for job shop production Planning and Scheduling.

It represents the results of a project which was carried out in the Central Workshops of AECI, Modderfontein, where, in October 1980, I was appointed to the position of Workshops Planning & Control Engineer. This appointment was as a result of overall management re-organization at the workshops, in order to improve the Engineering & Maintenance services given by the workshops to the various plants at the factory.

The re-organization was carried out shortly after the introduction of IBM'S planning & scheduling system, known as "CAPOSS", had failed. The "CAPOSS" system was thought to be the correct solution for improving services given by the workshops.

Since I graduated as an Industrial Engineer from the "Technion" - Israel Institute of Technology in 1975, I have dealt mainly with various types of Production Planning & Control systems I found this an opportunity to express my experience and knowledge in this field, through this project for the benefit of Industrial and System Engineers, Production Management personnel and students.

I wish to acknowledge the consultation and tution given to me by Professor R.T. Jamieson of the University of the Witwatersrand, Johannesburg, South Africa, in carrying out this project and in writing this text, and to thank Mr J. Becheano of the Witwatersrand University for his valuable suggestions.

Special apprecation is due to Mrs Elizabeth McFarlane of AECI, Modderfontein, South Africa for her excellent typing.

A. FRANCO

JOB SHOP PRODUCTION PLANNING & CONTROL - CASE STUDY

(AECI Modderfontein - Central Workshops)

Part A

Overall Management Study of Central Workshops and General Recommendations

Part A

C O N T E N T S

PREFACE

1. INTRODUCTION

2. SUMMARY AND CONCLUSIONS

3. RECOMMENDATIONS

4. FINDINGS

   4.1. Management

   4.2. Organisation

   4.3. Key Objective

   4.4. Production Planning & Control

   4.5. Estimating

   5.6. Labour, Recruitment and Training

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   3a Planning & Control responsible to Manager Industrial Engineering

   3b Planning & Control Section responsible to Workshops Manager

4. Key performance areas

5. Proposed organization structure of Planning & Control Section (Functional only)

6. Proposed individual incentive bonus schemes for CWS artisans

PREFACE

This report is the first in a series of reports concerning my project for a MSc degree.

The report covers the general findings and recommendations of an overall Management Study of central workshops at AECI Modderfontein. This study was carried out over a period of 1½ months (1.10.1981 to 15.11 1981) and consists of general guidlines for commencing the implementation of recommendations in various areas and aspects of the workshop management.

As the investigation included all possible subjects and issues of production and management in the workshops, the recommendations cover all aspects of management and do not concentrate on any particular subject in detail.

This will be done in the next stages, which will concentrate more on the production, and planning & control aspects of the system, with minor ramifications to all the other aspects, such as personnel, training estimating, quality control and procedures.

A. BLANCO

1. INTRODUCTION

A survey of the Central Workshops (CWS) was carried out in two stages:

1st October - 25th October followed by an interim report
and 26th October - 15th November

This report covers the total survey period and includes a programme of actions designed to correct the weaknesses found.

Object of Survey

The object of the survey was to investigate the causes of low Workshops efficiency, the reasons for the poor planning & control system, to recommend the actions necessary to enable the Workshops to function efficiently, and to implement the recommendations throughout all the management aspects of the shop: Production, Planning & Control, Estimating, Quality Assurance and Personnel.

2. SUMMARY AND CONCLUSIONS

During the past seven years, numerous reports on various aspects of the Workshops have been prepared and circulated.

The overall problem is that the Central Workshops is not providing a satisfactory service to the Factory in terms of delivery, quality and cost.

As a generalisation, this is true, although the degree varies from shop to shop.

Many of the previous reports have concentrated on the systems and procedures in use in the Workshops, such as estimating and planning. One of the many solutions was the introduction of a computerised Planning & Control system, which however, only aggravated the situation. Whilst it is true that there is scope for improvement in these areas, they are not the primary cause of the problems.

The key problem is one of management and control. With a more dynamic management, the problems which now exist in almost every aspect of the operation, would

a) not have arisen

or

b) have been corrected at an early stage

Oblique references to the management problem have been made in various reports (Appendix 1), but in general, the solutions proposed previously have concentrated on systems and procedures.

The primary conclusion therefore, is that the Factory Workshops Management should be strongly management and results orientated, and be able to motivate the personnel to provide the service for which the workshops exist.

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2.1. Key Objective

The key objective proposed for CWS is as follows:

To provide an engineering maintenance service to the Factory by providing central manufacturing, repair and maintenance facilities to undertake emergency, priority and routine work, in order to achieve:

a) Quality of service : delivery dates are met with 95% effectiveness

of product : as specified

b) Cost on average, to be less than outside contractors

c) Quantity of service to the Factory:

i) 100% for services which are not available from outside sources.

ii) X% by value of the routine services which can be provided (technically) either internally or externally.

iii) Y% by value of peak load service requirements during shutdowns.

NOTE: (ii) and (iii) percentages to be established after investigating and quantifying total Factory demand and workshop capacity.

3. RECOMMENDATIONS

3.1. Management and Organisation Structure

3.1.1. That the position of Production Engineer be introduced.

3.1.2. That the position of Planning & Control Engineer be introduced.

3.1.3. That the organisation structure be as shown in Appendix 3 (2 phases: (1) Planning & Control on behalf of the Manager of Industrial Engineering (2) on behalf of Workshops Manager)

3.1.4. That Job Specifications and Man Specifications be prepared for all staff positions.

3.1.5. That the key performance areas shown in Appendix 4 be adopted.

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3.2. Planning and Production Control

3.2.1. That the Planning Section be organised as shown in Appendix 5.

3.2.2. That CAPOSS be retained and it's effectiveness, planning approach and procedures be reviewed as and when management changes take place.

3.2.3. That the Factory Workshops Manager holds daily meetings with the Planning Engineer and Production Engineer to:

a) Check achievement vs plan

b) Check reasons for non-achievement

c) Institute corrective action

d) Implement corporate management strategy

3.2.4. That strict discipline in the use and application of CAPOSS procedures be enforced.

3.2.5. That management, planning, estimating, Q.C., supervisors and men be re-trained in the practical use of CAPOSS. (The need for system discipline; the procedures; the procedures for accommodating emergency work; the method of loading only X% to allow for low efficiency, emergency work, capacities control etc)

3.2.6. That a practical CAPOSS user's manual be prepared which details:

a) The routine procedures to operate the system.

b) The control information provided by the system, it's interpretation and the control action options..

3.2.7. That a "total Factory demand versus workshop capacity" investigation be carried out to quantify the capacity problem.

3.2.8. That, in the short term, CWS input should be limited to CWS capacity in diminishing priority sequence.

3.2.9. That a "Turnaround Time Analysis Due Date - Report" be used as a measure of achievement of customer satisfaction.

3.2.10. That a ""Turnaround Time Analysis First Calculated Finish Date-Report" be used as a measure of planning and control efficiency.

3.3. Estimating

3.3.1. That the estimating function retains line responsibility to the Industrial Engineering Group, with staff responsibility to the Central Workshops Management.

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3.3.2. That estimator selection and training programmes be reviewed to ensure a high standard of estimating.

3.3.3. That all basic and reference data be checked to ensure it's continued validity to the equipment, machines and methods currently in use.

3.3.4. That all repeat job standard times be checked to ensure their validity.

3.3.5. That repeat jobs be filed in such a way as to make retrieval quick and that repeat jobs always receive the same standard time per piece on each occasion. Set-up times should be shown separately.

3.3.6. That Route Cards give more detail of the job method used when estimating (to guide inexperienced Artisans).

3.3.7. That Route Cards show the set-up time and time per piece as well as the job time.

3.3.8. That Refresher Courses be carried out for all estimators (to re-establish departmental policies and estimating standards).

3.3.9. That an estimator record sheet be introduced,showing the work done by each estimator.

3.3.10. That a system of regular independent audits of sampled jobs be introduced, to check accuracy of estimates.

3.3.11. That provision be made for the estimation of additional and extra work on a job and for speedy attention to "tight time" appeals, whilst the job is still in progress.

3.3.12. That the time for estimating any single normal job will not exceed three days and, preferably, will be done within 24 hours. Emergency work should be estimated whilst the job is in progress.

3.4. Pay and Incentive Bonus

3.4.1. A clearly defined remuneration policy should be adopted in order to achieve the following objectives:

i) To attract personnel of the right calibre.

ii) To encourage them to achieve their job objectives.

iii) To reward them in accordance with the value of their contribution.

iv) To prevent loss of morale through dissatisfaction with pay levels.

v) To encourage them to stay with the Company.

vi) To achieve these aims at minimum cost.

5/...

3.4.2. That hourly rates for artisans be maintained in the upper quartile of competitors' rates. The employer sample used in the periodic surveys (by The Factory Industrial Relations Officer) should consist primarily of those employers who attract our employees.

3.4.3. That a merit grading scheme for artisans be introduced which rewards the man for the quality and range of his skills within his trade.

3.4.4. That the long service award scheme be retained, but that it be based on a percentage of the basic rate so that it's value remains significant (in relation to basic wages).

3.4.5. That an individual incentive bonus scheme be introduced throughout the workshops, in place of the present group scheme. (See Appendix 6).

3.5. Recruitment and Training

3.5.1. That apprentices be recruited and trained on two bases:

a) Those with matric who are potential supervisors, technicians, etc.

b) Those with lower academic achievements who have practical aptitudes and who are likely to remain operators, artisans or journeymen for a considerable time.

3.5.2. That the apprentice complement be maintained at a ratio of 1 to 2,5 artisans (establishment).

3.5.3. That recruitment and retention of skilled journeymen be intensified. A more attractive cash remuneration would assist. (See recommendations 3 and 4).

3.5.4. i) That recruitment of ICI workshops artisans [illegible]e UK be carried out in order to alleviate th[illegible]t shortage of artisans. (Maintain pension [illegible]s, etc)

ii) That recruitment from the Mediterranean countries (Spain, Italy, Greece) be carried out, as people from these countries tend to stay a long time in South Africa.

4. FINDINGS

4.1. Management

4.1.1. The present workshops management lacks the drive and motivation to bring the workshops under control. Most of the reports issued during the last few years have not been acted upon effectively. Many of the problems specified in the M&IE report MMS/P/76/16 issued in 1976 are still existing.

6/...

This lack of drive at the top has permeated all the way down to the shop floor, with the result that there is a general feeling of apathy in the whole workshops. Investigations are carried out, but nothing ever changes. Systems designed to assist Management, are not adhered to and produce results which are meaningless. Consequently, the systems fall into disrepute and are blamed for all the problems.

4.1.2. If the figures of the Production Manager, No. 4 Ammonia Plant are to be believed (and there is no reason to doubt them), then out of a total of R484 000 worth of work, which could have been done by CWS, R380 000 (78,3%) was put out to outside firms. This is a serious indictment on the workshops ability to provide an adequate service to the plants.

The lack of clear objectives for the CWS, not only with regard to quantity, delivery, quality and cost, but also it's capacity in relation to total demand has aggravated this situation, but one would expect competent management to insist on these being established, in order to measure performance. Forward capacity planning is a management function.

4.1.3. A vacuum exists between the Workshops Manager and the Foremen. It is not considered practical for the Workshops Manager to supervise all the Foremen adequately and carry out his other management duties and responsibilities.

The management and technical abilities of some of the Foremen are suspect, but until such times as these abilities are tested under proper supervision, it is not possible to state categorically, who these Foremen are and how far they are capable of doing their job.

In order to improve the management structure, the position of Production Engineer should be introduced. When established, this could be used as a training position for a graduate Mechanical or Industrial Engineer, after the incumbent has been in the position for at least 2 years.

4.1.4. It is believed that the present Planning and Control Superintendent has an excellent grasp of the mechanics of CAPOSS, but lacks the managerial experience to act on the information which is available.

He also lacks disciplinary control over his staff, which results in a lack of clear objectives on the part of his staff and a degree of sloppiness in the execution of their duties.

It is recommended that an Industrial Engineer be appointed to this position, to provide the necessary managerial and systems expertise.

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4.2. Organisation

4.2.1. The proposed organisation structure is shown in Appendix 2.

The main change is in the introduction of the positions of Production Engineer and Planning & Control Engineer.

Both the estimating and quality control sections should remain responsible to their respective departmental heads in order to retain impartiality. The proposed introduction of individual incentive bonus schemes makes this particulary important, especially in the case of the estimating section.

4.2.2. The proposed organisation for the Planning and Production Control section is shown in Appendix 5. The section is divided into 3 major units:

i) Planning, Scheduling, Material Procurement

ii) Progress and Control

iii) Administrative Convenience

If, as we believe is desirable, the CWS is geared to handle a far greater proportion of the total Factory requirements, then all work should be channelled through the CWS and the decision as to whether the work is sub-contracted or not should be a workshops decision, based on capability, delivery and price. In this case, the section would need to be expanded to deal with subcontract work. The present Spares Co-ordinator would also naturally fall into this area.

In all cases, the prime objective is to provide the various areas of the Factory with the service they require, including service out-of-hours, whether this be provided by the CWS facilities or sub-contractors.

4.2.3. One of the Workshops Manager's responsibilities is to ensure that all departments contributing to the succesful functioning of the workshops,operate as a team with a common objective.

4.2.4. It is desirable that an Industrial Engineer be placed in CWS. He would be responsible to the Workshops Manager and have functional links with the Industrial Engineering Group. It is recommended that he be responsible for the Production Planning and Control Section. During the initial upgrading phase, it is recommended that this section be directly responsible to the Industrial Engineering Group. (See Appendix 3A).

4.2.5. A Personnel Officer is shown on the organisation structure chart. We believe that closer liaison with personnel will prove beneficial in the future, as the shortage of artisans worsens.

8/...

4.3. Key Objectives

This is a complex subject and the resulting objective(s) will depend, to some extent, on Company policy.

Results from the recent Key Objective questionnaire which was circulated to the various Plant Engineers, range from:

a) Providing a 100% service to the Factory, to

b) Leasing CWS premises to an outside firm.

The true objective lies somewhere in between, and will probably vary with circumstances, both internal and external.

Part of the in-depth sutdy of the planning section will consist of establishing the key objectives of the workshops.

4.3.1. The assistance required by the plants from other sources falls into four broad categories:

a) Extra services during shutdown (high peak load).

b) Services from specialist outside companies, which are technically not available at the Factory.

c) Services from within the Factory which are not available outside, and which, due to Company policy, are available only from the CWS (mainly jobs for explosives plants).

CWS provides a percentage of category (a). It also provides a service in respect of categories (c) and (d).

The total Factory requirement in respect of these services is not known, but there are indications from Ammonia 4, that it exceeds the present workshops capacity by 300%. Allowing even for the workshops inefficiencies, it is still probably 200% of capacity. If one considers each shop in isolation, it is probable that the situation in respect of machinery and fitting is considerably worse.

A demand versus capacity investigation is required to quantify the problem.

4.3.2. Assuming that demand exceeds capacity by 300%, then the CWS can accept only 25% of the total Factory demand, if delivery dates are to be met. Also, if incoming emergency work equals the workshops capacity, then no other work can be accepted.

4.3.3. Assuming that:

a) The work load is restricted to the capacity of the CWS,

b) delivery dates are being met,

c) improved internal efficiency is resulting in greater cost competitiveness.

then the following questions arise:

9/...

"Should the CWS be expanded to cope with a greater proportion of the total work load ?"

"What is the desirable balance between keeping the work inside the Company and maintaining a healthy infrastructure ?"

4.3.4. It is misleading to take a "free enterprise" approach when evaluating the CWS against outside contractors. CWS management does not have entrepeneurial freedom that outside companies have.

a) The overheads structure is outside the control of the workshops management and is probably much greater than many of the outside companies.

b) The freedom to select only the profitable jobs does not exist.

c) The personal profit motivation which exists in many outside companies does not apply.

d) The freedom to manoeuvre on rates of pay does not exist.

e) The freedom to fire unsatisfactory employees does not exist (leading to carrying of "passengers")

f) The standard of quality expected from the workshops tends to be higher than that which is acceptable from outside contractors.

g) CWS is subject to all the procedural policies of a large Copmany, e.g. buying procedures, safety, labour agreements, pay policies, training, accounting, etc which are usually short circuited or non-existent in outside companies. These blunt the competitive spirit and produce slower responses. Changes become difficult and slow.

4.3.5. The CWS is essentially a service to the whole Factory and it's effectiveness should be judged on the contribution it makes to the wider context of Factory efficiency rather than the narrow view of departmental efficiency, or of cost comparisons of isolated jobs.

4.3.6. At present, the CWS is not providing a satisfactory service. This is perceived by the customers as being primarily a problem of poor delivery, with quality and cost respectively, being relatively minor problems.

The primary cause of this problem is that the volume of work accepted by the workshops, in relation to the shop capacity at present efficiency levels, is unknown. This is as a result of an inefficient planning & control section and not having the planning system geared to give this data.

10/...

4.3.7. In the immediate future, the workshops should therefore:

a) Improve delivery performance by limiting the volume of work accepted. (Emergency work receiving top priority, etc).

b) Improve internal efficiencies to maximise the effective shop capacity with existing resources.

c) Establish reports which will give an indication on demand versus capacity.

4.3.8. The Key Objective should be:

To provide an engineering service to the Factory by providing central manufacturing, repair and maintenance facilities to undertake emergency, ordinary and spares work to achieve:

a) Quality i) of service : delivery dates are met with 95% effectiveness

ii) of product : as specified

b) Cost is at least 10% (average) less than outside contractors.

c) Quantity of service to the Factory:

i) 100% for services which are not available from outside sources.

ii) X% by value of the routine services which can be provided (technically) either internally or externally.

iii) Y% by value of peak load requirements during shutdowns.

Note: (ii) and (iii) percentages to be established after investigating and quantifying total Factory demand and workshops capacity.

4.4. Production Planning and Control

4.4.1. It is suspected that:

There are fundamental faults in the introduction of CAPOSS as a planning system. These will be clarified in the implementation stage of the project.

Generally, system discipline in both the planning section and the shop floor, is extremely poor.

The management control facilities and information provided by the system are not being used, i.e. interpreted and acted upon.

11/...

The normal day-to-day problems encountered in the use of any system are not rectified and the same problems re-occur.

There seems to be a misunderstanding on the part of customers and the planning section, that CAPOSS is causing delayed delivery, when in fact, it is all the other problems mentioned which prevents the function from being controlled and effective.

4.4.2. Planning personnel need job specifications detailing their function and responsibilities.

4.4.3. There are 25 people in the planning section, of whom, 6 are there for administrative convenience. (PIMS Co-ordinator, handyman and 3 boys). This number is thought to be higher than necessary and it is considered advisable to investigate the possibility of reducing this number during the rectification of the application of the system.

Another feature of the personnel in this section, is the number who were posted for health reasons rather than suitability.

4.4.4. As stated before, this section should be fundamentally re-organised.

4.5. Estimating

4.5.1. The present situation in the estimating section is typical of a department which has been neglected over a number of years. The standard of estimating has dropped over the years, possibly as a result of the low status accorded to Productivity Services by the Company.

If, as recommended, an individual incentive bonus scheme is re-introduced, then the standard will have to improve if the Company is to retain control and obtain value for money. The selection and training of estimators must be of a high standard and their operating procedures and policies clearly defined and maintained. A "Refresher Course" for estimators is recommended.

4.5.2. In an incentive scheme context, it is important that the estimating section retains line authority with the Industrial Engineering Group rather than the operating department, so that the inevitable pressures to loosen standards can be resisted successfully.

12/..

4.5.3. In order to avoid delays between the receipt of an engineering works order into the workshops and entering that order into the planning system, it is recommended that a target maximum of 2 days be allowed for estimating normal jobs.

4.5.4. An attempt to measure estimator output should be made and standards applied. This has been successfully applied in other locations, normally in the form of "standard hours estimated per estimator hour". Different standards apply according to whether the work is a one-off job, repeat job, volume job, etc.

4.5.5. Estimator liaison with the shop floor and supervision should be improved. This will prove essential under incentive conditions, where speedy estimation of additional work, extra work and emergency jobs will be necessary.

4.5.6. Route cards require more details of the job method which the estimator assumed when preparing the time estimate. This will enable the artisan to see which method relates to the time allowed.

Much of the disrepute now attached to some of the estimated times arises because the artisans use different methods to those used by the estimator.

4.5.7. There is a considerable amount of work to be done by the Industrial Engineering Group to upgrade the estimating section.

4.5.8. The remuneration of estimators should be upgraded to such an extent that high quality personnel will be attracted. The total maintenance function is estimate driven. High standard estimates are of utmost impotance for successful operation.

4.6. Labour Recruitment and Training

4.6.1. Labour turnover is particularly high in the machine and fitting shops, and there is great difficulty in recruiting replacements.

The allowed and actual machine shop establishment is as follows:

	Allowed	Actual	
Skilled employees	26	18	(3 ex-apprentices)
Adult trainees	8	6	
Contractors	-	2	
Apprentices	10	11	
	44	37	

The recruitment problem also applies to Factory Made Spares (Isando Plant).

13/...

In the short term, the only real solution is to pay competitive rates of pay. The Factory Industrial Relations Officer carries out a periodic survey of the rates paid by outside companies, as a result of which, AECI rates are adjusted to match the upper quartile. It is recommended that the sample firms comprise those companies who are attracting our employees. These will tend to be smaller companies.

In view of the recession in the UK, a further possibility is the recruitment of ICI Workshops artisans who would retain pension rights and service benefits.

Another possibility is the recruitment of artisans from the Mediterranean countries such as Spain, Italy Greece etc, as these artisans are work-orientated and tend to stay longer in South Africa because of the better economic climate. Successful recruitment of these artisans would require basic changes to the Company housing and transportation schemes, as these people tend to live in Johannesburg, in flats rather than houses.

It is further recommended that a merit grading scheme be introduced to reward those with above average skills.

The present incentive scheme does not produce the desired motivation. It is a group scheme, calculated monthly and paid one month in arrears. The bonus earnings are low and not directly related to an individual effort. It is recommended that an individual incentive scheme be introduced which pays 33.1/3% of the basic rate for 100% operator performance. This should be calculated and published weekly and paid with the current months salary. The scheme would be straight proportional, to produce a strong incentive. The standard introductory procedures should be followed i.e. discussion with employees, documentation, agreements, learning periods etc.

It is important to recognise that cash remuneration is the most important factor of the pay package, in the present shortage of skilled labour situation.

4.6.2. In the long term, the solution to recruitment lies in training, both Black and White. This is expensive and wastage is high, but the larger companies have a responsibility which extends beyond the factory boundaries. It requires very special procedures and programmes for recruitment and training, but it is inevitable as a result of the economic development of this country.

The ratio of apprentices in training to artisan establishment should be around 1: 2,5 (average). At the present time, the mix of trades being geared to turnover patterns.

Attractive wage rates will continue to be important in the long term.

14/...

4.6.3. Current apprenticeship selection and training is biased towards academic development. Whilst this type of apprentice is necessary, the main objective of an apprenticeship should be to produce an artisan who is skilled at and proud of his trade and who will remain at that trade for a long period. The training of apprentices who then go on to be draughtsman and estimators is not increasing the reservoir of skills available. There is a need for apprentices with practical aptitudes and lower academic abilities.

APPENDICES

1. EXTRACTS FROM PREVIOUS CWS INVESTIGATIONS

2. LIST OF PERTINENT INFORMATION/FINDINGS/RECOMMENDATIONS OVER LAST 2 YEARS

3. PROPOSED ORGANISATION STRUCTURE OF PLANNING & CONTROL SECTION

   3A : Planning & Control Section responsible to Manager Industrial Engineering

   3B : Planning & Control Section responsible to Workshops Manager

4. KEY PERFORMANCE AREAS

5. PROPOSED ORGANISATION STRUCTURE OF PLANNING SECTION (FUNCTIONAL ONLY)

6. PROPOSED INDIVIDUAL INCENTIVE BONUS SCHEME FOR CWS ARTISANS

EXTRACTS FROM PREVIOUS CENTRAL WORKSHOPS INVESTIGATIONS

1. Report A by Maintenance and Industrial Engineering Department. Undated:

   Conclusion: "The only value a survey done by a consultant might have is the impartiality of his findings where they concern management."

2. Report B by Maintenance and Industrial Engineering Department. Undated:

   Para 3c. Motivation:

   " The shop floor is not motivated and perhaps this lack of motivation extends further up the management structure."

   Para 4a. Set standards:

   " Standards of performance should be established from top management down."

   Para 4d. Corrective Action:

   " This aspect is adequately covered in the opening remarks on the absence of a formalised corrective action plan. Also there is a distinct lack of discipline in the areas of the operation where I have been involved. This last section can well be covered with an Incentive Bonus scheme as far as shop floor personnel is concerned. This is not a panacea because the need for control also exists at a higher level than shop floor. A new bonus scheme will thus perforce be frustrated should the other elements that are lacking not be corrected."

   Recommendations:

   " Some staff changes may be necessary in order to invigorate the situation."

3. Memorandum, Maintenance and Industrial Engineering Department, 26.03.1980. (by B. Mills - the founder of the system)

   Introduction, Para 2:

   " The problems that exist cannot be isolated to the change in operating venues (of FMS) but to the manner in which the whole of the "CAPOSS" system is operated. Basically there are no fundamental differences in the problems to those that existed 9 months ago. The solution to them is people action, strong controls with good follow up procedures and a stable operating system."

   Conclusion:

   " Whatever system is employed to control the throughput of work, it is essential that the disciplines imposed by the system must be implemented and maintained at all times and not just paid lip service."

2/...

OTHER REFERENCES

1. PSD Project MMS/P/76/16:

   "Interim report on investigation into Central Workshops Planning", 1976 by I. Krigel/L.L. Sella

2. Report A

   "List of pertinent information/findings/recommendations over last 2 years" See Appendix 2.

3. Personnel Department:

   "Report on bonus scheme in Central Machine Shop" by T.G. Jenkin 11.6.80

4. Memo

   "Investigation into problems between Spares Production and Modderfontein Workshop" by B. Mills 26.3.80

APPENDIX 2

MAINTENANCE AND INDUSTRIAL
ENGINEERING DEPARTMENT

REPORT A

LIST OF PERTINENT INFORMATION/FINDINGS/RECOMMENDATIONS
OVER LAST 2 YEARS

DATE	REF	WHO	TO WHOM	INFO/FINDING/RECOMMENDATIONS
25/10/76	1	J.A. Newberry	Chief Eng.	a) Clean out and revamp estimate filing system. b) Microfilm estimates.
Feb. '79	3	A.H. Caldwell	?	a) New base rates for bonus scheme is required. b) Restructure schemes to utilise PIMS figures.
21/5/79	4	F.M Jay	Chief Eng.	a) Review machine shop time standards. b) Resolve computer problems with bonu schemes. c) Recording of waiting time and UCW on plants to be re-organised. d) Utilise surplus journeyman on other work.
25/5/79	5	F.M. Jay	W.A. Logeman FTSM ACE(M) FWE SPE	a) Check Time queried by HEKRO & BRUNSWICK (Ref. 3b). i) Times correct ii) Transcription errors b) Will issue method sheets if workshop management agrees.
1/6/79	6	H. Flein	Chief Eng.	PCI sheet identifying probable causes as i) Incorrect performance measurement ii) Low working rate iii) Use of incorrect methods iv) Unrecorded delays or waiting time v) Increase in quality standard
1/6/79	7	Meeting	FWE	a) Institute a proficiency increment.
20/6/79	8	F.M. Jay	FTSM	i) Modderfontein schemes are tight ii) This contributes to high turnover iii) Machineshop standards should be loosened iv) Cost of administering scheme is 12 man days per month instead of 4 because of poor system v) Computer Bureau has not resolved all the problems with the system

2/...

DATE	REF	WHO	TO WHOM	INFO/FINDING/RECOMMENDATIONS
1/10/79	9	F.M. Jay	Chief Eng.	i) Times are reasonable in general ii) Problem with times is not generally because of estimate problems but poor supervision iii) Observed unproductive time was mor- than 1½ hours per day after activity sampling. iv) A formal action plan needs to be drawn up.
27/2/80	10	H. Klein	F.M. Jay	a) Reasons for losses in bonus scheme MACHINE SHOP i) Waiting time not booked separate ii) Paid absenteeism booked as time taken iii) Poor performance iv) Extra work done and not claimed v) Jobs to be repeated (scrap) vi) Poor planning/grouping of jobs vii) High % idle time viii) Poor supervision - no experience ix) No motivation by supervision x) High overtime hours at low performance xi) High scrap costs WELDERS i) High waiting time ii) Complement too high iii) Waiting time during week and overtime after hours iv) Superivsion reluctant to use schemes v) Hightraining time - coding
12/3/80	11	H. Klein	QCE	i) Meeting between QCE and some journeymen ii) Complaints about times and procedures iii) Estimators not represented
13/3/80	12	H. Klein	F. Jay	i) Journeymen book non-existing time ii) Matter reported to FwE iii) FWE discussed matter with leading hand and requested a correction iv) Leading hand did not correct matt but "did another fiddle".
6/5/80	13	Meeting	FWE, SPE QCE, J.J. Watkins	i) Times allowed are not booked leading to losses in bonus scheme ii) Waiting time is caused by non-availability of electricians. iii) No action was minuted to discuss this with electrical section iv) Times are not adequate

3/.

DATE	REF	WHO	TO WHOM	INFO/FINDING/RECOMMENDATIONS
26/3/80	14	B. Mills	I. Krige cc. MIEM ACE(M) FWE SPE J. Watkins	i) Shopfloor supervision do not have worklists ii) Lack of action on known problem jobs iii) Scrap/ rework system ineffective iv) Work is not inspected in sequence v) Problems with materials because of poor control in planning vi) Work performed out of sequence vii) Relationship problem
23/4/80	15	SPE	I.A. Krige FWE J. Watkins	i) Incoming orders not grouped ii) This causes inefficiency
11/6/80	16	G. Jenkin	CE ACE(M) FWE FTSM FPM	i) Times, relationships, structure pay rates, induction, paperwork estimate data system, supervision cause problems ii) Ignorance of procedures by journey men iii) Communication gap
30/6/80	17	FWE	ACE(M)	i) Most jobs are late ii) Farm more work outside iii) Reduce incoming work load
July '80	18	SPE	M&IEM	i) Emergencies loaded on Isando cause late deliveries ii) Documentation, material jigs and jobs not tied up
July '80	19	IAK	-	1) Personal observation of worklists showed a distinct lack of working to the schedule. No. of times schedules were fairly high in most cases.

CONCLUSIONS

From the above it can be clearly seen that:-

1) A large number of problems have been identified during the last 2 years.

2) I have found no evidence of a formal concerted plan for corrective action.

3) With all the problems already identified and not solved a productivity survey by a consultant will not be of much benefit except for (4) below.

4) The only value a survey done by a consultant might have is the impartiality of his findings where they concern management.

4/...

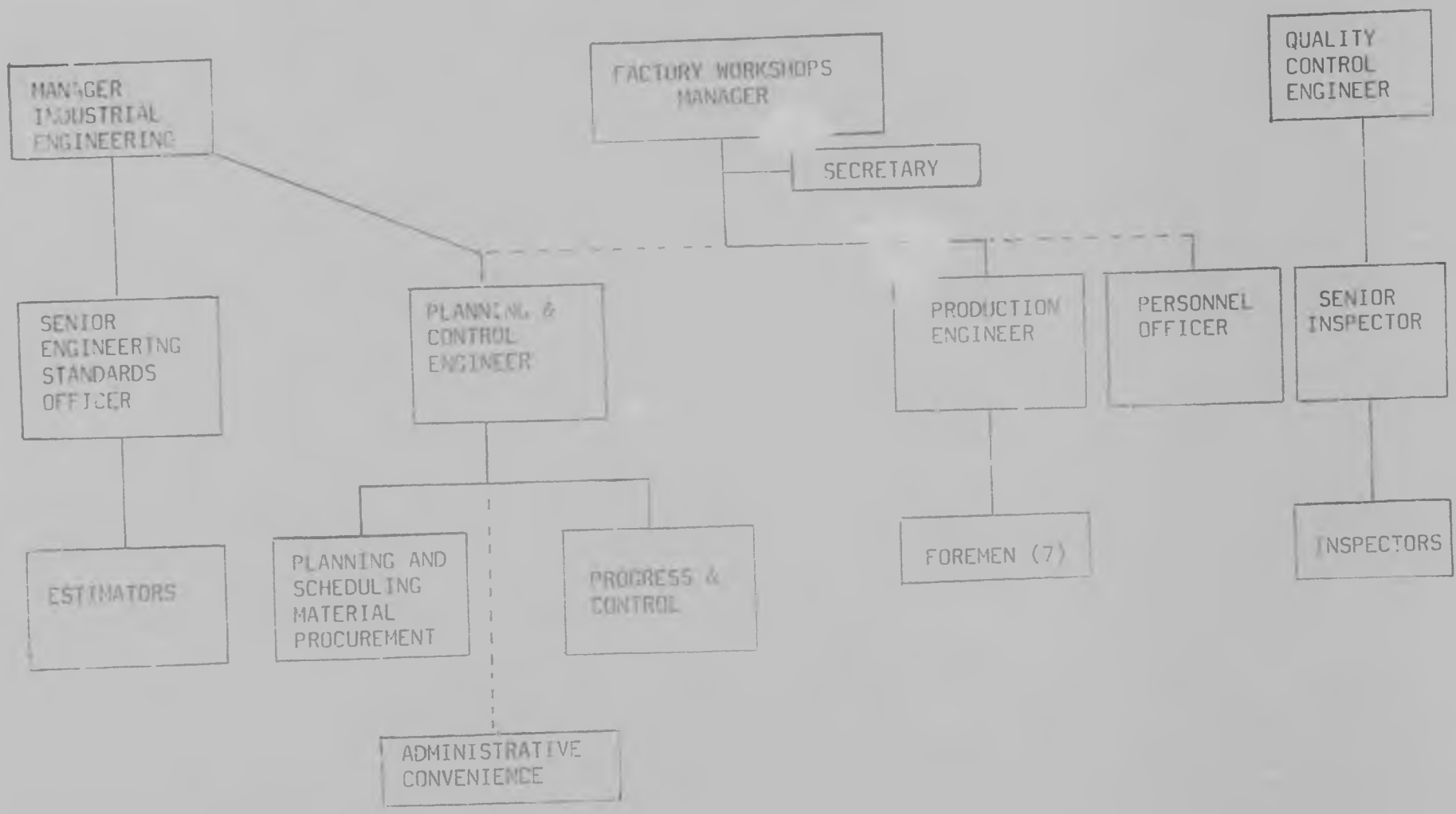
RECOMMENDATIO. 5

1) That a committee chaired by the Chief Engineer and consisting of whokshop management, Industrial Engineering and Industrial Relations be formed.

2) This committee should survey the existing data concerning problems in the workshops. The information still pertinent should be extracted and additional information gained where necessary.

3) A rational formal concerted plan to overcome the problem should be formulated. This plan should have specific objectives, spell out accountabilities and responsibilities clearly and have an action programme tied to a specified time scale.

PROPOSED WORKSHOPS ORGANISATION STRUCTURE

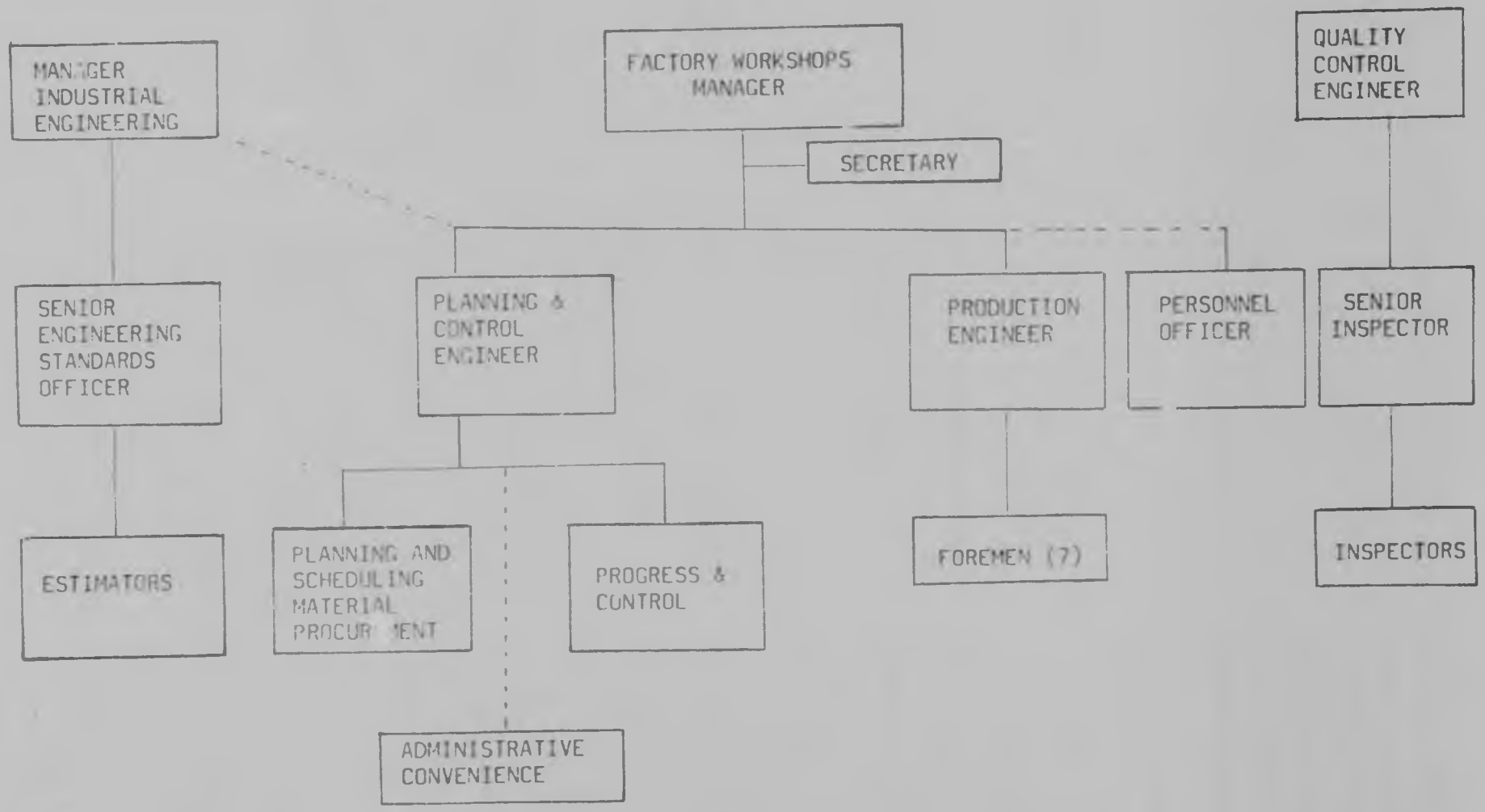


PHASE 1

Planning & Control Section responsible to Manager Industrial Engineering.

APPENDIX 3a

PROPOSED WORKSHOPS ORGANISATION STRUCTURE



PHASE 2

Planning & Control Section responsible to Manager Factory Workshops.

APPENDIX 3b

APPENDIX 4

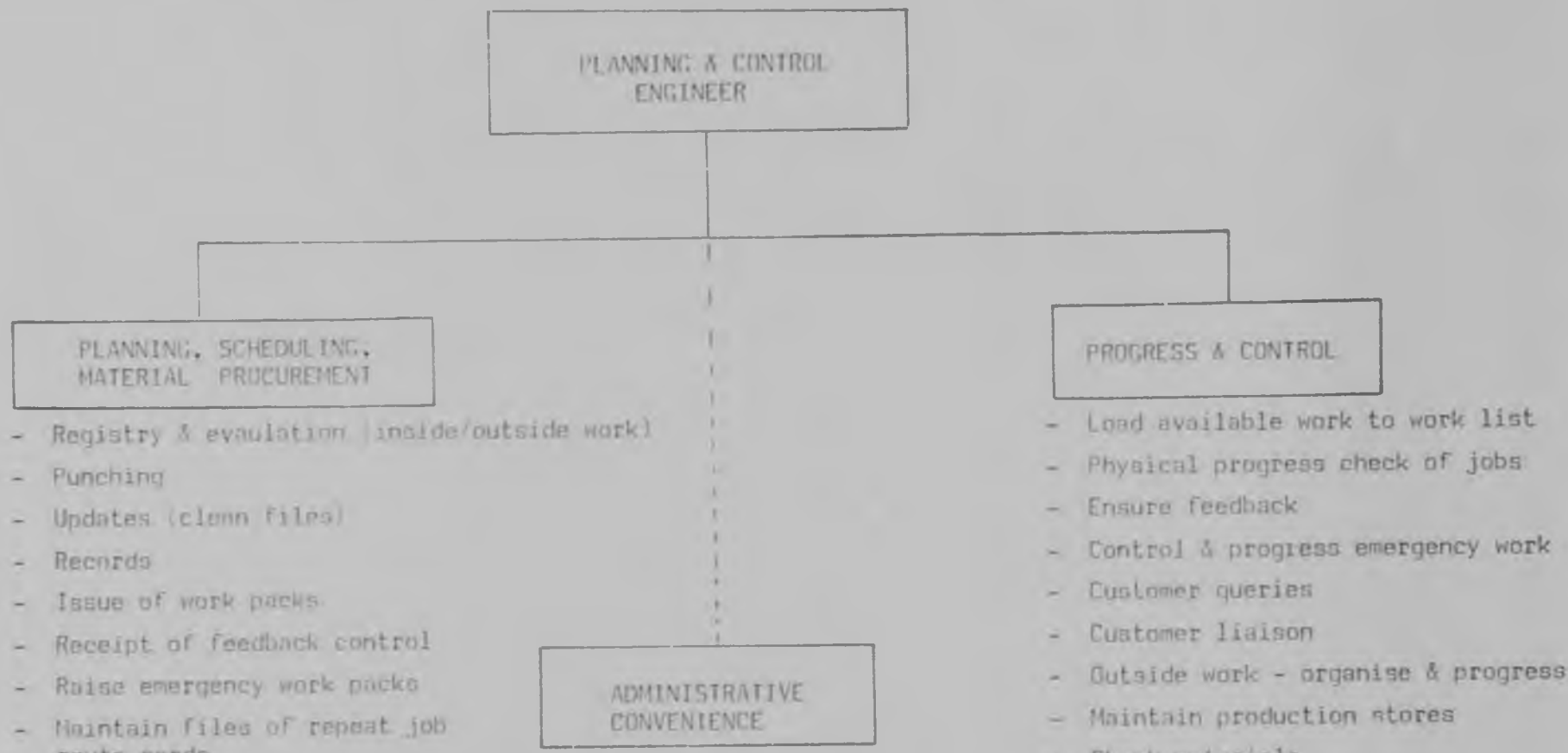
KEY PERFORMANCE AREAS

JOB	END RESULTS TO BE ACHIEVED	YARDSTICK
Leading Hand	1. The correct jobs are completed by the appropriate equipment & men in the section.	100% achievement of daily production programme and all emergency jobs issued by Planning to be started.
	2. Correct quality.	Scrap rate < 5% for section.
	3. Satisfactory time taken on each job.	Operator performance : 100%
	4. Adequate manpower utilisation.	Dept performance : 95% for section.
Foreman	1. The starting and completion of all emergency jobs received from Planning & Control.	- 0 % emergency jobs not started. - 95% emergency jobs completed within 24 hours.
	2. Department production targets achieved each day.	100% achievement of department daily production programme.
	3. Department manpower utilisation.	Dept programme:95% for Dept
	4. Average of operators output	Average O.P. : 100% for Dept
	5. Quality	Dept scrap rate <5%
Production Engineer	1. Satisfactory delivery performance of the total workshops as planned.	95% of ordinary jobs delivered within ± 3 days of due date (excluding emergencies)
	2. Emergency jobs processed without delay.	95% emergency jobs completed within 48 hours
	3. Control production costs (directs) (to be defined more closely)	< R X per Std. hour
Planning & Control Engineer	1. Convert customer requirements into practical, achievable daily production plans.	- 0% jobs lost - <5% jobs with CFD* in ± 5 days excess of FCFD**
	2. Control workshops input to the capacity available	LSD load % not be exceed 130% in any work centre.
Factory Workshops Manager	1. Ensure that the resources are available to enable CWS to achieve the key objective.	
	2. Ensure that the key objective is achieved.	
	3. Ensure that within the constraints of (2), the workshops Total Resource Productivity is optimised.	
	4. Carry out corporate strategy: Evaluate trends, prepare forecasts, review key objectives, prepare plans, evaluate, implement.	

* CFD - Current Finish Date ** FCFD - First Calculated Finish Date

PROPOSED ORGANISATION STRUCTURE OF PLANNING SECTION

(Functional Only)



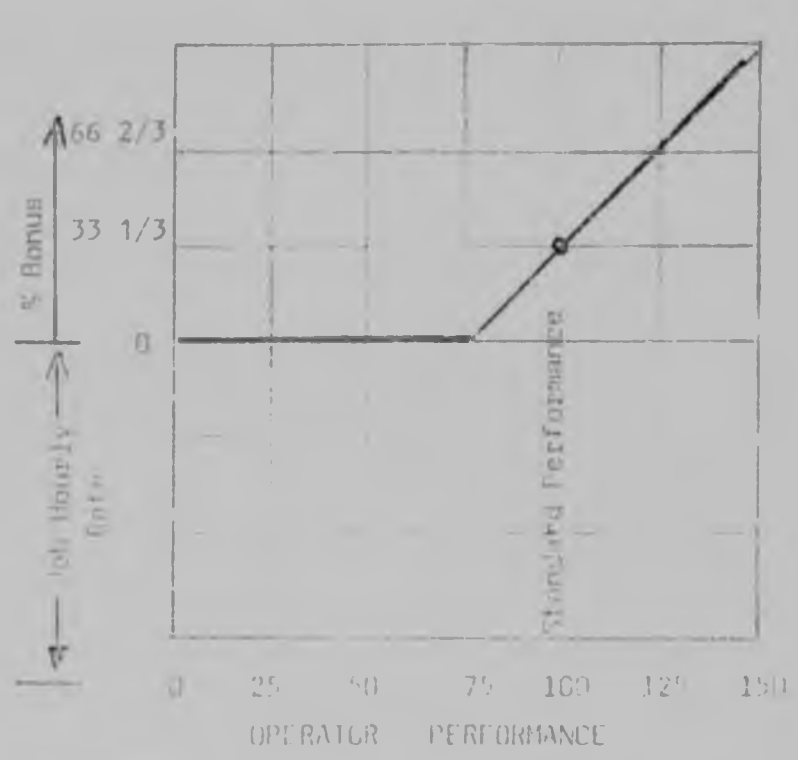
APPENDIX 5

PROPOSED INDIVIDUAL INCENTIVE BONUS SCHEME FOR CWS ARTISANS

The scheme proposed for the CWS is the standard straight proportional scheme based upon operator performance.
It would be an individual scheme.

$$\text{Operator Performance} = \frac{\text{Standard time for measured work}}{\text{Time taken (excluding diverted time and waiting time)}} \times 100$$

It is recommended that bonus calculations be based upon the Average Operator Performance for a week rather than on a job by job basis.
An average operator performance of 100 (i.e. Standard Performance) will result in bonus percentage of 33 1/3 % of the artisan hourly rate.
An average operator performance of 75 is the threshold performance and is 0 % bonus.



The main principle only is detailed here. A fully detailed set of conditions under which the scheme will operate will require to be drawn up.

JOB SHOP PRODUCTION PLANNING & CONTROL - CASE STUDY

(AECI Modderfontein - Central Workshops)

Part B

"CAPOSS" - Philosophy, Features, Areas of Application, Inputs,
Reports and Frequencies, Procedures and General Description

Part B

C O N T E N T S

PREFACE

		PAGE
1.	Introduction to CAPOSS	1
2.	Purpose and objectives of scheduling	2
	2.1 General	
	2.2 Solution	
3.	Planning a Job	5
	3.1 General	
	3.2 Scheduling techniques	
4.	Prerequisites	10
	4.1 Description of Data	
	4.2 Work centres	
	4.3 Shop Calendar	
5.	Features of CAPOSS	13
	5.1 Operation splitting	
	5.2 Lot splitting	
	5.3 Overlapping	
	5.4 Related facilities	
	5.5 Operation Grouping	
	5.6 Alternate Possibilities	
	5.7 Overtime	
	5.8 Statistics	
	5.9 Priorities and Loading Procedures	
	5.10 Urgent Orders and changes	
	5.11 Pull early procedure	
	5.12 Costing	
	5.13 Materials	
6.	Input	17
	6.1 User input	
	6.2 Main content of Rout card	
	6.3 Specification of work centres	
	6.4 Parameters	
7.	System output	19
	7.1 Printed output	
	7.2 Output files	
8.	Transactions and Feedback	30
	8.1 Transactions	
	8.2 Feedback	
9.	Processing Description	32

APPENDICES

1. Description of Data

2. Workshops CAPOSS Calendar

3. Route Card Input

4. Printed Output

5. a. Input coding note for additions
   b. Input coding note for cancellations and change

6. Processing Description

7. Programming System

PREFACE

This report is a 2nd in a sequence of reports for the MSc degree project of the author.

The report describes in brief the I.B.M. Capacity Planning Operation Sequencing System ("CAPOSS"), its main philosophy, its features and its functions.

It contains descriptions of; the areas of application, the Inputs and the reports produced.

The major part of this report is a summary based on my experience as a user of the system and as such I tried to give an overall picture from the view point of the system's suitability to a practical Production Planning and Control situation.

The theoretical part of this report has been extracted from the IBM Manual For Programme Product (GH 12-5105-1).

A. FRANCO

1. INTRODUCTION TO CAPOSS

In the past scheduling programmes were used mainly in manufacturing areas. Because of the new features, solutions are also available to the process industry including the mining basic metals, chemical and petroleum industries as well as the paper, rubber, ceramics, glass, textile and footwear industries whenever the production involves limited quantities for a definitable order. This is in contrast to complete flow production.

In manufacturing, the lateness is very often detected too late to avoid delay therefore a much better solution is to control the complete flow of an order, beginning with the customer inquiry. Manufacturing itself then is a part of the overall production cycle and can be controlled using realistic end dates.

CAPOSS can be installed for the overall control of all projects within a company and then can be used in more detail to schedule the job shop, as well as all activities for a single project in a department e.g. design, or development of new products.

CAPOSS uses general principles and as such can be used for any kind of scheduling control.

CAPOSS can be used to determine the load profile for an order or typical product by scheduling all individual activities. This can serve as a model for overall planning.

As this type of programme can be used efficiently for make to order manufacturing the system was adopted as planning and control system for the Central Workshop of AECI Modderfontein.

By introducing this system the idea was to achieve the following advantages :-

- Quick reaction to changed requirements
- Production of a daily scheduling reflecting the actual conditions as reported by feedback from the shop floor
- Control over capacity requirements
- More realistic start and end dates for activities
- Furnishing of operation dispatch lists considering the interactions between all activities and orders
- Processing of a large amount of data which can't be treated manually with the same frequency.

The answer, if all these advantages have been achieved, and the reasons for not achieving, in the case of AECI Modderfontein Workshops will be given in Part C of this project.

2. PURPOSE AND OBJECTIVES OF SCHEDULING

2.1 General

The Major scheduling objectives of CAPOSS are to assist in :-

(i) Meeting target dates
(ii) Reducing the lead time f a project or order, which normally results in a reduction of the capital invested in work in process
(iii) Keeping resources fully occupied
(iv) Performing capacity requirements planning
(v) Providing management with an up to date and realistic solution.

The above objectives have different priorities in different environments and the first four of them are conflicting objectives. CAPOSS attempts to find the best compromise between all extremes.

Schematically, objectives in scheduling are looked at as follows :-

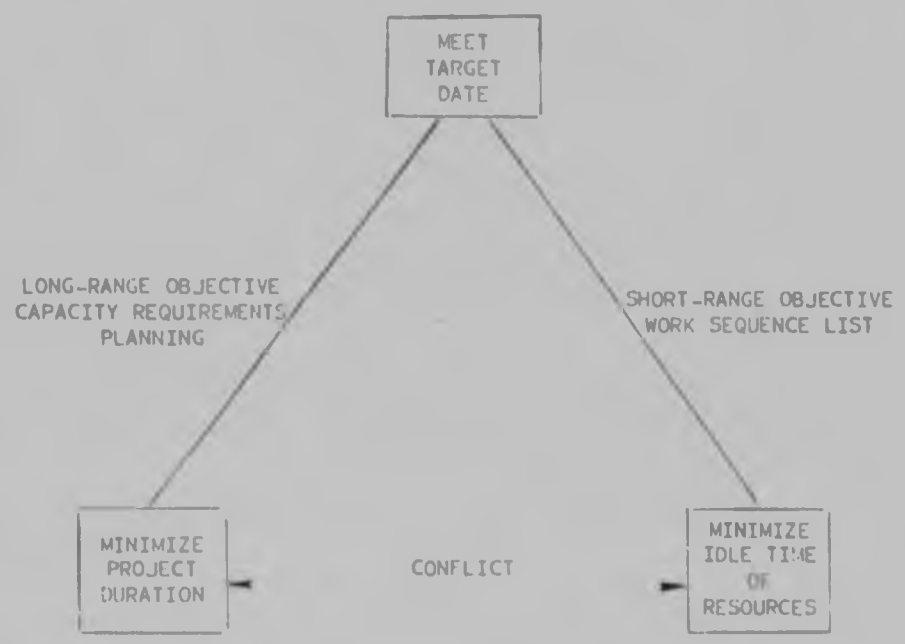


Figure 1 Objectives of Scheduling

A simplification of the above theoretical figure to the day to day management view of the Workshops is shown in figure 2.

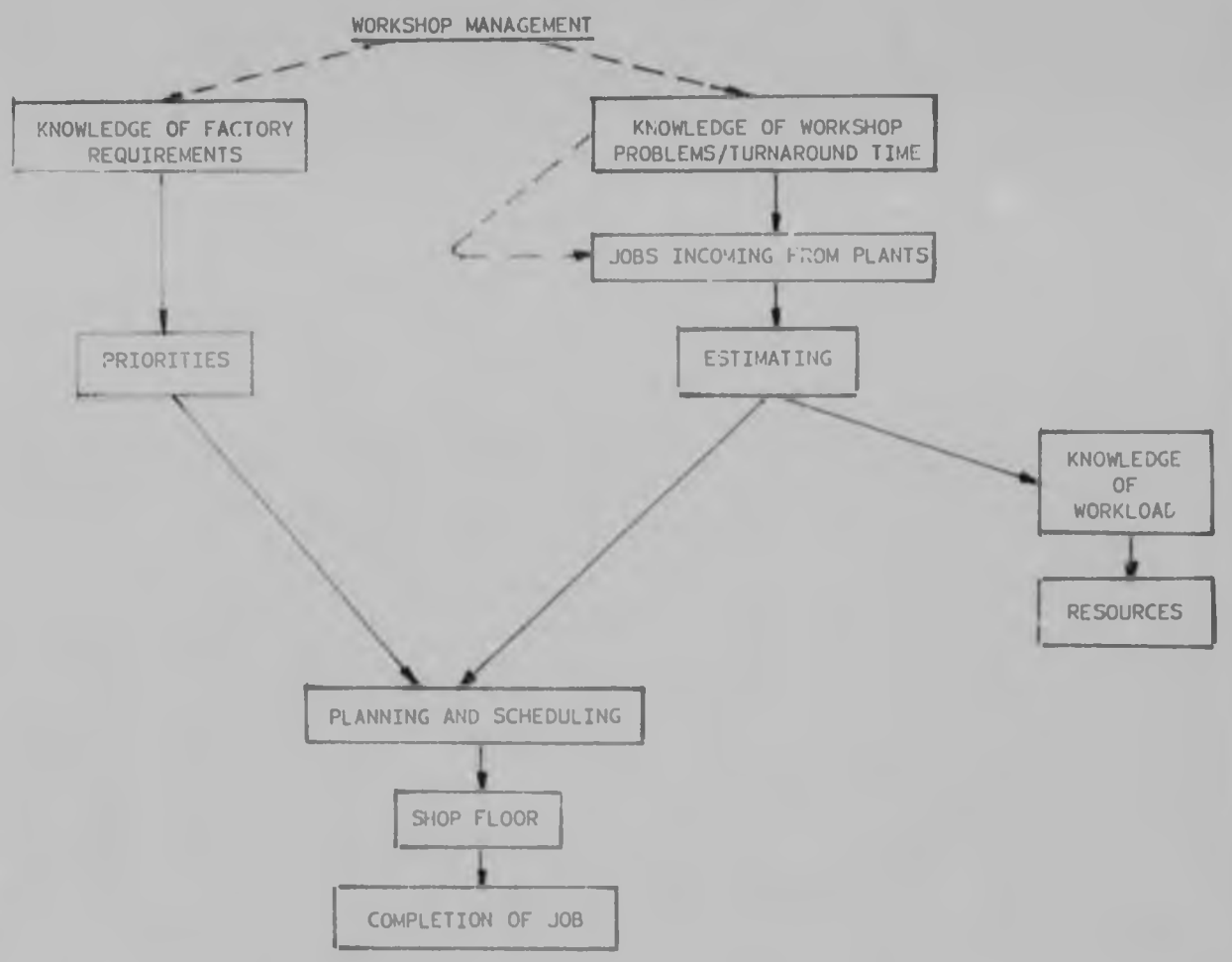


Figure 2 Day to day management view of workshop

2.2 Solution

The approach taken in the CAPOSS system to answer the above questions is to divide the problem into three areas and to apply different solutions to each. This allows the use of different levels of control which increase, with respect to individual orders, as the time approaches to execute or manufacture them.

CAPOSS contain the following types of scheduling :-

- Capacity requirements planning - (long range scheduling)
- Completion time estimating - (middle range scheduling)
- Operation sequencing - (short range scheduling)

These are illustrated in figure 3.

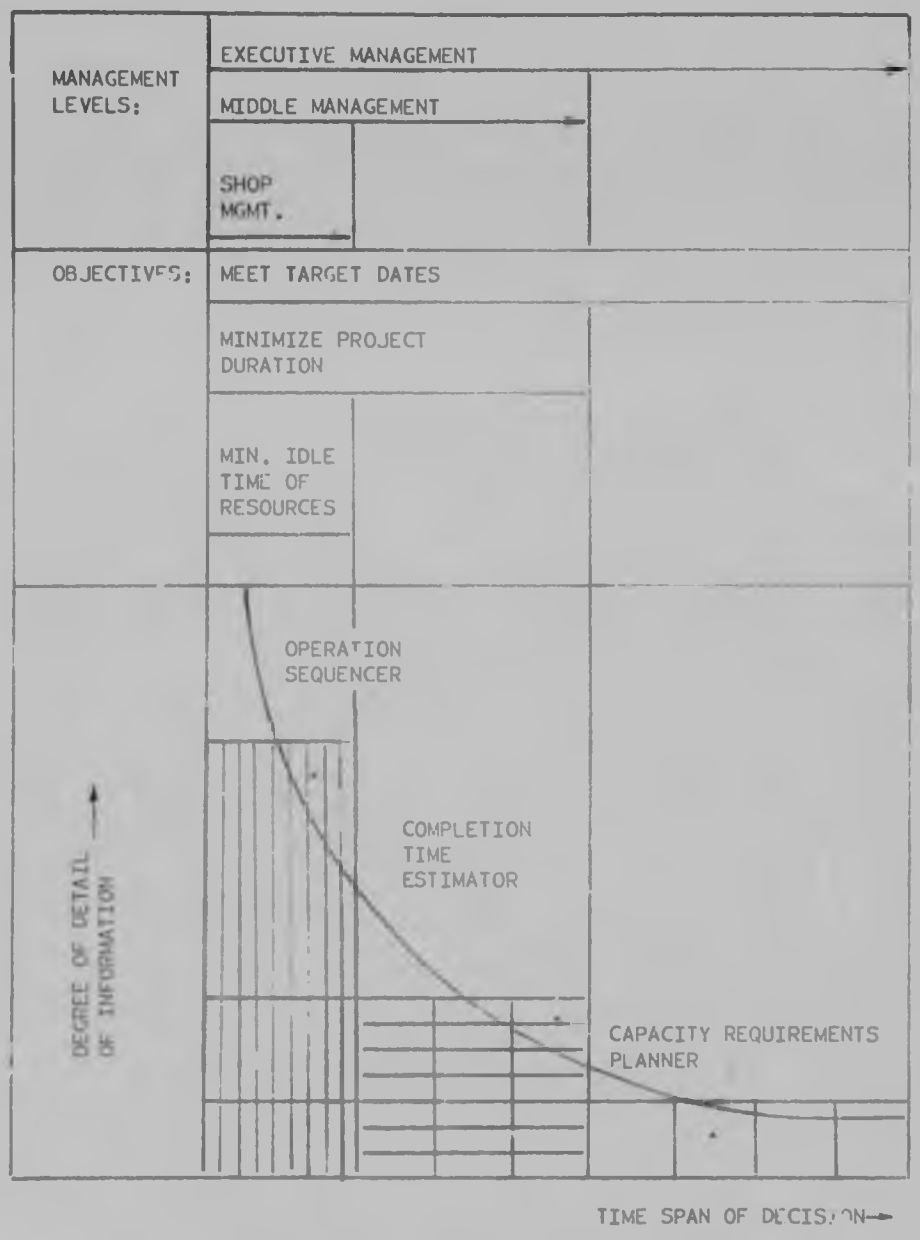


Figure 3 Information and scheduling

The 3 types of Scheduling produce the most important reports for control :-

(i) Capacity requirements planning report
(ii) Detailed output from operation sequencing and completion time estimating (Daily work list).

These reports are discussed in detail in item 7.1 - Printed Output.

3. PLANNING A JOB

3.1 General

In many jobs, multi-trade work is required. Jobs are hence split into the relevant parts, each requiring a different resource. Each part is given an estimated duration and the parts are put into the correct processing sequence.

In CAPOSS terminology: An order is made up of a sequence of operations, each requiring a certain duration at a specified work centre.

The order is given a priority and due date. If unable to start immediately it can be given an early begin date.

3.2 Scheduling techniques

The scheduling solutions for the 3 ranges of planning use different techniques and are designed to satisfy the different levels of accuracy required.

The types of loader are :-

- Bucket loader
- Horizontal loader
- Vertical loader

3.2.1 Bucket loader

The Bucket loader is used in the Capacity Requirements Planner and considers the capacities of a work centre. It assumes that all machines in the work centre are equal in performance and the work centre capacity is the total of the individual machine capacities.

The tasks of this type of loading are :-

(i) To compute the expected earliest and latest start dates for each operation in the order file.
(ii) To load operations to work centres in a given time.
(iii) To level loads where possible.
(iv) To plot out graph load for each work-centre.

The resulting load profile is normally very irregular as shown in figure 4.

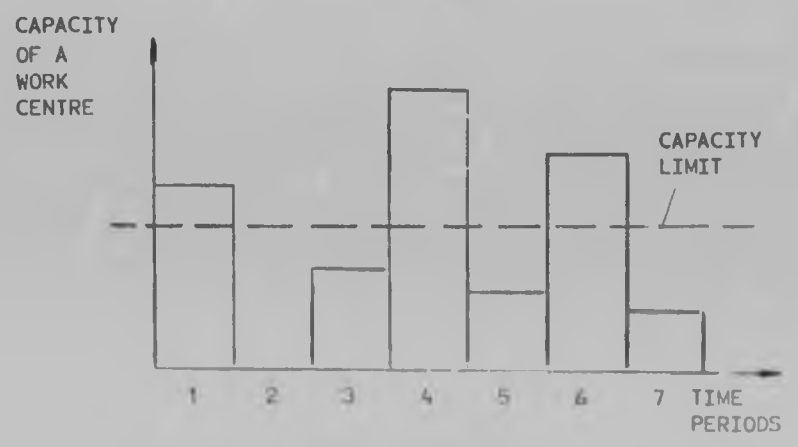


Figure 4 Capacity Requirements

The bucket loader smooths out the irregularities and produces a load that is consistent with the capacity available. This is known as load leveling (Task (iii)) and is shown in figure 5.

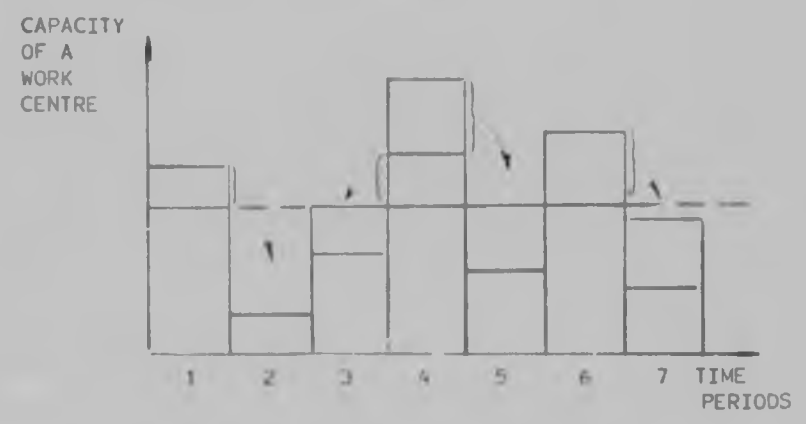


Figure 5 Load Leveling

The Graph (Task (iv)) shows capacity requirements for each work centre if every due date is to be met.

As mentioned earlier it is for use by Senior Management to decide on future machine/manpower levels required and/or contracting out.

It gives global view and does not consider individual order.

5.2.2 Horizontal loader

The horizontal loader considers each individual order and generally it does the following :-

(i) Loads orders in priority sequence.
(ii) Each order has its operations loaded in sequence to the appropriate work centre.
(iii) The work is loaded to the daily capacity of the work centre.

By means of the e it shows the possible completion date of each order (with given capacities) if work is done in priority sequer. e - thus highlights jobs which are unlikely to be completed by due date and shows work centre loading/ bottleneck.

The results produced by such a horizontal loader are sensibly accurate when considered over a medium time range and are for use by middle level Management to consider action to relieve the medium range problems i.e. certain orders should be contracted out.

3.2.2.1 Order Priority

The sequencial priority of order is a function of 5 weighting elements (x1, x2, x3, x4, x5) and Scheduling Status x6.

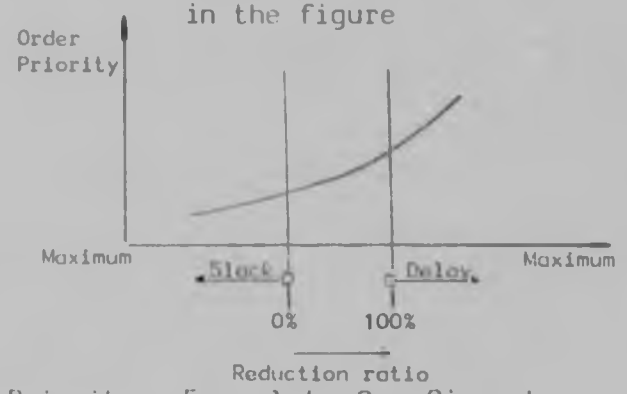
...e Variables

Order Priority = y = x1 + x2 + x3 + x4 + x5 + x6

x1 - Delay : The amount of time an order will be finished after due date = CURRENT FINISH DATE - First Calculated Finish Date.

x2 - Slack : The amount of time between the earliest begin date and the start date of an order that still allows the order to be finished on time.

x3 - Reduction ratio : The percentage between a slack of zero and a delay of zero as shown in the figure



x4 - External Priority : From 1 to 9. Given by customer and translated internally to various weights.

x5 - Capital cost : The greater the cost of the order, the greater the weight given.

x6 - Scheduling status : Order already scheduled = 12
Order waiting on queue = 0

The present values of the variables are as follows :-

x1 - Delay		x2 - Slack		x3 - Reduction Ration	x4 - Priority		x5 - Capital Cost	x6 - Schedule Status	
Days	x1=	Days	x2=	x3=30%**	Ext.	x4=		Start	Queue
0-5	1	0-20	Not		1	1	Not imple-	12	0
5-10	2	20-30	imple-		2	1	mented*		
10-20	3	30-40	mented*		3	2			
20-40	4	40-50			4	3			
40-70	5	50-60			5	3			
70-110	6	60-70			6	12			
110-160	7	70-80			7	13			
160-220	8	80-90			8	13			
220+	9	90+			9	17			

* - Recommended as not practical for use by the I.B.M. experts
** - Value recommended by the I.B.M. expert

3.2.2.2 Summary

In middle term planning, management has two tools to make its decision. The capacity requirements planning graphs highlight the capacity problems that can be expected to exist while the Completion Time Estimator phase shows which orders are affected. The two sets of results interact in as much as the capacity requirements are respected the delays resulting from the above will be reduced.

3.2.3 Vertical Loader

The above discussed scheduling techniques provide management with the information required for capacity planning. They do not provide the control function required by shop management to produce workable sequence of work for the shop to follow.

The purpose of a vertical loader is to analyse the results of the horizontal loader and produce a workable sequence of day to day work.

The main characteristics of the vertical loader are :-

(i) Considers each single machine in a work centre
(ii) Considers all operations on their calculated operation priority (Not on the order priority)
(iii) Loads highest priority operation to relevant work centre. Puts next operation into appropriate queue.
(iv) Loads all work centres in this way on a time interval (say 1 hour) then loads for 2nd interval etc
(v) Takes into consideration similar work, etc, if specified.

The vertical loader gives shop floor Management the "best" work sequence for each machine today - considering capacity, jobs already started etc.

3.2.3.1 Operation Priority

Operation Priority is determined by means of a function consisting of 6 Variables which can be divided into 3 groups.

The function

OPERATION PRIORITY = R = /xx/yyy/z/

group 1 - xx

- If operation is in process	xx : 99
- Partial Feedback	xx - 99
- Forced by user can give 90+ parameter 0 TO 9	xx = 90-99
- System gives	70 + ORDER PRIORITY
- Successive operation	xx = 60
- If delay > certain amount and it falls into the future it gets	40 + ORDER PRIORITY
- If nothing like this happens to the operation it groups the operations to 3 groups :	30, 20, 10

group 2 - yyy

DUE DATE - LATEST START DATE + 800

group 3 - z

THE SHORTEST OPERATION DURATION

3.2.4 Summary

In the previous items I tried to explain the philosophy of priorities which the CAPOSS is based on through the application of the scheduling techniques.

Actually, the most important reports don't include the same data with regard to priorities.

The order file which gives the list of orders and operations as per schedule highlight only the external priority given by the customer.

The daily work list which is the operations sequencing of the vertical loader gives the order priority (Horizontal loader) and the first group (xx) of the operation priority (Vertica loader). An utmost important factor in the application of this philosophy is the control over inputs such as External Priorities, and Due Dates given by customers and the control over capacity requirement by management. This will be discussed in Part C of this project.

4. PREREQUISITES

4.1 Description of Data

Within the programme, each record must have a unique identity. This is achieved by the hierarchy of identification as shown in figure 6.

The complete identification sequence is the project number, order number, operation and alternate operation numbers.

The length and format of each number is specified by the user as they exist in his environment (Workshop's description of data - See Appendix 1).

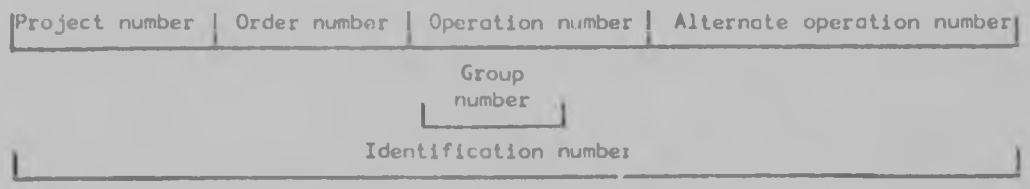


Figure 6 Identification number

In our particular case the identification number is as follows :-

4.1.1 Area

This number defined the plant or department from which the order is initiated.

4.1.2 Order Number

This number defines the customer order, a work order, a project, a network, etc.

4.1.3 CAPOSS Number

This number defined the sequential nubmer of order in the planning system. All plant queries and correspondence about orders with planning is done through this identification number.

4.1.4 Group Number

Orders can be grouped together by defining the leftmost digits of the CAPOSS number as group number.

The group could be sub-assembly, an assembly, or any convenient group of orders. The group can be used to specify interrelationships of associated orders with other orders.

4.1.5 Operation number

This is the serial number of the routing operation, and unless specified by an alternate routing it defines the sequence of manufacturing.

4.1.6 Alternate Operation Number

This number identifies a substitute routing and can be one of the following :-

Single connection

Single connection forms a path between operation and primary operation as shown in figure 7. The primary operation is performed after completion of the secondary.

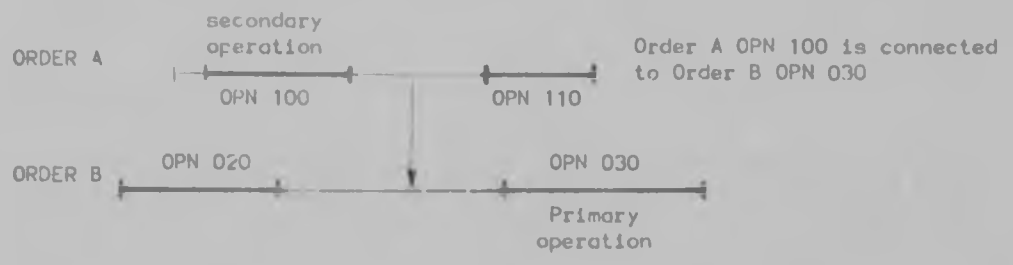


Figure 7 Single connection

Group connection

Group connections are a shortened method of defining a number of single connections from a common group of orders (i.e. common group number) to a single primary order.

A group connection can exist only from the last operation of each order in the group as shown in figure 8.

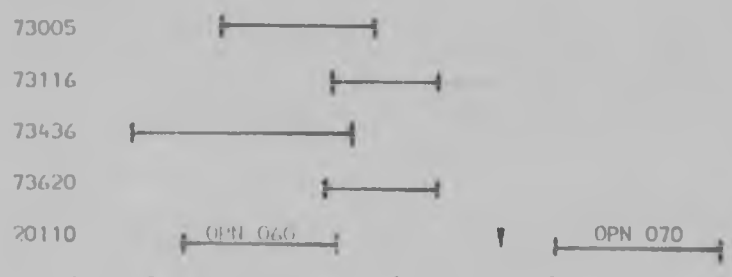


Figure 8 Group connection

4.2 Work centres

4.2.1 General description

Each operation or material requires a work centre. The work centre is described in sufficient detail to allow the determination of inter operation times, institute times and cost calculations. Capacity details are given, including shift starts, and number of shifts, to perform loading to finite capacity.

The description of Work centre may include : men or machines of equivalent performance, a single person or a machine, an assembly department, a storage area, an external supplier, etc.

A Work centre can be referred to as finite capacity if its capacity has physical limitations or as infinite capacity. an example for infinite capacity is "problem solver" work centre.

4.2.2 Sub-groups

Sometimes work can be done only on specific machines within a work centre because of different skill classifications, special fixtures, tolerance ranges, etc. In these cases work centres can be divided into "sub-groups" and loading will be done on sub-groups capable of doing the work.

4.2.3 Single machines

If applicable, different capacities and capacity changes can be specified for single machines.

4.2.4 Alternate Work centres

If a bottleneck occurs at a work centre and an alternate routing is not available the alternate work centres define possible substitutes for the prime work centre.

4.3 Shop Calendar

All date computations and specifications are made in working days. To achieve this and show the results effectively it is necessary to be able to reference each working day. The shop calendar which is used in Central Workshop's is shown in Appendix 2 of this report.

The calendar uses 4 digit numbers : The first digit shows the last digit of the calendar year. The remaining 3 digits are used for consecutive numbering of working days.

5. FEATURES OF CAPOSS

5.1 Operation splitting

Simultaneous processing of an operation on several machines may be required, the objective being to reduce the throughput time of the operation. This action is known as operation splitting.

The user can indicate which operations are to be split and can define his own limit to the maximum number of splits possible.

The different options for splitting operations can be specified :-

- Quantity to be split
- Run time is to be split
- More than one single machine is to be assigned to each piece.

5.2 Lot splitting

Sometimes it it necessar split an order into 2 lots to achieve a fast throughput of limited portion of the order. The remaining portion follows at normal speed. Lot splitting can be achieved during shop floor feed back.

5.3 Overlapping

It may be desired to process two consecutive operations in parallel with each other. This is the case when the run time is long and it is practical to start the succeeding operation before the preceding operation has completed the planned quantity. The result can be a considerable saving in throughput time. The conditions for overlapping are illustrated in figure 9.

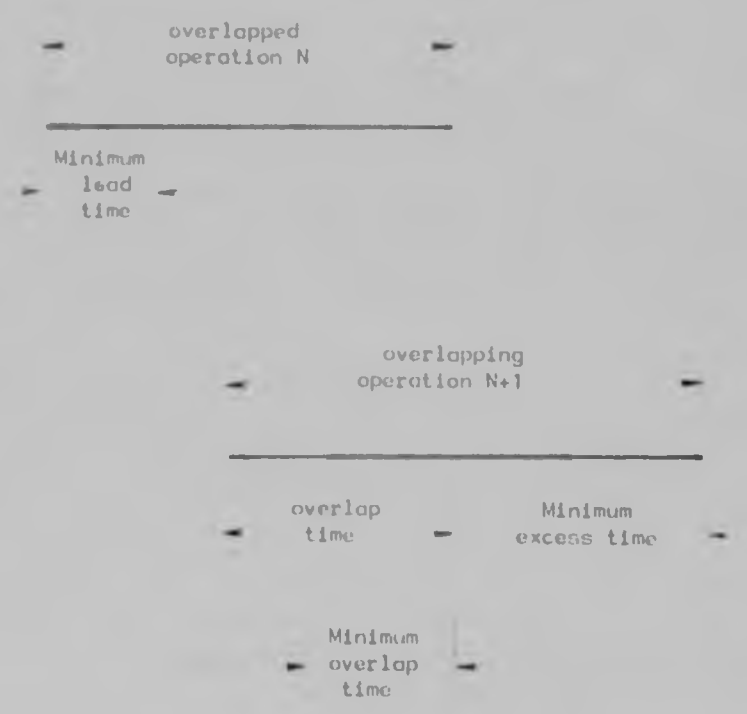


Figure 9 Conditions for overlapping

5.3 Overlapping to avoid delay

The user can ask for additional overlapping to be automatically applied. The overlap occurs where possible, between the operation in which the delay was detected and the following operation.

5.4 Related Facilities

A problem that often arises in the manufacturing is that more than one facility must be available at the same time to work together on a common operation. This may be men and machines or tools and machines.

Two different kinds of relationships within an order must be distinguished:

i) Forced parallel operation : This relationship requires the facilities to be available at the start of the run time.



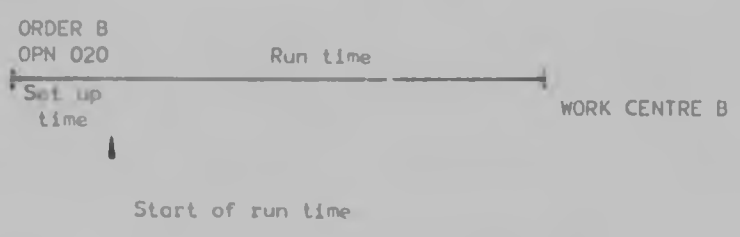


Figure 10 Forced Parallel operation

ii) Forced overlap : Both facilities may have different run times, but the shorter run time must not exceed the range of the longer run time.

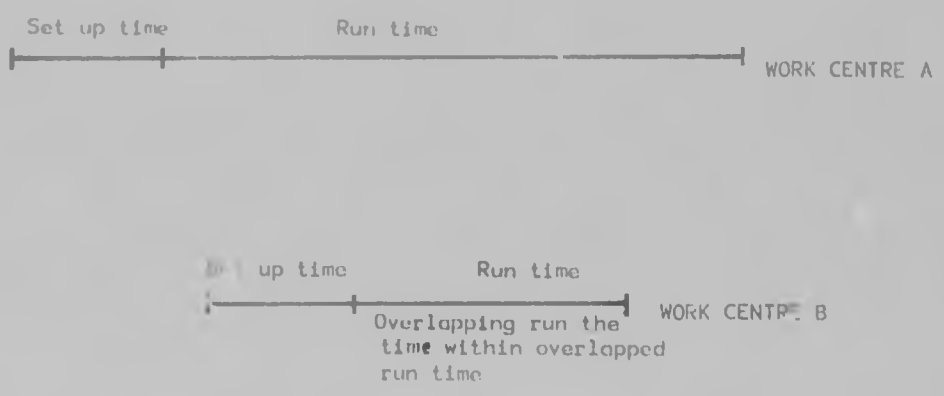


Figure 11 Forced overlap

5.5 Operation Grouping

Sometimes there is the need to group operations to take full advantage of their similarit

The reasons for grouping are economic, technical or a combination of the two.

Grouping is achieved by CAPOSS regardless of which type of grouping the user requires.

5.6 Alternate Possibilities

A scheduling system must be capable of handling alternatives. Two possibilities are allowed.

i) Substitution of an operation by an alternate operation or routing.

ii) Off-loading of operations from a work centre onto an alternate work centre with capacity available.

5.7 Overtime

Decision on applying of overtime in case of overloading situations are furnished to the programme as permanent capacity changes or via the work centre file

5.8 Statistics

The statistics information is computed from the scheduling data. All order data can be saved on a separate file and will be available to user programme.

The following three categories of statistics are maintained :-

- Statistics on times and quantities
- Statistics on costs and
- Statistics on number of operations.

5.9 Priorities and loading Procedures

As discussed on item 3.

5.10 Urgent orders and changes

The user can supply input data for new orders into the short range scheduling cycle.

In doing so he may want to make sure that the new order is available for processing immediately or to pull an order early which already exists in the long range scheduling.

Changes are accepted via shop floor feedback. They can include changes to the number of pieces of an order, new due dates, and insertion of operation in an order.

5.11 Pull early procedure

If there is a waiting time as a result of shortage of work, by means of pulling early operations are being done earlier and as a result better utilization of resources and elimination of waiting time accordingly is achieved.

5.12 Costing

Can be used for the order priority calculation. Cost factory is a function of : Materials, labour, overheads, P iosurcharges and cost method.

5.13 Materials

The programme considers materials availability on scheduling the operations and highlights delays due to the non-availability of materials to be prepared/procured from outside.

6. INPUT

6.1 User input

Order data furnished to the programme can be given by card, tape or disk.

At present, in AECI order data is given by cards.

The input is mostly derived from two sources :-

i) Production control which specifies order quantities and required dates according to customer orders or forecast requirements.

ii) Engineering control (Estimating) which maintains manufacture routing information.

Either or both of these areas are prepared as input on a ROUT CARD (ROUT CARD input See Appendix 3)

6.2 Main content of ROUT CARD

The data derived from the rout card is being punched into 4 main types of cards.

CARD	DATA		Originated by
	Use as it originated	Inserted by planning	
CW-52 ORDER CARD	Identification data Area code, order no, Caposs no, item code, description, initials and quantity	Due date, early begin date Caposs priority	Plants, other customers
CW-52 OPERATION CARD	Identification data Operation no, work centre, group code, description, quantity standard time, inspection, PL Men, Assistant	Delay before operation, alternate work centre	Estimating section
CW-42 MATERIALS REQUIRED	Identification data (DUP) Operation no, work centre no, stores code no, description status, quantity stores location	-	Estimating section
	If outside order	Purchase requisition no, delivery date, quantity, cost centre	Planning section
CW-72 OPERATION CONNECTION	Identification data (DUP) Operation no, primary area, primary work order no, primary Caposs no, primary operation no.	-	Estimating section

The input data of the rout card is being used to produce the following records :-

- Project record
- Group record
- Order record
- Material record
- Operation record
- Alternate operation record and
- Connection record.

Where the supplied data is not available, estimated values are used. By making use of these values a rapid implementation of the programme can be achieved and a complete schedule can be produced even though some values may not be known accurately.

6.3 Specification of work centres

The description of work centres is given in fixed format cards and stored on disk. The information required can be grouped into four types as follows :-

i) Constant data for the work centre such as factors for computing inter-operation times, substitute times, cost, etc.

ii) Alternate work centres for main work centre.

iii) Details of single machines/men within the work centre; individed capacities, capacity changes and belonging to a sub-group within the work centre.

CAPOSS provides for the allocation of an operation to a particular single machine or sub-group. Thus, a work centre can be divided into a work centre sub-group, but this is not being used by Central Workshops.

6.4 Parameters

Parameters are stored more than once with different values. This allows the user to decide which variation of the parameters is required for a specific execution without having to refurnish the parameters that have changed since the last execution. An example would be a request for a full schedule report on a monthly basis but a report on exceptional items once a week.

7. SYSTEM OUT-PUT

The output of the scheduling system can be divided into two groups as follows :-

i) Printed output, which includes all planning and scheduling reports for direct use by the departments involved.

ii) Output files, some of which contain intermediate information or are part of the complete scheduling cycle and are permanent.

7.1 Printed Output

The printing of output data follows the same pattern as that for input. Data required for printing is set up in the fixed format output area.

All output reports can be written to the printer or on tape or disk where they are available for further processing. Appendix no. 4 is a file consisting of all possible printed output. In the following items detailed explanation on content is given only for the daily operation worker list report, capacity requirement report and the order file report as they represent all the data of the outputs.

7.1.1 Daily operation work list

Example of the report is shown in figure 12. The report is daily and consists of 3 parts :-

i) Work centre data

Period number	: consecutive days
Starting date	: The date referred to the period
Available capacity	: The net hours available at the stated period
Planned time	: As above (not used)
Set up times	: Where applicable
% Set up times	: To be reduced from the available capacity
Idle hours	: As a result of not having work available
% Idle hours	: Only for indication
Load chart	: Derived from the above values
W/C efficiency	: Average efficiency at the W/C
Capacity status	: FINITE/INFINITE
Shift length	: Number of working hours per shift
Operation grouping	: (Not used)
Schedule type	: Early start date/Latest start date
Balanced capacity key	: Leveling by scheduling
Maximum idle time	: Gaps in scheduling
Statistics	: Average waiting time of job in the W/C to be loaded under 4 groups of order priority.

ii) Operations list data

Urgent type	: Orders external priority
Area code Order number CAPOSS number	: Identification numbers
Operation number	: As per routing
Group	: Of operations
Description	: Of the operation
Quantity	: As required
Bin number	: The location of material for the operation in the binning room
Delay hours	: Delay before operation as stated on the rout card
Times scheduled	: The number of time operation appeared on the top of the list and has not been done for some reasons
Req/Load	: Automatic loading (Priority 9)
Stores purchase no	: Outside order
CSD	: Calculated starting date
Assistant	: Assistance from other work centre
From Work centre	: Previous work centre from where the job should come
From CFD	: The current finish date at the previous work centre
Inspection	: If required after completing the operation
To Work centre	: The next work centre to which the job should be moved
To CSD	: The current starting date of the next work centre
PLND Men	: Number of men required for the operation at the present work centre
Standard time	: The time required to complete the operation
Priority	: Order Priority/Operation Priority

iii) Work centre queue : Data

Operation waiting in the queue for the next 2 days. The format data is of the same structure as of ii).

Figure 12 Daily operation work list report

7.1.2 Capacity Requirement - Planning Report

The report is weekly and gives the long term loading situation for every work centre as stated before it is used by high level management.

The total period range can be pre-determined and divided into a number of sub-periods with various lengths. An example of the report is shown in figure 13.

The following data is given in this report :-

Period	: Sub-period number
Starting date	: Of the Sub-period
Available hours	: The available hours in the sub-period
ESD hours	: Production hours required for operation if scheduling is based on earliest starting date
LDS hours	: Production hours required for operation is scheduling is based on latest starting date
ALT hours	: Latest start date load in hours offloaded to or from this work centre when considering alternate work centre
LSD load	: Load graph based on latest start date with indication from 0% of loading to 200%
Surplus hours Extra	: Surplus hours in the sub-period to be utilized if working only on 100% on overload situations
Normal	: Waiting time as a result of unavailability of work
Unavoid overload	: Overload hours in the subperiods if all due dates are to be met (graph)
Period hours	: Overload hours in the subperiod assuming present capacity limits
Cumulative hours	: Cumulative overload hours assuming present capacity limits
Sequential overload	: Not used.

IBM CAPACITY PLANNING AND OPERATION SEQUENCING SYSTEM VERSION 01 MOD 04, 55-2 KEY DATE 1083 21-04-81 PAGE 23

CAPACITY REQUIREMENTS PLANNING REPORT FOR WORK CENTER 504 H/C DRILL MACH

NUMBER OF SINGLE MACHINES 1 ALTERNATE WC NO'S SEC LOAD TYPE NO LOAD

PER	START DATE	PER LEN	AVAIL HRS	---LSD LOAD % 0 100 200 ESD HRS	LSD HRS	ALT HRS	SURPLUS NORM HRS	SURPLUS EXTR HRS	SURPLUS CAP % 0 50 100	UNAVOID PER HRS	UNAVOID CUM HRS	OVERLOAD % 0 50 100	*SEC LOAD* ESD HRS	*SEC LOAD* LSD HRS
				(*) (+)	(+)		(*)	(+)		(*)	(+)			
1	1083	5	60	278	258					198	198	R	0	0
2	1088	5	60	59	67					7	205		0	0
3	1093	5	60	2	13			43			154		0	0
4	1098	5	60	0	5			55			100		0	0
5	1103	10	120	0	3		17	120					0	0
6	1113	10	120	0	0		120	120					0	0
7	1123	10	120	0	0		120	120					0	0
8	1133	10	120	0	0		120	120					0	0
9	1143	10	120	0	0		120	120					0	0
10	1153	10	120	0	0		120	120					0	0
TOTALS		80		344			617			205			0	
			960		342			818						0

CAPACITY REQUIREMENTS PLANNING REPORT FOR WORK CENTER 506 GRIND CYLIND 1

NUMBER OF SINGLE MACHINES 3 ALTERNATE WC NO'S SEC LOAD TYPE NO LOAD

PER	START DATE	PER LEN	AVAIL HRS	---LSD LOAD % 0 100 200 ESD HRS	LSD HRS	ALT HRS	SURPLUS NORM HRS	SURPLUS EXTR HRS	SURPLUS CAP % 0 50 100	UNAVOID PER HRS	UNAVOID CUM HRS	OVERLOAD % 0 50 100	*SEC LOAD* ESD HRS	*SEC LOAD* LSD HRS
				(*) (+)	(+)		(*)	(+)		(*)	(+)			
1	1083	5	150	389	222					72	72		0	0
2	1088	5	150	257	111						33		0	0
3	1093	5	150	194	65								0	0
4	1098	5	150	193	43								0	0
5	1103	10	300	265	142								0	0
6	1113	10	300	0	6								0	0
7	1123	10	300	0	2		202	274					0	0
8	1133	10	300	0	36		300	300					0	0
9	1143	10	300	38	138		263	263					0	0
10	1153	10	300	0	100		300	300					0	0
TOTALS		80		1336			1065			72			0	
			2400		865			1137						0

Figure 13 Capacity requirement - planning report

7.1.3 Order File ("Bible")

This is a detailed working report which includes all the orders in the system and is given once a week.

As the system uses the same order file layout through all stages of the programme on common phase can print the order information at any stage in the programme.

The report could be summarised for different point selection such as for work centre, project or period. An example of the report is shown in figure 14.

The report gives the following data :

Area	As on the Daily operations work list
Order number	
Caposs number	
Operation number	
Group code	
Description	
Registration date	The date the order was registered in planning (before) punching
Early begin date	As stated on the input
Due date	The requested delivery date by customer
FCF date	First calculated delivery date by the programme
CSD*	Current starting date (by the vertical loader)
CFD*	Current finish date (by the vertical loader)
Quantity	As required
Work centre	To which operation should be done
Standard hours	Standard hours to do the operation
Delay hours	Hours in which operation shall be delayed
Assistant	Assistant from other work centre
Originator	The initials of the order originator in the plant.
Complete { Operation	Number of operation completed already
Complete { Hour	Number of hours completed already
Late - *	Indicates the operation is late
Urgent type	Job which shall appear on the top of the list
Priority	The external order priority

* - Changes every run to give higher priority job incoming to the system.

IBM CAPACITY PLANNING AND OPERATION SEQUENCING SYSTEM-EXTENDED RELEASE 1.3 P7-2 KEY DATE 1223 17.11.81 PAGE 0001

MODERNFACTORY CENTRAL WORKSHOPS

P7-2 BRANCH OF ORDERS SCHEDULED

A/R/F/A NUMBER	WORK ORDER NUMBER	WORKSHOP	OP NO	S/C/L/P	DESCRIPTION	REQD DATE	FD DATE	DUE DATE	PCF DATE	CSE	CRC	QTY	COMPLETED DPS/HOURS STD W/C	COMPLETED DPS/HOURS DELAY HOURS	L/A/Y	U/R/G	P/R/I/S/T	CHG INT
					P STORES / DEL M PURCHASE S REQ.NO.				DATE									
03 A03089	0816259C0				MAKE SWEEPER PLATES FOR FILLING PRESSN01		31		0068 0070	1223	1228	10	7	22.2	*	P	5	
		7777			FINAL INSPECTION					1223	1223	10	198	0.1		0		
		8888			PLANT ACCEPT JOB					1225	1225	10	P98	0.1		0		
		9999			PLANNING CLOSE JOB					1227	1227	10	P99	.1		0		
14 C09867	0586022800				62345 BOB DU PONT CARTRIDGE PADDLE	N74	76		0122 0158	1242	2006	12	3	3.6	*	S	5	
		C010			ASS SHAFTS & PADDLES CHECK FOR THLT					1242	1242	12	518	0.1		0		
		C040			FILE & FIT KEYS TO SHAFTS TAPE KEY					1243	1251	12	531	62.5		0		
		7777			FINAL INSPECTION					2001	2001	12	198	0.1		0		
		8888			PLANT ACCEPT JOB STORE *EX*					2003	2003	12	P98	0.1		0		
		9999			PLANNING CLOSE JOB					2005	2005	12	P99	0.1		0		
10 81720*	0586022801				62345 BOB DU PONT PADDLE		1172		1175 1176	1223	1234	9	5	11.2	*	X	5	
		C020			62345 BOB DU PONT PADDLE					1223	1232	9	198	2.0		0		
10 81720*	3058022801	C035			CONNECTED TOT													
14 C09867	0586022801	0135																
14 C09867	0586022801				62345 BOB DU PONT CARTRIDGING PADDLE	N73	76		0122 0141	1223	1240	12	15	294.2	*	S	5	
		0120			QUALITY CONTROL TO X-RAY					1223	1223	12	198	0.1		0		
		0130			FINAL MACHINE TO ORGETC SHIFT SHAFT					1225	1238	12	518	42.7		0		
		7777			FINAL INSPECTION					1238	1239	12	198	0.1		0		
14 C09867	0586022801	7777			CONNECTED TO:													
14 C09867	3066228CC	E535																
14 B08807	0070119CC				COUPLING AIRCRE RING		504 1150		1148 1174	1223	1227	1	5	14.5	*	X	5	
		C040			COUPLING CENTRE RING					1225	1223	1	504	4.2		0		
		7777			FINAL INSPECTION					1223	1223	1	198	0.1		0		
		8888			PLANT ACCEPT JOB MIDLANDS					1224	1224	1	P98	0.1		0		
		9999			PLANNING CLOSE JOB					1225	1225	1	P99	0.1		0		
14 C12894	0109438CC				62711 828 IRONWOOD SABR CUBES		115		0174 0191	1223	2091	500	3	137.9	*	S	5	JJW
		C040			BEVEL EDGES & CORNERS					1223	1239	500	CR2	416.0		0		
		7777			FINAL INSPECTION					2081	2081	500	C99	0.1		0		
		8888			PLANT ACCEPT JOB					2088	2088	500	P98	0.1		0		
		9999			PLANNING CLOSE JOB					2090	2090	500	P99	0.1		0		
14 C13687	0122368CC				62771 410 GRIPPER ASSEMBLY		N57 1126		1132 1133	1223	1228	8	2	4.9	*	Y	7	
		7777			FINAL INSPECTION					1223	1223	8	198	0.1		0		
		8888			PLANT ACCEPT JOB					1224	1224	8	P98	0.1		0		
		9999			PLANNING CLOSE JOB					1225	1225	8	P99	0.1		0		
14 C14527	0133078CC				62236 227 DOG THRUST PLATE ASSEMBLY		N40 147		0197 1034	1225	1239	40	8	16.2	*	S	5	JJW
		C010			SANDVIK				6 MD174733 1202	1223	1223	50	P18					
		C070			FIT TC INSERTS TO PLATES					1231	1234	40	531	3.0		0		
		7777			FINAL INSPECTION					1233	1233	40	198	0.1		0		
		8888			PLANT ACCEPT JOB STORE *EX*					1235	1235	40	P98	0.1		0		

Figure 14 Order file report

*CODEHPONTEIN CENTRAL WORKSHOPS

CTL2 REPORT OF ENGINE SCHEDULED

A ORDER NUMBER	WORKORD NUMBER	OP NO	G A C L R	DESCRIPTION	REQD DATE	EE DATE	DUE DATE	PCP DATE	P STORES / PURCHASE # REQ.NO.	CFL DATE	CSC	CFC	QTY	COMPLETED QRS/HOURS W/C	STD HOURS	DELAY HOURS	L A T	U R G	P R I A S	CRG INT
		9999		PLANNING CLOSE JOB							1237	1237	40	P99	0.1	0				
15 C12701 01A405360				82172 769 YOKE		A57	171		0177	1058	1223	1228	2	18	3.9	*	S	5		
	2222			FINAL INSPECTION							1223	1223	2	198	0.1	0				
	5588			PLANT ACCEPT JOB STORE C							1225	1225	2	P98	0.1	0				
	9999			PLANNING CLOSE JOB							1227	1227	2	P99	.1	0				
14 C15797 01A737802				82271 410 GRIPPER ASSEMBLY		2AD	169		0211	1370	2022	2024	6	1	0.0	*	S	7	JJW	
	CC40			ASSEMBLE GRIPPER BAR AS PER DRG							2022	2022	6	531	3.2	0				
	7777			FINAL INSPECTION							2023	2023	6	198	0.1	0				
	8888			PLANT ACCEPT JOB STORE PCP							2024	2024	6	P98	0.1	J				
	9999			PLANNING CLOSE JOB							2025	2025	6	P99	0.1	0				
14 C15797 01A737802				82271 410 GRIPPER ASSEMBLY GRIPPER BAR#28			169		0211	1057	2017	2020	6	4	14.1	*	S	5	JJW	
	CC20			GRIPPER ASSEMBLY							2017	2019	6	526	2.1	0				
	7777			FINAL INSPECTION							2019	2019	6	198	0.1	0				
14 C15797 01A737802	7777			CONNECTED TO:																
14 C15797 01A737802	CC40																			
14 C18601 01A737802				82271 410 GRIPPER ASSEMBLY		MDF	1181		1190	1195	2015	2016	6	5	0.0	*	Y	5		
	CC10			THOMAS E PILLINER				6	WC	74726	2005	2014	2014	6	P18					
	CC20			82271 410 GRIPPER ASSEMBLY								2015	2016	6	521	6.4		0		
14 C18601 01A737802	CC20			CONNECTED TO:																
14 C15797 01A737802	CC30																			
13 B02928 01521452B				10 FIS18T ASSEMBLE 24 TAMP ARDEER M/C			1048		1095	1053	1223	2001	3	8	10..3	*	X	5		
	CC25			ASSEMBLE ARDEER PACKER							1223	1248	1	M25	200.0		0			
	7777			FINAL INSPECTION							1249	1249	3	198	0.1		0			
	8888			PLANT ACCEPT JOB BY FACT 2							1251	1251	3	P98	0.1		0			
	9999			PLANNING CLOSE JOB							1253	1252	3	P99	0.1		0			
13 B02928 01521452B				10 FIS18T DRLR INDEX WHEEL A/PACKER			1181		1186	1189	1223	1224	3	3	27.9	*	X	5		
	7777			FINAL INSPECTION							1223	1223	3	198	0.1		0			
14 C17197 01B614BC0				82135 D4B DUPLEX PINION & BUSH		MEL	1099		1059	1122	1225	1241	2	1	0.0	*	S	5		
	CC20			REGOLD CROFT	2			6	WC	74350	1190	1223	1222	3	P18					
	CC30			DUPLEX PINION & BUSH								1231	1231	4	518	3.6		0		
	CC40			DUPLEX PINION & BUSH								1233	1234	2	531	0.8		0		
	7777			FINAL INSPECTION								1235	1236	2	198	0.1		0		
	8888			PLANT ACCEPT JOB								1238	1238	2	P98	0.1		0		
	9999			PLANNING CLOSE JOB								1240	1240	2	P99	0.1		0		
14 C17297 01721B060				74163 OFF BUSH "MK.D"			1187		1240	1213	2040	2053	4	0	0.0	*	X	5		
	CC10			THOMAS E PILLINER				6	WC	74760	2030	2038	2038	4	P18					
	CC20			74163 OFF BUSH "MK.D"								2042	2047	4	518	5.1		0		
	CC21			INTERMEDIATE INSPECTION								2044	2044	4	193	0.1		0		

Figure 14 Order file report

7.1.4 Summary of reports, issue frequencies and users

As stated before appendix 4 file includes all the CAMOSS reports used by central workshop.

The following table presents the list of reports included on this file, their frequency of issue and the users of them.

Frequency	No	Description	User: Management	Pl. off	RR. Sup.	Foremen	Progress	Mat. co.	Mat. prep.	Customer	Stores	Remarks
Daily	-	Master file (per request)	X		X	X						Exception report (W/C, project, customer)
	1	Daily operation work list				X	X					-
	2	Material prepartions							X			Materials to be prepared 10 days before CSD
	3	Binning					X		X			Location of material per order
	4	Material deletion audit list							X			Feedback for materials preparation
	5	Order deletion audit list		X	X							Completed orders
	6	Deliveries			X							Completed orders accepted by plant
	7	Messages		X								Errors to be rectified
	8	Input audit list		X								Total input
	9	Periods and shop calendar	X	X	X							See appendix no. 2
Weekly	10	Order file		X								-
	11	Capacity requirements	X									-
	12	Plant report	X							X		List of plant orders and CFD'S
	13	Outside orders						X				Orders from outside in process
	14	Stores requisitions							X		X	List of materials to be applied
	15	Spares delivery dates and load times			X					X	X	Input for stores inventory system
	16	Work centre loading analysis	X									Hours loaded by various customers
	17	Orders and hours remaining by plant and priority	X									-
	18	Orders and hours loaded by plant and priority	X									-
	19	Order residence time	X									For identifying old jobs
Monthly	20	Turnaround time analysis (2 reports*)	X									Jobs turnaround time per priority
	21	Work centre capacity, queue time		X	X							Statistics
	22	Cost allocation	X	X								Computer costs

* - Reports based on DUE DATES and on FCFD

7.2 Output files

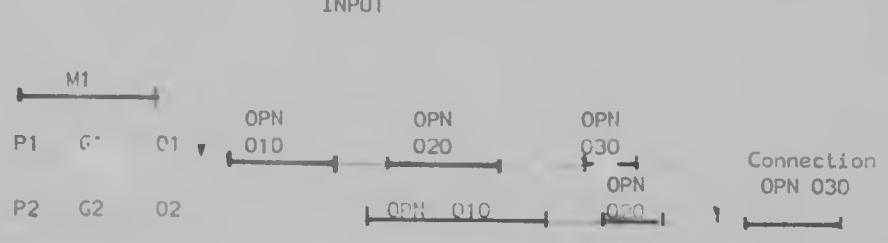
7.2.1 Run data files

The run data files : Parameter file, Work Centre file and Capacity Event file are created from fixed format parameter and work centre input. They contain all phase parameters and work centre data. The parameter file must be on line for all.

7.2.2 Order file

The order file contains all data derived from the input and maintained with additions, changes, cancellations, total cancellations, completions, total completions and partial completions. This file contains all information required for a complete description of the project.

The structure of the order file is shown in figure 15.



P1 HDR	P1G1	P101	P101 M1	P101 OPN 010
P101 OPN 020	P101 OPN 030	P101 CP 202 OPN 030	[illegible]	P2 HDR
P202	P202 OPN 010	P202 OPN 0.	P202 OPN 030	P2 TR
P3 HDR	etc.			

RECORDS IN ORDER FILE

P = PROJECT
G = GROUP
O = ORDER
M = MATERIAL
OPN = OPERATION
C = CONNECTION
HDR = HEADER
TR = TRAILER

Figure 15 Layout of order file

The project trailer record is generated internally and contains statistical information for cost (if available), times and operations.

The order file is a sequential file and can therefore be stored on disk or tape. This allows the programme to process large volume order files on a machine configuration with limited storage units.

7.2.3 Subset Order File

The Subset Order File is created from the Order file using a data range. It serves as a basis for the short range scheduling (daily) where direct access processing is essential.

7.2.4 Data file

The Data file contains all input records. As unsorted Data is added to this file it must be stored before being input to the Order file creation phase.

7.2.5 Deletion file

This file includes all completion, partial completions, order deleted because of errors and the final information from the scheduling system including shop floor feedback and are then available for statistics or other purposes.

8. TRANSACTIONS AND FEEDBACK

8.1 Transactions

The system allows the existing order-dependent files to be updated to reflect the actual situation in the scheduling environment.

The following types of transactions are accepted :-

- addition
- partial completion
- cancellation
- total cancellation
- change
- completion
- total completion.

The transactions are given either by daily coding (Examples are given in Appendix 5 - Input coding note for addition, cancellation and change), or by a daily feedback card which will be described on the next item.

8.2 Feedback

8.2.1 Operations

Daily feedback on completion of operation is given by cards produced by the system as per routing. The cards are produced by the system as new order is entering to the Data file. In the rout cards the last 3 operations are always :-

Operation		Description
7777	-	Final inspection
8888	-	Plant accepted job
9999	-	Planning close job

Once operation 9999 is fed back, the system will close the job totally.

8.2.2 Actual Quantity completed

There is the option to use it, but as a result of practical reasons except where a scrap job is involved there is no need to work with it.

8.2.3 Actual time

The system can use actual time in order to give additional reports such as for bonus scheme, etc, but at present it is not used and the programme assumes planned time values when updating statistics of time completed.

However, where an actual quantity differs from the planned quantity the planned time will be adjusted.

8.2.4 Operation out of Sequence

Whenever operation is reported completed although the previous operations has not completed, the user can specify whether or not those previous operations are to be automatically considered as completed.

In Central Workshop's case we prefer operation to be completed one following the other for better control, but if we feedback operation 7777 - final inspection all previous operations are considered completed.

8.2.5 Partial completion

The founders of the programme found that it is impractical to report frequent partial completions for very long operations, thus, there are few possibilities to feed partial completion such as predetermined rate of production, zero quantities, etc. However, we found that partial completion is essential and does not require a large amount of daily coding, so we implemented it.

8.2.6 Capacity changes

Changes in capacity for a single machine, work centre and for the complete shop can be reported.

Obviously it is not recommended to do it frequently.

9. PROCESSING DESCRIPTION

- A copy of I.B.M.'s Manual (GH125105-1) - Processing Description is given in Appendix No. 6.

- A copy of I.B.M.'s Manual (GH125105-1) - Programming Systems is given in Appendix No. 7.

APPENDICES

1. Description of Data
2. Workshops CAPOSS Calendar
3. Rout Card Input
4. Printed Output
5. a. Input coding note for addition

   b. Input coding note for cancellation and change
6. Processing Description
7. Programming System

APPENDIX 1

CW 32

ENGINEERING WORK ORDER

CENTRAL WORKSHOPS JOB CARD

AREA | WORK ORDER No | CAPOSS NUMBER | PLANT ITEM CODE | COMMODITY OR DRAWING No

JOB TITLE | Originator's Initials

Originator		Phone
Plant Section		Date Originated
Early Begin Date	Date required	Clearance reqd ?

Work Requested

DATA ON THIS PART GIVEN

BY CUSTOMER

PRIORITY

Production loss	☐	Red safety hazard	☐
Imminent red safety	☐	Planned shut-down	☐
Small job	☐	Imminent production loss	☐
		Planned	☐

Reason for priority

Priority Authorisation

*CIRCLE WHICHEVER APPLICABLE

QUOTE (R)

Quote required* YES NO Signature

Quote accepted* YES NO Signature

FOR WORKSHOP USE ONLY

CW 82

5 21 as above

Material		28
Labour		35
Overheads		42
Prio surcharge		49
TOTAL		56
Cost Method*	1 2 3 4 5	57

PRIO RITY | U | EARLY BEGIN Y D D D | DUE DATE Y D D D | FWD SCH | QUANTITY

DATA GIVEN BY PLANNING

CW 52 | 5 21 as above | OPERATION DETAILS | CARD PAGE OF | OF

O.P. No.	W.C. No.	G P C D	BIN No	DESCRIPTION	SPEC. BY / DATE	QTY.	STD. TIME	ENG	P L Man	Alt W.C.	Alt Set	Oper Brdn Cd	ESTIMATE NUMBER	INSP INT.

DATA GIVEN BY ESTIMATING

7777			FINAL INSPECTION
8888	P98		PLANT ACCEPT JOB
9999	P99		PLANNING CLOSE JOB

AICIM ENG L223e 7867

CHECK NUMBER OF EMPLOYEE WHO IS TO DO THE JOB:

MATERIAL REQUIREMENTS

CW 42 | AREA | WORK ORDER No | CAPOSS NUMBER

O P No	W C No	BRISCH CODE	DESCRIPTION	STATUS	STORES PURCHASE REQ No	DEL DATE	QTY	COST CENTRE	ALLOC	ISS
			DATA GIVEN BY ESTIMATING							

OPERATION CONNECTIONS

CARD CODE	AREA	WORK ORDER No	CAPOSS NUMBER	O P No	Primary Area	PRIMARY WORK ORDER No	PRIMARY CAPOSS NUMBER	PRIMARY O P No
CW72								
CW72								
CW72								

QUALITY RECORD

QUALITY CONTROL ENGINEERING

OP	WC	M/C	OPER	FIRST OFF INSPECTION				PATROL INSPECTION							QTY MOVEMENT		
				ACC	REJ	SIGN	DATE	PERIOD	1st	2nd	3rd	4th	5th	6th	ORDER	PASSED	SIGND
				DATA GIVEN BY INSPECTION													

REJECTION INFORMATION

OP No	TIME	DATE	CAUSE OF REJECTION	CORRECTIVE ACTION	NUMBER REJECTS	REJECTION REWORK	REWORK INSPECTION		
							ACC	REJ	SIGND

AECI/M ENG/L223b 7807

"First off MUST be approved by Quality Control before starting production."

APPENDIX 2

CENTRAL WORKSHOPS SHOP CALENDAR

CAPOSS SHOP CALENDAR 1981

DAY	JAN		FEB		MARCH		APRIL		MAY		JUNE		JULY		AUG		SEPT		OCT		NOV		DEC	
	DATE		DATE	SHOP DAY	DATE	SHOP DAY	DATE	SHOP DAY	DATE	SHOP DAY	DATE	SHOP DAY	DATE	SHOP DAY	DATE	SHOP DAY	DATE	SHOP DAY	DATE	SHOP DAY		SHOP DAY	DATE	SHOP DAY
M			2	1022	2	1042					1	PH			3	1148					2	1212		
T			3	23	3	43					2	1104			4	149	1	1169			3	213	1	1233
W			4	24	4	44	1	1064			3	105	1	1125	5	150	2	170			4	214	2	234
T	1	PH	5	25	5	45	2	65			4	106	2	126	6	151	3	171	1	1190	5	215	3	235
F	2	1001	6	26	6	46	3	66	1	1084	5	107	3	127	7	152	4	172	2	191	6	216	4	236
M	5	1002	9	1027	9	1047	6	1067	4	1085	8	1108	6	1128	10	1153	7	PH	5	1192	9	1217	7	1237
T	6	03	10	28	10	48	7	68	5	86	9	109	7	129	11	154	8	1173	6	193	10	218	8	238
W	7	04	11	29	11	49	8	69	6	87	10	110	8	130	12	155	9	174	7	194	11	219	9	239
T	8	05	12	30	12	50	9	70	7	88	11	111	9	131	13	156	10	175	8	195	12	220	10	240
F	9	06	13	31	13	51	10	71	8	89	12	112	10	132	14	157	11	176	9	196	13	221	11	241
M	12	1007	16	1032	16	1052	13	1072	11	1090	15	1113	13	1133	17	1158	14	1177	12	1197	16	1222	14	1242
T	13	08	17	33	17	53	14	73	12	91	16	114	14	134	18	159	15	178	13	198	17	223	15	243
W	14	09	18	34	18	54	15	74	13	92	17	115	15	135	19	160	16	179	14	199	18	224	16	PH
T	15	10	19	35	19	55	16	75	14	93	18	116	16	136	20	161	17	180	15	200	19	225	17	244
F	16	11	20	36	20	56	17	PH	15	94	19	117	17	137	21	162	18	181	16	201	20	226	18	245
M	19	1012	23	1037	23	1057	20	PH	18	1095	22	1118	20	1138	24	1163	21	1182	19	1202	23	1227	21	1246
T	20	13	24	38	24	58	21	1076	19	96	23	119	21	139	25	164	22	183	20	203	24	228	22	247
W	21	14	25	39	25	59	22	77	20	97	24	120	22	140	26	165	23	184	21	204	25	229	23	248
T	22	15	26	40	26	60	23	78	21	98	25	121	23	141	27	166	24	185	22	205	26	230	24	249
F	23	16	27	41	27	61	24	79	22	99	26	122	24	142	28	167	25	186	23	206	27	231	25	PH
M	26	1017			30	1062	27	1080	25	1100	29	1123	27	1143	31	1168	28	1187	26	1207	30	1232	28	1250
T	27	18			31	63	28	81	26	101	30	124	28	144			29	188	27	208			29	251
W	28	19					29	82	27	102			29	145			30	189	28	209			30	252
T	29	20					30	83	28	PH			30	146					29	210			31	253
F	30	21							29	103			31	147					30	211				

AECI/M ENG'L 84 8067

CAPOSS SHOP CALENDAR 1982

DAY	JAN		FEB		MARCH		APRIL		MAY		JUNE		JULY		AUG		SEPT		OCT		NOV		DEC	
	DATE		DATE	SHOP DAY	DATE	SHOP DAY	DATE	SHOP DAY	DATE	SHOP DAY	DATE	SHOP DAY	DATE	SHOP DAY	DATE	SHOP DAY	DATE	SHOP DAY	DATE	SHOP DAY	DATE	SHOP DAY	DATE	SHOP DAY
M																								
T																								
W																								
T																								
F																								
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M																								
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W																								
T																								
F																								

APPENDIX 3a

CW 32 — EI … IRK ORDER — SINGER & CAI

Forward … ordinator immediately — MDF – NITROGEN — ARD

AREA 02 — Work Order H6364A — Caposs No. 123,4K,5P1 — Drawing No 03-22369/1&3

WORK REQUESTED TITLE: FIT MODIFIED ADAPTOR SHAFT TO MAKE UP

Originator's Initials: GR

Originator: G RICHTER — Phone: 3 — Plant Section: MAINT 4 — Date Originated: 27 11 — Early Begin Date: 27 11 80 — Date Required: 30-11-80 — Critical Path: YES

Work Requested:

FIT MODIFIED ADAPTOR SHAFT AS PER DRAWING

REMARKS: P & REPAIR AS PER ATTACHED DRAWINGS DWG. NOS 03-22369 1 — 7 EXCEPT 3

CAPOSS PRIORITY (Tick one box)

IMMEDIATE ACTION	Y	X
S.F.'s Signature		
URGENT REQUIREMENT		
PLANNED SHUTDOWN	D	
NORMAL WORK	P	

*CIRCLE WHICHEVER APPLICABLE — QUOTE (R)

Quote required* YES NO Signature

Quote accepted* YES NO Signature

FOR WORKSHOP USE ONLY

CW 82 — 521 as above

Material		28
Labour		35
Overheads		42
Prio surcharge		49
TOTAL		56
Cost Method*	1 2 3 4 5	57

PRIORITY	U	EARLY BEGIN Y D D D	DUE DAT Y D D D	FWD SCH	QUANTITY
7	Y		1 2 3 2		2

CW 52 — 521 as above — OPERATION DETAILS — CARD 1 OF 5 — PAGE OF

OP No.	WC No	GP CD	BIN No.	DESCRIPTION	SPEC BY JOR DATE	QTY	STD TIME	ESTIMATE NUMBER	IN IN
0100	P02			CUT 12.5" M.S. PKT 2.00 DIA		1			
				CUT 2.50" M.S. PKT 2.50 DIA		1			
0200	P02			M/C BEARING CAP AS PER DRG PT 1		1	16	03552	
0300	P01			M/C SINGER SEAL TO DRG PT 5		1	13	07405	
0400	P01			MARK & DRILL BEARING CAP TO DRG PT 1		1	06	24995	
7777	P98			FINAL INSPECTION METRIC		2	01		
8888	P98			PLANT ACCEPT JOB					
9999	P99			PLANNING CLOSE JOB					

AECI M ENG L221a '81

CHECK NUMBER OF EMPLOYEE WHO IS TO DO THE JOB:

MATERIAL REQUIREMENTS

CW 42 | AREA | WORK ORDER No | CAPOSS NUMBER

O.P. No	W.C. No	BRISCH CODE	DESCRIPTION	STATUS	STORES PURCHASE REQ. No	DEL. DATE	QTY.	COST CENTRE		
010		125415	3PK S/S PLT 120x120	JS			1			
020		125417	3PK S/S PLT 230x230	JS			1			

OPERATION CONNECTIONS

CARD CODE	AREA	WORK ORDER No	CAPOSS NUMBER	O.P. No	SUB	PRIMARY WORK ORDER No	PRIMARY CAPOSS NUMBER	PRIMARY O.P. No
CW72	02	163414	125	2222	01	163402		0060
CW72								
CW72								

QUALITY RECORD

QUALITY CONTROL ENGINEERING

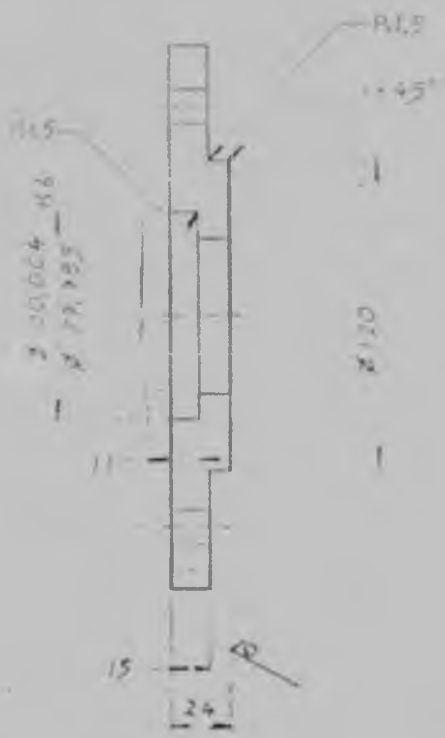
OP	WC	M/C	OPER	FIRST OFF INSPECTION				PATROL INSPECTION						QTY MOVEMENT		
				ACC	REJ	SIGN	DATE	PERIOD	1st	2nd	3rd	4th	5th	6th	ORDER	PASSED	SIG

REJECTION INFORMATION

OP No	TIME	DATE	CAUSE OF REJECTION	CORRECTIVE ACTION	NUMBER REJECTS	REJECTION REWORK	REWORK INSPECTIO		
							ACC	REJ	SIG

AECI M ENG. L223b

"First off MUST be approved by Quality Control before starting production"



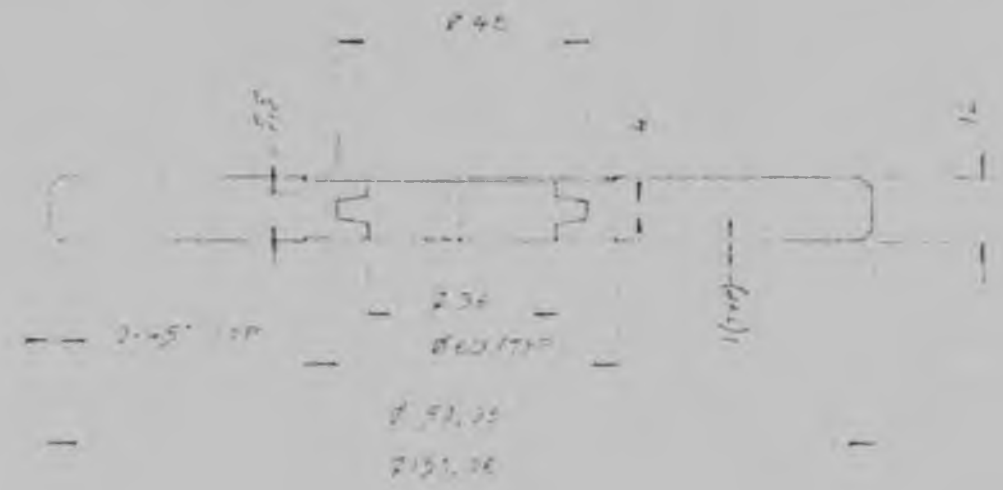
Nº OFF 2
MAT'L BS 1449 GR 304
(12541 591)
NOTE 32/ UNLESS SHOWN

NEXT ASSY.

A/o 1231050

AECI Limited MODDERFONTEIN FACTORY	3-2236 B	APPROX.					
PROPERTY AND COPYRIGHT OF AECI MAY NOT BE USED OR COPIED IN ANY WAY EXCEPT WITH EXPRESS PERMISSION OF AECI	REFERENCE DRAWINGS	REV. SIGN. DATE. REVISIONS	DRWN	CD	SCALE	DEPT. NITROGEN & NºG AMMONIUM NITRATE SECTION TITLE VOI SOLUTION TANK BEARING - CAP -	REFERENCE NUMBER 03-2223/19/1
					A3		REV.

2



MAT'L BS 1449 GR 304
1.4301 - 1.4307

3/8" ALL OVER

1 OFF SKF FELT SEAL
N° F1 190

MARK 1 OFF

No 12310601

AECI	AECI Limited MODIFICATION FACTORY	SHEET			DRAWN	SCALE	DEPT NITROGEN	REFERENCE NUMBER
	PROPERTY AND COPYRIGHT OF AECI MAY NOT BE USED OR COPIED IN ANY WAY EXCEPT WITH EXPRESS PERMISSION OF AECI	REFERENCE DRAWINGS	REVISION / DATE / REMARKS		CHKD	FIRST	SECTION N°6 AMMONIUM NITRATE	03-
					SUPD	SECT	TITLE	
				CD		PAGE(S) A3		REV

Form M 219.

APPENDIX 3b

CW 32

ENGINEERING WORK ORDER

CENTRAL WORKSHOPS JOB CARD

AREA | WORK ORDER No | CAPOSS NUMBER | PLANT ITEM CODE

COMMODITY OR DRAWING No: 2-B 1457/10

JOB TITLE: 62241-011 P.E.T.N. PRIMING

M/C

Originator's Initials

Originator		Phone
Plant Section		Date Originated
Early Begin Date	Date required	Clearance reqd

Work Requested: POWDER CONTAINER HOLDER

PRIORITY

Production loss		Red safety hazard	
Imminent red safety		Planned shut-down	
Small job		Imminent production loss	
		Planned	

Reason for priority

Priority Authorisation

*CIRCLE WHICHEVER APPLICABLE — QUOTE (R)

Quote required* YES NO Signature

Quote accepted* YES NO Signature

PRIO RITY | U | EARLY BEGIN Y D D D | DUE DATE Y D D D | FWD SCH | QUANTITY

CW 82 — 5-21 as above

FOR WORKSHOP USE ONLY

Material		28
Labour		35
Overheads		42
P ..urcharge		49
TOTAL		56
Cost Method*	1 2 3 4 5	57

CW 52 — 5-21 as above — OPERATION DETAILS — CARD PAGE OF 3 OF 74

OP. No.	WC No.	GP CD	BIN No.	DESCRIPTION	SPEC. BY / DATE	QTY.	STD. TIME	Insp	P.L. Man	Air W/C	Assist	Delay Before OP	ESTIMATE NUMBER
	ϕϕ1			CUT 16mm DIA EN58E x 57ϕ LONG		1	ϕ.2						
ϕ2ϕ	S18			M/C RODS TO DRG & POLISH 2 OFF EACH.		4	1.4	I					32194
ϕ4ϕ	S21			MARK & CUT PLATE TO DRG.		1	ϕ.6	I					18912 18912/1
ϕ5ϕ	S26			FILE & DRESS PLATE TO DRG. MARK & DRILL SET PLATE & RODS FOR WELDING.		1	1.7	I					18912/2 18912/3
ϕ6ϕ	ϕ1			WELD PLATE & RODS TO DRG.		1	ϕ.4	I					13000/1
ϕ7ϕ	S26			CONSTRUCT HOLDER AS PER DRG. LEVEL PLATE, DRESS WELD, FILE RADII POLISH COMPLETE. MARK, DRILL & C'S'K VERTICAL PLATE.		1	4.3						18915
7777	I98			FINAL INSPECTION		1	1						
~~5555~~	~~P55~~			~~PLANT ACCEPT JOB~~ RETAIN FOR ASS.									
~~9999~~	~~P99~~			~~PLANNING CLOSE JOB~~									

AECI/M/ENG/L223a

CHECK NUMBER OF EMPLOYEE WHO IS TO DO THE JOB:

MATERIAL REQUIREMENTS

CW 42 | AREA | WORK ORDER No. | CAPOSS NUMBER

O.P. No.	W.C. No.	BRISCH CODE	DESCRIPTION	STATUS	STORES/ PURCHASE REQ. No.	DEL. DATE	QTY.	COST CENTRE	Alloc. No.	Line No.
10	02	1234206	16/16mm Dia x 6mm L	D			1			
20	02	1254	16/13mm TH x 130 x 250	D			1			

OPERATION CONNECTIONS

CARD CODE	AREA	WORK ORDER No	CAPOSS NUMBER	O.P. No.	PRIMARY AREA	PRIMARY WORK ORDER No.	PRIMARY CAPOSS NUMBER	PRIMARY O.P. No
CW72								
CW72								
CW72								

QUALITY RECORD

QUALITY CONTROL ENGINEERING

OP	WC	M/C	OPER	FIRST OFF INSPECTION				PATROL INSPECTION							QTY. MOVEMENT		
				ACC	REJ	SIGN	DATE	PERIOD	1st	2nd	3rd	4th	5th	6th	ORDER	PASSED	S.C

REJECTION INFORMATION

OP No.	TIME	DATE	CAUSE OF REJECTION	CORRECTIVE ACTION	NUMBER REJECTS	REJECTION REWORK	REWORK INSPECTIC		
							ACC.	REJ.	SIG

AEC I/M/ENG/L223b

"First off MUST be approved by Quality Control before starting production."

APPENDIX 4

CAPOSS REPORTS

Frequency	No.	Description
Daily	4.1	Daily operation work list
	4.2	Materials preparation
	4.3	Binning
	4.4	Material deletion audit list
	4.5	Order deletion audit list
	4.6	Deliveries
	4.7	Messages
	4.8	Input audit list
	4.9	Periods and shop calendar
Weekly	4.10	Order file
	4.11	Capacity requirements
	4.12	Plant report
	4.13	Outside orders
	4.14	Stores requisitions
	4.15	Spares delivery dates and lead time
	4.16	Work centre loading analysis
	4.17	Orders and hours remaining by plant and priorities
	4.18	Orders and hours loaded by plant and priorities
	4.19	Order residence time
Monthly	4.20	Turnaround time analysis
	4.21	Work centre capacity, queue time
	4.22	Cost allocation

WORKSTATION DATA -- WORKSTATION NUMBER 2240 GROUP 0060 SOG CHIND CYLIND 1 NO. OF SHFS 3 PER LEN 1

IND NO	START DATE	AVAIL CAP HRS 100.0%	UTIL PERC HRS	UTIL TIME HRS PERC	IDLE TIME HRS PERC	0 20 40 60 80 100 PERC
1	1083	40.0	32.0 80	0.0 0	0.0 0	
2	1084	40.0	32.0 80	0.0 0	0.0 0	
3	1085	40.0	32.0 80	0.0 0	0.0 0	
TOTAL		40.0	40.0 100	0.0 0	0.0 0	

W/C EFF.%	CAPACITY STATUS	SHIFT LENGTH	-OPERATOR ASSIGNING- PRIMARY / ESD RANGE	SCHEDULE TYPE	BALANCED CAP. KEY	MAXIMUM IDLE TIME	-STATISTICAL QUEUE TIME FOR PRIORITY GROUPS- 0-3	4-8	9-12	13-17
100	PEN	10.0		ESD	BAL	.0	21.0	10.4	8.4	4.5

U/M	WORK ORDER NUMBER	OP NO.	G/M	CRITICAL RATIO	BIN NO.	DEL DAYS	TS IC / MR EE	OPERATIONS / QUEUE	A/S	FROM W/C	CSD	TO W/C	CSD	PLN/SID	PRICH TIME	QM/OP
EA	01342300	0060		EATH MANDREL	5	N62	0 10			083			S10 084	1	16.0	16/56
S MS	0C4015H00	0050		ORK THAT SHAFT TO DWG	4	N50	0 08			083			198 085	1	2.4	10/50
S IA	01910T	01540300	0060	SPINDLE TO DWG	66	N55	0 05			083			198 085	1	3.1	7/47
A 03	014184	10475850	0080	ORK STELLAR PUNCHES	100	N04	0 02 L			083			S10 085	1	5.0	7/47
S IA	0254RT	10425A00	0050	ARK ROLLERS	2	N12	0 03			083			198 085	1	0.4	6/46
X	341312	10541A00	0010	CLH INITIATION SOU SYSTEM	1		0 04			083			193 080	1	1.4	6/46
S IA	0236RT	10139800	0040	NDRELS FOR 1" G-LIGNITE SHELLS	12	NEL	0 07 L			083			S10 085	1	0.1	5/45
S IA	0246RT	10167400	0030	INAL PUNCH WIRD	46	N51	0 04			083			S10 085	1	7.4	5/45
A 03	N3201A	10610300	0040	DUCT - SUPPLY & CRF WORM WHEEL SHAF	4	IF6	0 03			083			198 085	1	4.4	5/45
S IA	0250ST	10407800	0050	SHELL MACHINED FOR 1.375" PUNCHES	6	NE2	0 07 L			084			S10 086	1	14.6	4/44
S IA	0384RT	42535A00	0110	ATIVE DRIVE WORM	1	N57	0			084	S18 083		196 085	1	1.4	19/89
S IA	0251RT	10644800	0060	GRIND BESH (WORM) TO DWG	30	N38	C			084	S02 083		206 085	1	6.7	6/46
V IA	01014T	00742800	0110	INTRODUCE ACMES	2	N31	C	A		084	S18 082			1	1.9	19/89
F IA	0245RT	10458500	0010	FINISH HOOK SCREWED FORM DIA	20	N56	0	L		084	S16 083		S21 085	1	2.0	6/46
S IA	0241ST	10419500	0100	TOR DRIVE SHAFT	2	NEL	0	L		084	S21 083		S31	1	2.3	4/44
S IA	0255RT	10503A00	0040	ROLL SPINDLE	1		0	L		084			194 087	1	1.2	3/43
V IA	01234M	01523A00	0040	CATE WORK HOLDER	6		0	A		085			194 086	1	4.9	17/57
S IA	0170ST	01451800	0110	Index Knobs As P.N. 1R0	12	N54	0			085	S26 085		S31 086	1	0.0	8/48
E IA	0233RT	1005 3500	0020	SHING BLANK FROM1 TO DWG	50	N36	C			085	S06 084		193 090	1	35.4	6/46
S IA	0247RT	10400 50	0060	SHAFT	5	SD1	0	L		085			198 087	1	1.9	3/43
S IA	0261RT	10520A00	0240	HARDING REQUIREMENTS	4	NEF	C 01 L			085			S21 086	1	1.9	3/43
S IA	0260ST	1030 3400	0030	SHELL MACHINE FOR MCS DIE	1	N62	0	L		085			S10 088	1	10.6	2/42
S IA	0261ST	10413A00	0060	CAM 2 SPECIFICATIONS	1	N21	0 02			085			P14 087	1	0.5	2/42

WORKSTATION 03A WORK CENTER 03A

IA	0 [illegible]	0		[illegible]	1	N3A	1			085	P14 084	144 085	1	1.0	0/56
V IA	[illegible]	0		[illegible]	10		0	W		086	P14 085	14- 0--	1	0.0	1220V

WORKSTATION LOAD GRAPH - STATISTICAL ANALYSIS/ZOOM QUEUE 511 GRIND SURF 1 NO. OF SHFS 1 PER LEN 1

PER NO	START DATE	AVAIL CAP HRS (110.0)	%	TIME FREE HRS (**)	%	SETUP TIME HRS (+)	%	IDLE TIME HRS	%	0 20 40 60 80 100 PERC
1	1083	10.0		10.0	100	0.0	0	0.0	0	
2	1083	10.0		10.0	100	0.0	0	0.0	0	
3	1083	10.0		10.0	100	0.0	0	0.0	0	
TOTAL		30.0		30.0	100	0.0	0	0.0	0	

W/C EFF.%	CAPACITY STATUS	SHIFT LENGTH	-OP NATION GROUPING- ORD.PRI / LSD RANGE	SCHEDULE TYPE	BALANCED CAP. KEY	MAXIMUM IDLE TIME	-STATISTICAL QUEUE TIMES FOR PRIORITY GROUPS- 0-3	4-8	9-12	13-19
100	FIN	10.0		ESO	BAL	.0	31.6	13.3	8.1	9.6

UNIQUE OP NO	A R E A C D	WORK ORDER NUMBER	WORKSHOP NUMBER	OP NO	G N C U P	CHECK CODE	DESCRIPTION	QTY	EIN NO.	DEL HRS	TS IC / MH EE SD	N E G L O A T D REQ.NO.	STORES / PURCHASE	A S I S	FROM W/C	CPD	I N S P	TO W/C	CSD	M L N D N	STD TIME	PRIOR OR/OP
	14	C07083	[illegible]14800	0060			SURFACE GRIND TO DRG	4	N63	0	08				083			198	084	1	0.9	11/51
S	14	C11981	010003R30	0040			STRAIGHTEN BAR IF REQD	6	N63	0	03				083			510	083	1	0.1	9/49
P	01	G23368	015515500	0040			HEAT TREAT & SURFACE GRIND TO *10TH	50	N17	0	63	L			083			P13	089	1	2.5	9/49
P	13	BG5109	015307504	0080			GRIND TO THICKNESS	72		0	05				083			511	085	1	5.2	9/49
S	14	C16734	016748800	0050			GRIND CUTTING EDGE OUT TO LENGTH	100	N42	0	10	L			083			198	087	1	16.1	8/48
P	03	DM8470	005426500	00e0			GRIND BLADES AS PER DWG	6	FAB	0					085	F13	083	198	087	1	2.9	11/51
P	13	BG5103	015307504	0040			GRIND TO WIDTH CHECK HOLE CENTRE	72		0					085	511	083	510	087	1	9.8	9/49

WORKCENTRE JOB QUEUE 511

S	14	C23J8T	E0112580C9	0100			WASTE CHAMFER&EJECTOR VALVE	4	N37	0					086			531		1	0.9	2/42
S	14	C0A2WT	0017064800	0e30			SURFACE GRIND BOTH SIDES TO DRG	4	N53	0					087	F13	085	506	087	1	3.1	11/51

WORKCENTER LOAD GRAPH/STATISTICS/WORKSTATION DATA P21 MATERIALS CALIM.CAP. FIX LEN 1

NO OP.SCHP

W/C EFF.%	CAPACITY STATUS	SETUP DIRECT	OPERATION OVERLAP/ QUEUE/WAIT	SCHEDULE TYPE	BALANCED CAP. KEY	MAXIMUM IDLE TIME	-STATISTICAL SLEUE TIME 0-3	4-9		FCT FACILITY GROUPS- 12-19
100	INFIN	9.2			BAL	.0	28.1	15.9	5.5	4.7

U R F G A T Y P E	W/C NUMBER	WORKSHOP NUMBER	CP	G N L D	SHIFTS	DIM QTY	DEL TS IC MM EE SD	G S L U P A T D	STORES / PURCHASE REQ.NO.	A S A L	FROM W/C SEQ	I N P	TO W/C SEQ	V L I D	STD TIME	PRICE/UM
			AC	P		NO.	HRS	SD								

WORKCENTER JOB QUEUE P21

Y	03	PC11NG	01P502500	0010		J	1	0	Y SIE
S	14	C1067N	02C121500	0010		C	3 11H	0 R	Y M15
S	14	C1067N	02C121500	0020		C	3 11H	0 R	Y M15
S	14	C1067N	02C121500	0085		C	3 11H	0 R	Y M15
S	14	C1M46N	01M532P00	0010		C	12	0 R	Y M1E
S	14	C1P84N	01M532P00	0050		C	12	0 R	Y M1E
S	14	C125HN	02A781A00	0010		J	1	0 H	Y M1P
X	01	R42456	12C31R100	0010		CMJ	1	0 R	Y F11
X	01	R42456	10C31R100	0020		AMJ	1	0 R	Y F11
X	05	11400F	10121C250	0010		J	1	0 R	Y M15
X	07	C1A76R	01431P400	0020		C	2 25I	0	Y M1F
S	14	C2M7T	10155M5C0	0010		J	1 N33	0 H	Y S1S
S	14	C2M10J	10155M5C0	0010		C	40	0 H	Y S11
X	01	C1M61H	11A724500	0020		C	1	0 H	Y S31
S	14	C2024N	020GP3P00	0010		C	4 4PE	0 H	Y M26
S	14	C2024N	020GP3P00	0030		L	16 4PE	0 H	Y M2C
S	14	C2024N	020M3M5C0	0010		C	32 4PE	0 H	Y M2F
S	14	C2024N	020GP3P00	0020		C	32 4PE	0 H	Y M2G
S	14	C2024N	020GP3P00	0040		C	32 4PE	0 H	Y M2J
S	14	C2024N	020GP3P00	0050		C	8 4PE	0 H	Y M2K
S	14	C2024N	020M3M5C0	0060		C	8 4PE	0 H	Y M2L
S	14	C2024N	020GP3P00	0100		C	8 4PE	0 H	Y M2M
S	14	C2024N	020GP3P00	0110		C	16 4PE	0 H	Y M2N
S	14	C2024N	020GP3P00	0120		C	8 4PE	0 H	Y M2P
S	14	C2024N	020GP3P00	0130		C	8 4PE	0 H	Y M2Q
S	14	C2024N	020GP3P00	0140		L	8 4PE	0 H	Y M2R
S	14	C2024N	020GP3P00	0150		C	8 4PE	0 H	Y M2S
S	14	C2024N	020GP3P00	0160		C	8 4PE	0 H	Y M2T
S	14	C2024N	020GP3P00	0170		C	8 4PE	0 H	Y M2U
S	14	C2024N	020GP3P00	0180		C	8 4PE	0 H	Y M2V
S	14	C2024N	020GP3P00	0190		C	8 4PE	0 H	Y M2W
S	14	C2024N	020GP3P00	0200		C	8 4PE	0 H	Y M2X
S	14	C2024N	020GP3P00	0210		C	8 4PE	0 H	Y M2Y
S	14	C2024N	020GP3P00	0220		C	8 4PE	0 H	Y M2Z
S	14	C2024N	020GP3P00	0230		C	8 4PE	0 H	Y M30
S	14	C2024N	020GP3P00	0240		C	8 4PE	0 H	Y M31
S	14	C2024N	020GP3P00	0250		C	8 4PE	0 H	Y M32
S	14	C2024N	020GP3P00	0260		C	8 4PE	0 H	Y M33
S	14	C2024N	020GP3P00	0270		C	8 4PE	0 H	Y M34
S	14	C2024N	020GP3P00	0280		C	8 4PE	0 H	Y M35
S	14	C2024N	020GP3P00	0290		C	8 4PE	0 H	Y M36
S	14	C2024N	020GP3P00	0300		C	8 4PE	0 H	Y M37
S	14	C2024N	020GP3P00	0310		C	8 4PE	0 H	Y M38
S	14	C2024N	020GP3P00	0320		C	8 4PE	0 H	Y M39
S	14	C2024N	020GP3P00	0330		C	8 4PE	0 H	Y M3A
S	14	C2024N	020GP3P00	0340		C	8 4PE	0 H	Y M3B
S	14	C2024N	020GP3P00	0350		C	8 4PE	0 H	Y M3C
S	14	C2024N	020GP3P00	0360		C	8 4PE	0 H	Y M3D
S	14	C2024N	020GP3P00	0370		C	8 4PE	0 H	Y M3E
S	14	C2024N	020GP3P00	0380		C	8 4PE	0 H	Y M3F
S	14	C2024N	020GP3P00	0390		C	8 4PE	0 H	Y M3G
S	14	C2024N	020GP3P00	0400		C	8 4PE	0 H	Y M3H
S	14	C2024N	020GP3P00	0410		C	8 4PE	0 H	Y M3I
S	14	C2024N	020GP3P00	0420		C	8 4PE	0 H	Y M3J
S	14	C2024N	020GP3P00	0430		C	8 4PE	0 H	Y M3K
S	14	C2024N	020GP3P00	0440		C	8 4PE	0 H	Y M3L
S	14	C2024N	020GP3P00	0450		C	8 4PE	0 H	Y M3M
S	14	C2024N	020GP3P00	0460		C	8 4PE	0 H	Y M3N
S	14	C2024N	020GP3P00	0470		C	8 4PE	0 H	Y M3O
S	14	C2024N	020GP3P00	0480		C	8 4PE	0 H	Y M3P
S	14	C2024N	020GP3P00	0490		C	8 4PE	0 H	Y M3Q
S	14	C2024N	020GP3P00	0500		C	8 4PE	0 H	Y M3R
S	14	C2024N	020GP3P00	0510		C	8 4PE	0 H	Y M3S
S	14	C2024N	020GP3P00	0520		C	8 4PE	0 H	Y M3T
S	14	C2024N	020GP3P00	0530		C	8 4PE	0 H	Y M3U
S	14	C2024N	020GP3P00	0540		C	8 4PE	0 H	Y M3V
S	14	C2024N	020GP3P00	0550		C	8 4PE	0 H	Y M3W
S	14	C2024N	020GP3P00	0560		C	8 4PE	0 H	Y M3X
S	14	C2024N	020GP3P00	0570		C	8 4PE	0 H	Y M3Y
S	14	C2024N	020GP3P00	0580		C	8 4PE	0 H	Y M3Z
S	14	C2024N	020GP3P00	0590		C	8 4PE	0 H	Y M40
S	14	C2024N	020GP3P00	0600		C	8 4PE	0 H	Y M41
S	14	C2024N	020GP3P00	0610		C	8 4PE	0 H	Y M42
S	14	C2024N	020GP3P00	0620		C	8 4PE	0 H	Y M43
S	14	C2024N	020GP3P00	0630		C	8 4PE	0 H	Y M44
S	14	C2024N	020GP3P00	0640		C	8 4PE	0 H	Y M45
S	14	C2024N	020GP3P00	0650		C	8 4PE	0 H	Y M46
S	14	C2024N	020GP3P00	0660		C	8 4PE	0 H	Y M47
S	14	C2024N	020GP3P00	0670		C	8 4PE	0 H	Y M48
S	14	C2024N	020GP3P00	0680		C	8 4PE	0 H	Y M49
S	14	C2024N	020GP3P00	0690		C	8 4PE	0 H	Y M4A
S	14	C2024N	020GP3P00	0700		C	8 4PE	0 H	Y M4B
S	14	C2024N	020GP3P00	0710		C	8 4PE	0 H	Y M4C
S	14	C2024N	020GP3P00	0720		C	8 4PE	0 H	Y M4D
S	14	C2024N	020GP3P00	0730		C	8 4PE	0 H	Y M4E
S	14	C2024N	020GP3P00	0740		C	8 4PE	0 H	Y M4F
S	14	C2024N	020GP3P00	0750		C	8 4PE	0 H	Y M4G
S	14	C2024N	020GP3P00	0760		C	8 4PE	0 H	Y M4H
S	14	C2024N	020GP3P00	0770		C	8 4PE	0 H	Y M4I
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S	14	C2024N	020GP3P00	0790		C	8 4PE	0 H	Y M4K
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S	14	C2024N	020GP3P00	0820		C	8 4PE	0 H	Y M4N
S	14	C2024N	020GP3P00	0830		C	8 4PE	0 H	Y M4O
S	14	C2024N	020GP3P00	0840		C	8 4PE	0 H	Y M4P
S	14	C2024N	020GP3P00	0850		C	8 4PE	0 H	Y M4Q
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S	14	C2024N	020GP3P00	0870		C	8 4PE	0 H	Y M4S
S	14	C2024N	020GP3P00	0880		C	8 4PE	0 H	Y M4T
S	14	C2024N	020GP3P00	0890		C	8 4PE	0 H	Y M4U
S	14	C2024N	020GP3P00	0900		C	8 4PE	0 H	Y M4V
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S	14	C2024N	020GP3P00	0920		C	8 4PE	0 H	Y M4X
S	14	C2024N	020GP3P00	0930		C	8 4PE	0 H	Y M4Y
S	14	C2024N	020GP3P00	0940		C	8 4PE	0 H	Y M4Z
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S	14	C2024N	020GP3P00	3070		C	8 4PE	0 H	Y MAW
S	14	C2024N	020GP3P00	3080		C	8 4PE

ACCELERATED CENTRAL WORKSTORE

SEQUENTIAL MATERIAL DELETION ACCOUNTING

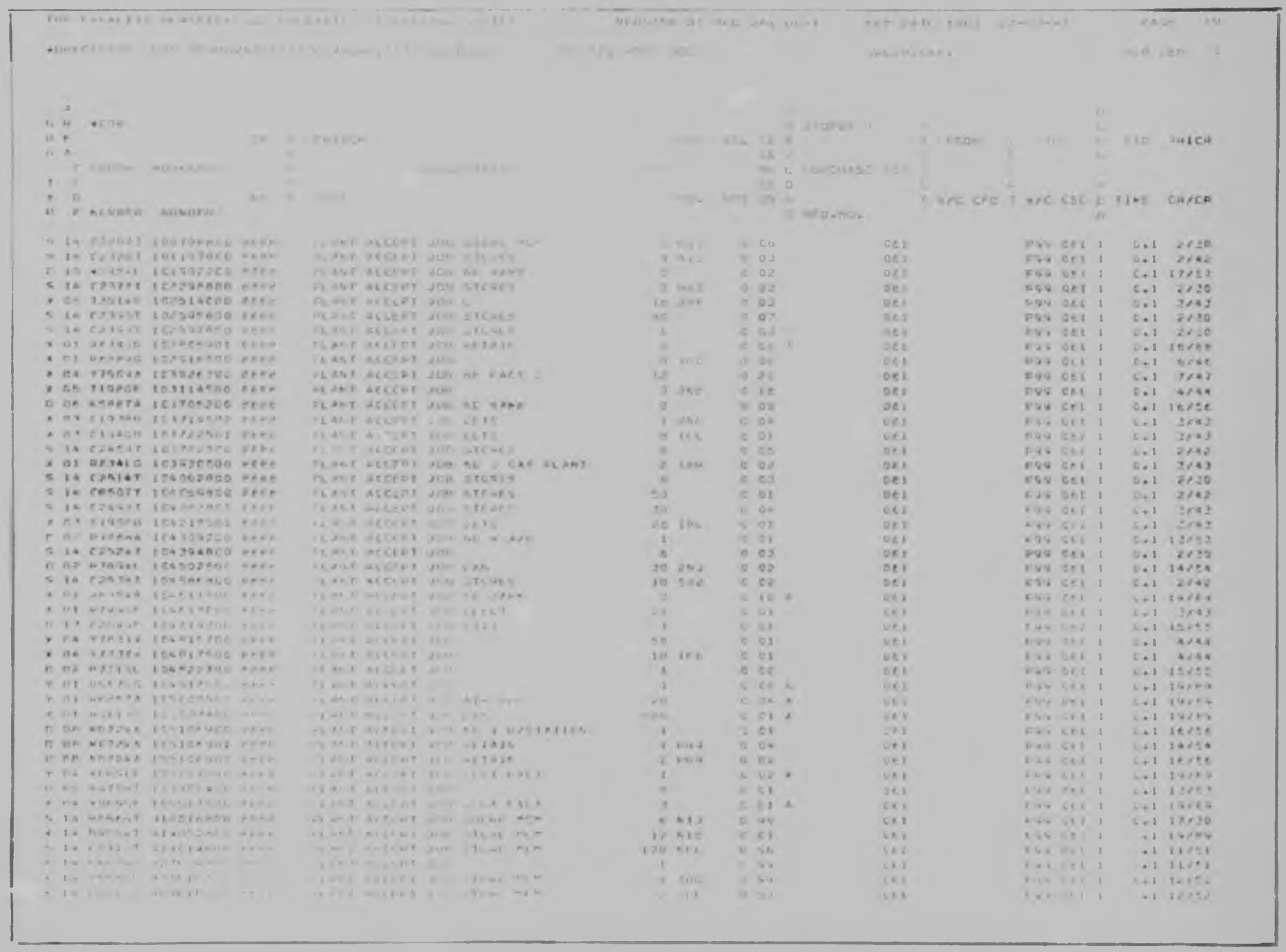
T	A	WORK					P	A	STOCK /				
W	O		WORKSHOP	EP						DEL.	COST	AL	LN
A	F	GROUP			DESCRIPTION	QTY	MFC	P	M	PURCHASE			
N	A		NUMBER	RC						DATE	CENT	SC	RC
S		NUMBER					T	S	REL. NO.				
S	14	C25171	1031044000	CC14	1855413V WORM X 2INCH	C	1	P21	6				
S	14	C25197	1035590001	CC01			2	P18	6	MD 74126			
S	03	N06411	1037610501	CC10	11278453CHANNEL SCREW LONG	J	1	P21	6				
S	03	N06411	1037610101	CC04	11278371LAT BAR ROUND LG	J	1	P21	6				
S	04	G14460	1037233500	CC17	11304750 RD PAN SCREW LONG	J	1	P21	6				
S	04	G14460	1037233507	CC12	11304501 PAN HEAD SCREW LONG	J	1	P21	6				
S	03	G14434	1037289500	CC20	11271592725 PL ESCREW	J	1	P21	6				
S	14	C25529	1037886000	CC15			100	P18	6	MD 74125			
S	03	N12540	1043006501	CC12	11304320 SQ PAN SCREW LONG	J	1	P21	6				
S	01	N01550	1043744100	CC11	11721353 SCREW LONG	J	1	P21	6				
S	01	N01550	1043744100	CC27	11721353 SCREW LONG	J	1	P21	6				
S	01	N01570	1043745100	CC25	11302570 SCREW LONG	J	1	P21	6				
S	14	C25215	1043955000	CC10	11581736SCRW PL M 28 ID	J	1	P21	6				
S	03	N17470	1044144500	CC20	11325507SCRW DIAMOND LG	J	1	P21	6				
S	03	N17470	1044145100	CC31	11342502SCRW DIAMOND LG	J	1	P21	6				
S	03	N17470	1044145200	CC41	11327154SCRW DIAMOND LG	J	1	P21	6				
S	01	X75402	1044148C0C	CC11	12198154 SCREW AL PLJ	J	2	P21	6				
S	04	X31574	1044157000	CC11	11726035 SCRW LONG	J	1	P21	6				
S	14	C25459	1048902003	CC11	TUFNOL		1	P16	6	MD 74152			
S	03	N17070	1049044500	CC11	11726835 SCREW LONG	J	1	P21	6				
S	02	+X75618	1053175200	CC10	12541164ISCREWECX1MM ZPI PL	J	1	P21	6				
S	03	N44041	1053206000	CC10	11 [illegible] SCREW M/S PJ		1	P21	6				

[illegible] END OF REPORT [illegible]

MICROPLATE IN CENTRAL WORKSHOPS

T	A	WORK				P					PLANS	ACT	
R	D	ORDER	WORKSHOP	DESCRIPTION	QTY	M	RELD	EDD	DUE	FCFC	COMP	TOTAL	TOTAL	REMT
A	V	NUMBER	ROUTE			I	DATE		DATE		DATE	HOURS	HOURS	HRS
N		NEW TW				C								
S						N								
	1A	0E0S4T	P732705	PANEL ASM MAKE LIGHT BLACK HOLE		1	9	9804		8245	9801	1057	0048	0247	14
	1A	H0P5PN	Q7385G3	27345 ASM INSTALLED DISTRIBUTION BOX		2	5	21		0042	0041	1039	1.1	6.3	7
	1A	H01S2E	9A2A412	10 FIELD MAKE ENGINE		2	4	1017		1017	1012	1057	1.1	1.1	4
	1A	C0P15N	C01H0B400	ROUGH CUT MAKE PACKER CASINGS		6	3	1027		1057	1111	1057	Make	72.0	21
	0Z	0P25WM	0057TP4U	MAKE UP TWO SETS OF PLATES	0H3	2	4	38		0035	0064	1057	21.7	61.7	15
	1A	C1W07C	011117BW	WELL PUMPS ASM JACK		1	9	115		0115	0125	1057	0.1	P.0	7
	1A	C1A5PN	013R05A0B	PIPE END PAC CAPS WELD		2	3				1061	1057	1042	1043	5
	1A	R0P5PN	015224A72	12 FOOTER ATTACHED HOOKS	1NE	12	5	1041		1055	1061	1057	5.3	5.3	7
	1A	C1A11N	015401U00	ASSEMBLE AND CHECK DISTANCE CASTING	94B	8	3	104		0221	0217	1057	4.1	6.3	5
	1A	C1A40T	01F017P00	PRINT AND CORRELATION FOR BLADE	HST	50	4	104		0165	0254	1057	4.5	12.7	4
	1A	C1T4RT	01T50F021	MAKE ASSEMBLY CHECK SEAL BLOCK	BAT	1	3	1P4		1044	1034	1004	0.4	4.1	0
	1A	W0V20M	015Y21J0	MAKE CHANNEL TO SAVE SWITCH	2WL	10H	5	145		0203	0232	1057	0247	4.9	5
	0F	H2P47G	015515000	OPERATE BLANK HEAT FROM D CASTING	2DN	1	5	1026		1027	1044	1039	17.0	17.0	9
	1A	E2P33T	023754V00	ASSEMBLE CHECKER	938	400	3	244		0252	1012	1057	19.0	14.4	5
	0A	40S7JM	02308A1G1	10 FINISH SQUARE TUTOR SHAFT	2WL	1	3	1027		1039	1052	1057	9.1	4.1	8
	1A	G2W2PA	07822T201	10 FINISH MAKE TO ASSEMBLE/DISASSEMBLE		1	4	1005		1005	1020	1057	21.5	27.1	8
	1A	C2P1PL	C2412P4C4	ASSEMBLE AND CHECK ASSEMBLY ASA	ILR	1	4	243		0215	1004	1057	8.4	6.4	7
	1A	C0P4PT	02455S5U2	PRINT SET MAKE READY	N24	200	3	246		0247	1011	1057	53.0	11.0	6
	0A	K2W32A	025705J00	10 FINISH SAFELY SHELVES		2	5	1011		1010	1005	1057	4.6	4.6	14
	03	G7W31L	10E304200	10 FINISH MANUFACTURE PIPE SUPPORTS		41	5	1050		1021	1041	1057	69.8	29.8	8
	03-	S4W27A	10C4C1S00	10 FINISH MAKE CL COLLECTOR DOGS	N40	4	5	1070		1026	1052	1057	3.4	3.4	7
	3A	0R2T0P	10CP3C4C2	10 FINISH MAKE ASSEMBLY AS PER SKETCH	2C3	200	5	1011		1017	1032	1057	17.7	11.7	5
	0A	T2W42P	10E1F3P4C	10 FINISH ASSEMBLE SUPPORT BRACKET		3	5	1046		1047	1054	1057	2.1	4.1	4
	1A	C2T40T	10118A7U0	FINISH SET MAKE TOOL AS PLAN	502	150	3	1017		1043	1042	1057	7.7	7.7	6
	0T	W1R37M	10120B100	10 FINISH MAKE UP COIL		1	9	1023		1025	1046	1057	29.1	29.1	9
	1A	W5V49T	10137D0U0	10 FINISH WELD FINISH DRIVE UNIT		1	9	1030		1032	1012	1057	3.3	3.3	7
	31	T5W41L	103221C02	10 FINISH MAKE UP NEW SHAFTSTOP OIL		7	9	1023		1022	1031	1057	15.7	15.5	10
	0A	F0W4WC	10E4F5T0	10 FINISH SET UP MACHINE ELEMENTS		47	5	1015		1019	1015	1057	2.1	2.1	4
	1A	P1W4CE	0P1W7T1C	FINISH SET INSPECTOR READY ASSEMBLY		2	5	1042		1042	1014	1057	2.1	1.1	4
	0T	4T0W5A	E0P7E4H0	10 FINISH MAKE ASSEMBLY AS PER SKETCH		1	5				1141	1057	42.3	42.3	14
	31	T1P23Z	E07P54H0	10 FINISH TAPE ELEMENT HEAT TO WELDS		1	9	1037		1037	1034	1057	2.2	2.2	4
	0T	W1W4W4	E07P01H0	10 FINISH MACHINE JOINT		1	9	1034		1034	1042	1057	1.6	1.6	4
	0T	0T0P1R	E07S27U0	10 FINISH MAKE STUDS AS PER SKETCH		150	9	1045		1044	1053	1057	4.4	4.4	4
	0T	0T5P1R	E07P3T0U	10 FINISH MAKE STUDS & NUTS		630	9	1037		1041	1052	1057	45.2	45.2	5
	0T	0E4W00	E07E2T40	10 FINISH SET UP MACHINE SEAL HEAT		1	5	1034		1034	1044	1057	2.1	2.1	4
	0T	2W1T3A	E07W4T0U	MAKE SPACER AS PER SKETCH NO 5 NO SET		1	4	1046		1041	1051	1057	33.7	33.7	9
	0A	Y7P5AA	E07W5T50	10 FINISH ASSEMBLE BLADES		4	4	1041		1041	1052	1057	17.1	13.5	5
	1A	C2W1AC	104C05U10	10 FINISH SET BLOCK SHEETS INTO JOHN		2	5	1042		1042	1044	1057	2.2	2.2	5
	0T	4R1T4G	104C04T0C	10 FINISH SET UP MACHINES TEMPER HEADPIECE		2	4	1041		1041	1044	1057	11.1	11.1	8
		12T0W4	E0P7U0U0	10 FINISH MAKE VALVE SEAT		2	4	1045		1051	1044	1057	1.1	1.1	4
	0T	N7P0U0	104T1E0C	10 FINISH MACHINE FRONTPOST AS PER SK		2	4	1041		1041	1012	1057	2.1	2.1	4
	0T	4M0T04	104E1P0C	10 FINISH MAKE UP MOLDS AS PER SKETCH		1	4	1045		1045	1051	1057	4.4	4.4	5
	0T	5T40W3	1L1T1E0C	10 FINISH MAKE SUPPORTING STRIPS		4	5	1048		1043	1114	1057	2.7	2.7	4
	0A	Y3T0P4	104P2E0C	10 FINISH SET UP MILL PUNCTURE BL		6	4	1040		1041	1053	1057	5.4	5.4	6
	0A	Y7P0P4	104P4T0C	10 FINISH SET UP MACHINE TO CHECK		2	4	1044		1042		1057	4.4	4.4	5
	0T	W2T0T4	1C4P1T0C	FINISH SET UP MACHINE		4	4	1001		1014		1057	4.4	4.4	5
	0T	W2T0P4	1C4P2T0C	FINISH SET UP MACHINE TO CHECK		1	4	1001		1034		1057	1.1	1.1	4
		12T1E	1C4T1P0C	MAKE	ATL	14	3	1041		1044	1011	1057	2.1	17.1	12

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WORKSTATION GROUP ANALYSIS ... INCONSISTENCY CODES ... USE DESCRIPTION NOTE ... UNIMPLEM. ... PER LEN 1

W/C ID	WORK CENTER NUMBER	CD	C O N V	SHIFT DESCRIPTION	QTY	BIN NO.	DEC HRS	TO SU	C O N V F C T O R	STORES / PURCHASE REQ.NO.	A S S I G N	FROM T/C	I N S P E C T	TO T/C	MOVE TIME	STD QTY/HR
S 14	037077 10027PPUD	PPPP		PLANT ACCEPT JOB GEORGE PLA	3	N11		C 06				061		PPP 061	1	0.1 2720
S 14	037081 10015700D	PPPP		PLANT ACCEPT JOB STEVES	4	N12		C 03				061		PPP 061	1	0.1 2740
S 10	WC454I 10130C2C0	PPPP		PLANT ACCEPT JOB NO 4PPP	3			C 02				061		PPP 061	1	0.1 17457
S 14	037071 10210P80D	PPPP		PLANT ACCEPT JOB STEVES	9	N43		C 03				061		PPP 061	1	0.1 2720
X 05	730149 10251AC00	PPPP		PLANT ACCEPT JOB S	36	2MP		C 02				061		PPP 061	1	0.1 3743
S 14	037150 10250P830	PPPP		PLANT ACCEPT JOB STEVES	40			C 03				061		PPP 061	1	0.1 2720
S 14	037151 10250P85C	PPPP		PLANT ACCEPT JOB STEVES	4			C 03				061		PPP 061	1	0.1 2720
Y 01	WP3A1C 10P0P5A01	PPPP		PLANT ACCEPT JOB METALS	2			C 01	A			061		PPP 061	1	0.1 18755
X 01	WP3P4G 10P0P450N	PPPP		PLANT ACCEPT JOB	8	N1C		C 05				061		PPP 061	1	0.1 5745
X 04	Y75C1A 10302C3DU	PPPP		PLANT ACCEPT JOB OE FACT 2	12			C 21				061		PPP 061	1	0.1 7747
X 05	719P0F 10311A50D	PPPP		PLANT ACCEPT JOB	3	2KE		C 18				061		PPP 061	1	0.1 4744
D 0E	X7P87A 10170520D	PPPE		PLANT ACCEPT JOB AE 4PPP	2			C 0E				061		PPP 061	1	0.1 18756
X 01	719150 10171A50T	PPPP		PLANT ACCEPT JOB STEVES	1	2NP		C 04				061		PPP 061	1	0.1 3743
X 01	C1A4CP 10170C00T	PPPP		PLANT ACCEPT JOB STEVES	3	1C1		C 01				061		PPP 061	1	0.1 3743
S 14	C1A45T 10170C45C	PPPP		PLANT ACCEPT JOB STEVES	8			C 05				061		PPP 061	1	0.1 2742
A 01	WP3A1G 10390C00	PPPP		PLANT ACCEPT JOB NO 2 EAS PLANT	2	1EN		C 0Y				061		PPP 061	1	0.1 3743
S 14	037147 10430C70D	PPPP		PLANT ACCEPT JOB STEVES	9			C 03				061		PPP 061	1	0.1 2720
S 14	037077 10470P80D	PPPP		PLANT ACCEPT JOB STEVES	53			C 01				061		PPP 061	1	0.1 2742
S 14	037141 10430C70D	PPPP		PLANT ACCEPT JOB STEVES	30			C 04				061		PPP 061	1	0.1 3742
X 01	WP3P4G 10421C00T	PPPP		PLANT ACCEPT JOB LETS	28	1PL		C 01				061		PPP 061	1	0.1 3743
D 01	WP3P4A 10430470D	PPPP		PLANT ACCEPT JOB NO 4 AAA	4			C 01				061		PPP 061	1	0.1 13753
S 14	037147 10439A80D	PPPP		PLANT ACCEPT JOB	6			C 03				061		PPP 061	1	0.1 2720
D 02	P3P0AE 10450750C	PPPP		PLANT ACCEPT JOB CAN	38	2NJ		C 02				061		PPP 061	1	0.1 14754
S 14	037147 10450P85C	PPPP		PLANT ACCEPT JOB STEVES	30	504		C 02				061		PPP 061	1	0.1 2742
Y 01	WP3P4A 10411C00	PPPP		PLANT ACCEPT JOB OE 4PPP	4			C 10	A			061		PPP 061	1	0.1 19754
X 01	W73A1P 10421PC00	PPPP		PLANT ACCEPT JOB SHEET	20			C 01				061		PPP 061	1	0.1 3743
D 11	P3P0AP 10431A50D	PPPP		PLANT ACCEPT JOB CARD	4			C 01				061		PPP 061	1	0.1 15755
X 04	Y7P81A 10481A50D	PPPP		PLANT ACCEPT JOB	56			C 01				061		PPP 061	1	0.1 4744
X 04	Y7P81A 10481P50D	PPPP		PLANT ACCEPT JOB	18	1PE		C 01				061		PPP 061	1	0.1 4744
D 02	P7P1GL 10482P00	PPPP		PLANT ACCEPT JOB	1			C 02				061		PPP 061	1	0.1 15751
Y 01	WP3P4G 10401C00	PPPP		PLANT ACCEPT JOB	1			C 0C	A			061		PPP 061	1	0.1 19754
X 01	WP3P4A 10402P50T	PPPP		PLANT ACCEPT JOB MILLING	20			C 04	A			061		PPP 061	1	0.1 19754
X 0E	P3P1GA 10410C00	PPPP		PLANT ACCEPT JOB CAN	100			C 01	A			061		PPP 061	1	0.1 19754
D 0P	WP3P4A 10410P00	PPPP		PLANT ACCEPT JOB OE EMPLOYEES	1			C 01				061		PPP 061	1	0.1 18756
D 0P	WP3P4A 10410P00	PPPP		PLANT ACCEPT JOB STEVES	1	PPP		C 0P				061		PPP 061	1	0.1 18754
D 0P	WP3P4A 10410P00	PPPP		PLANT ACCEPT JOB STEVES	2	PPP		C 02				061		PPP 061	1	0.1 18756
X 0E	P3P0AE 10410C00	PPPP		PLANT ACCEPT JOB	1			C 0E	A			061		PPP 061	1	0.1 19754
S 14	037077 10410P50T	PPPP		PLANT ACCEPT JOB STEVES	8			C 01				061		PPP 061	1	0.1 13753
Y 0E	P3P0AG 10411C00	PPPP		PLANT ACCEPT JOB	1			C 01	A			061		PPP 061	1	0.1 19754
S 14	WC454I 10410P00	PPPP		PLANT ACCEPT JOB STEVES	4	N13		C 04				061		PPP 061	1	0.1 17750
X 14	P3P1GI 10410P00	PPPP		PLANT ACCEPT JOB STEVES	12	N13		C 01				061		PPP 061	1	.1 19755
S 14	037147 10410P00	PPPP		PLANT ACCEPT JOB STEVES	100	N11		C 0N				061		PPP 061	1	.1 13751
S 14	037141 10410P00	PPPP		PLANT ACCEPT JOB	1			C 0N				061		PPP 061	1	.1 13751
X 01	P3P1GA 10410P00	PPPP		PLANT ACCEPT JOB STEVES	1	PPP		C 0N				061		PPP 061	1	0.1 14754
X 14	WP3P4A 10410P00	PPPP		PLANT ACCEPT JOB STEVES	1	1PP		C 01				061		PPP 061	1	0.1 19754

			DATA FIELD		
#042	INVALID DUC DATE	01052100 24C0963A	1132 16009 01132	T 0217	
#042	INVALID DUC DATE	10C07400 24C2B5E8	1158 15 1150		0323
1150	CHECK MI ASSIGNED				
1150	001144				
1151	C05000				
1152	C05030				
1153	C05059				
1154	C00130				
1155	C03455				
1156	E05000				
1157	E05CCC				
1158	E05000				
1159	E05000				
1160	E06007				
1161	E05007				

PO-1 INPUT AL II 1.1.1 MISCELLANEOUS CENTRAL WORKSPACE

TI AT AP MP DE	RT OF FC AT	WORKORDR NUMBER	OP SQ	SE OP LE ST ALPHA	DESCRIPTION	QTY	P I N T	U N G S	REQC DATE	LE CATE	ELE CATE	PLN ALT W/C	PLN ALT MIN	PLANG ALT TIME	T/I / HOURS	SIG DELAY	A S T	L C	A Y	A K C
							P T S	A M	ORL DATE	STCHES / PLACERSE REQ.	NC.	PLN W/C	AL	LA NC	CC:T CC:T					
52 13	802920	0152246XX	0130		MAKE 1 SETS SHUTTLES 1.25 CARTRIDGE	3						C03	1	10.5	0				Y	
52 13	802920	0152246X	0140		MAKE 2 SETS SHUTTLES 1.25 CARTRIDGE	3						C03	1	42.5	0				Y	
52 13	802920	0152246X	0150		MAKE 3 SETS SHUTTLES 1.25 CARTRIDGE	3						C02	1	1.5	0				Y	
52 13	802920	0152246X	7777		FINAL INSPECTION	3						C99	1	0.1	0				Y	
52 13	802920	0152246X	8888		PLANT ACCEPT JCP EXP	3						P98	1	0.1	0				Y	
52 13	802920	0152246X	9999		CLEARING CLOSE JCP	3						P99	1	0.0	0.1				Y	
52 13	802920	0152246X			10 FIRST MAKE CRIMPER BEAMS FF E AP	3	5	X	1061		1063									
52 13	802920	0152246X	0010		MAKE CRIMPER BEAMS 5"64" A/BRACKETS	3						C02	1	3.0	0				Y	
52 13	802920	0152246X	0020		MAKE CRIMPER BEAMS 5"64" A/BRACKETS	3						C02	1	1.5	0				Y	
52 13	802920	0152246X	0030		MAKE CRIMPER BEAMS 5"64" A/BRACKETS	3						C02	1	1.0	0				Y	
52 13	802920	0152246X	0040		MAKE CRIMPER BEAMS 5"64" A/BRACKETS	3						C02	1	1.0	0				Y	
52 13	802920	0152246X	0050		MAKE CRIMPER BEAMS 5"64" A/BRACKETS	3						C02	1	7.5	0				Y	
52 13	802920	0152246X	0060		MAKE CRIMPER BEAMS 5"64" A/BRACKETS	3						C02	1	5.3	0				Y	
52 13	802920	0152246X	0070		MAKE CRIMPER BEAMS 5"64" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0080		MAKE CRIMPER BEAMS 5"64" A/BRACKETS	3						C02	1	1.5	0				Y	
52 13	802920	0152246X	0090		MAKE CRIMPER BEAMS 5"64" A/BRACKETS	3						C03	1	6.1	0				Y	
52 13	802920	0152246X	0100		MAKE CRIMPER BEAMS 5"64" A/BRACKETS	3						C03	1	10.5	0				Y	
52 13	802920	0152246X	0110		MAKE CRIMPER BEAMS 5"64" A/BRACKETS	3						C03	1	6.1	0				Y	
52 13	802920	0152246X	0120		MAKE CRIMPER BEAMS 5"64" A/BRACKETS	6						C02	1	0.5	0				Y	
52 13	802920	0152246X	7777		FINAL INSPECTION	3						C99	1	0.1	0				Y	
52 13	802920	0152246X	8888		PLANT ACCEPT JCP EXPIRERS	3						P98	1	0.1	0				Y	
52 13	802920	0152246X	9999		CLEARING CLOSE JCP	3						P99	1	0.0	0.1				Y	
52 13	802920	0152246X			10 FIRST MAKE PIN BOARDS 1.25" A/P	3	5	X	1061		1063									
52 13	802920	0152246X	0010		MAKE PIN BOARDS 1.25" PIN A/BRACKETS	3						C02	1	0.9	0				Y	
52 13	802920	0152246X	0020		MAKE PIN BOARDS 1.25" PIN A/BRACKETS							C02	1	1.5	0				Y	
52 13	802920	0152246X	0030		MAKE PIN BOARDS 1.25" PIN A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0040		MAKE PIN BOARDS 1.25" PIN A/BRACKETS	3						C02	1	1.0	0				Y	
52 13	802920	0152246X	0050		MAKE PIN BOARDS 1.25" PIN A/BRACKETS	3						C02	1	4.0	0				Y	
52 13	802920	0152246X	0060		MAKE PIN BOARDS 1.25" PIN A/BRACKETS	3						C02	1	4.0	0				Y	
52 13	802920	0152246X	0070		MAKE PIN BOARDS 1.25" PIN A/BRACKETS	3						C02	1	4.0	0				Y	
52 13	802920	0152246X	7777		FINAL INSPECTION	3						C99	1	0.1	0				Y	
52 13	802920	0152246X	8888		PLANT ACCEPT JCP EXPIRERS	3						P98	1	0.1	0				Y	
52 13	802920	0152246X	9999		CLEARING CLOSE JCP	3						P99	1	0.0	0.1				Y	
52 13	802920	0152246X			10 FIRST MAKE STRAIN 1.25" A/BRACKETS	3	5	X	1061		1063									
52 13	802920	0152246X	0010		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	1.0	0				Y	
52 13	802920	0152246X	0020		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	2.5	0				Y	
52 13	802920	0152246X	0030		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	2.0	0				Y	
52 13	802920	0152246X	0040		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	5.0	0				Y	
52 13	802920	0152246X	0050		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	1.0	0				Y	
52 13	802920	0152246X	0060		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0070		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	2.0	0				Y	
52 13	802920	0152246X	0080		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0090		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0100		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0110		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0120		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0130		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0140		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0150		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0160		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0170		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0180		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0190		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0200		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0210		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0220		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0230		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0240		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0250		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0260		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0270		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0280		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0290		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0300		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0310		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0320		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0330		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0340		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0350		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0360		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0370		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0380		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0390		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0400		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0410		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0420		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0430		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0440		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0450		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0460		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0470		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0480		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0490		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0500		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0510		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0520		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0530		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0540		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0550		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0560		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0570		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0580		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0590		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0600		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0610		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0620		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0630		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0640		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0650		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0660		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0670		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0680		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0690		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0700		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0710		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0720		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0730		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0740		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0750		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0760		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0770		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0780		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0790		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0800		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0810		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0820		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0830		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0840		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0850		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0860		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0870		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0880		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0890		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0900		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0910		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0920		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0930		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0940		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0950		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0960		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0970		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0980		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	0990		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1000		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1010		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1020		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1030		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1040		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1050		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1060		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1070		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1080		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1090		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1100		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1110		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1120		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1130		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1140		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1150		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1160		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1170		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1180		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1190		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1200		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1210		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1220		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1230		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1240		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1250		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1260		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1270		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1280		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1290		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1300		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1310		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1320		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1330		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1340		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1350		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1360		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1370		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1380		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1390		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1400		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1410		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1420		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1430		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1440		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1450		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1460		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1470		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1480		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1490		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1500		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1510		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1520		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1530		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1540		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1550		MAKE STRAIN 1.25" A/BRACKETS	3						C02	1	0.5	0				Y	
52 13	802920	0152246X	1560		MAKE STRAIN 1.25" A/BRACKETS	3					

[illegible]

[illegible]

[illegible]	DAY OF WEEK						
[illegible]	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
1				[illegible]	[illegible]	1 *	2 *
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1 *	2 *
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1 *	2 *
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1 *	2 *
	[illegible]	[illegible]	[illegible]				

CAPACITY REQUIREMENTS PLANNING REPORT FOR WORK CENTER 504 N/C DRILL MACH

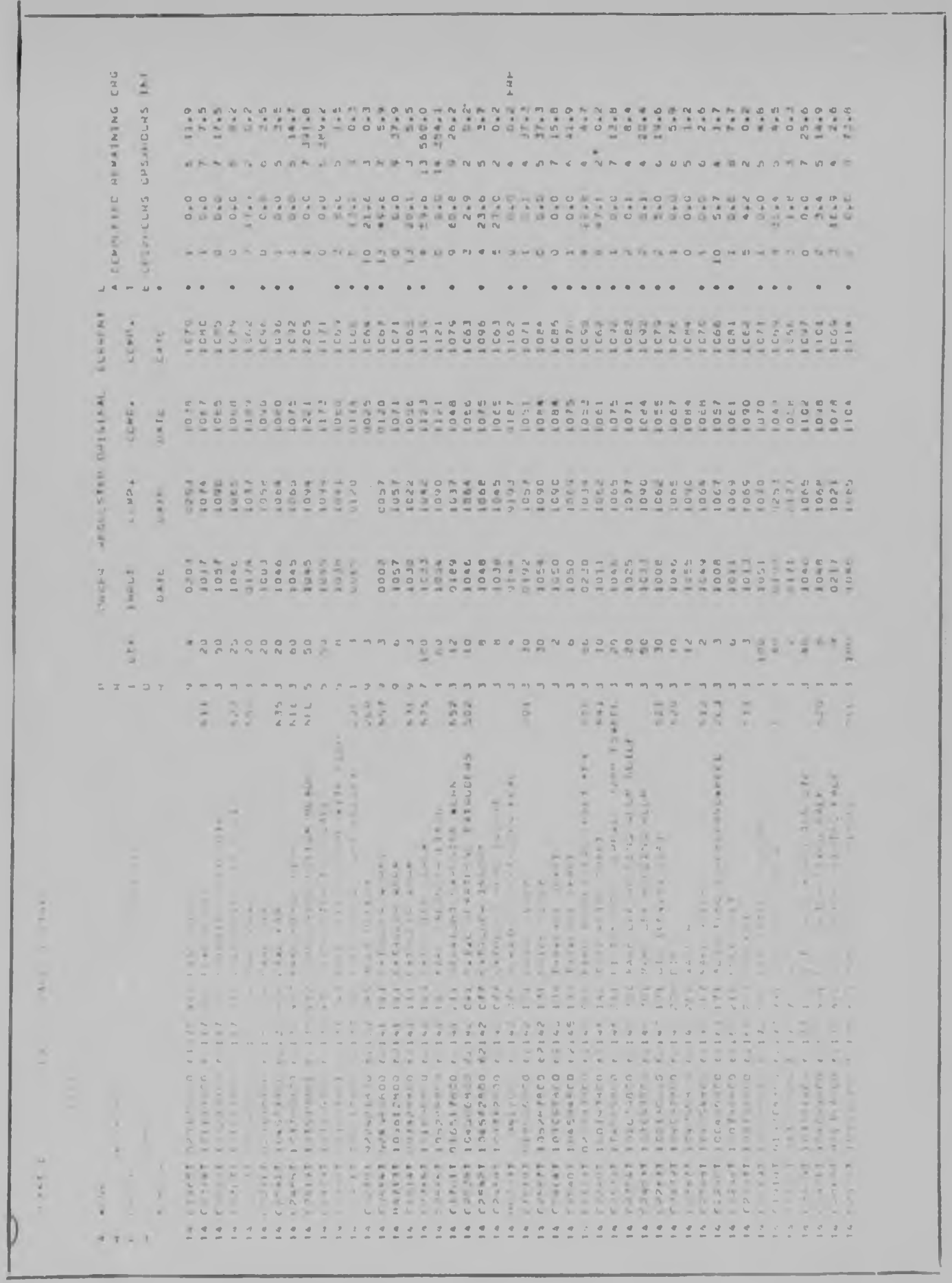
NUMBER OF SINGLE MACHINES 1 ALTERNATE WC NOTS SEC LOAD TYPE NO LOAD

PER	START DATE	PER LEN	AVAIL HRS	ESD HRS (*)	LSD HRS (*-)	ALT HRS	---LSD LOAD % 0 100 200	NORM HRS (*)	EARL HRS (*)	SURPLUS -- SURPLUS CAP % 0 50 100	PER HRS (*)	UNAVOID CUM HRS (*)	OVERLOAD % 50 100	*SEC LOAD* ESD HRS	LSD HRS
1	1081	5	60	278	258		********** *** **				194	194	**********	0	0
2	1086	5	60	59	67		**********				7	201	**********	0	0
3	1091	5	60	2	13		**		43	**********		154	**********	0	0
4	1096	5	60	5	5		*		55	**********		108	**********	0	0
5	1101	10	120	0	3			17	120	**********				0	0
6	1111	10	120	0	0			120	120	**********				0	0
7	1121	10	120	0	0			120	120	**********				0	0
8	1131	10	120	0	0			120	120	**********				0	0
9	1141	10	120	0	0			120	120	**********				0	0
10	1151	10	120	0	0			120	120	**********				0	0
TOTALS		80	960	344	342			617	818		201			0	0

CAPACITY REQUIREMENTS PLANNING REPORT FOR WORK CENTER 506 GRIND CYLIND 1

NUMBER OF SINGLE MACHINES 3 ALTERNATE WC NOTS SEC LOAD TYPE NO LOAD

PER	START DATE	PER LEN	AVAIL HRS	ESD HRS (*)	LSD HRS (*-)	ALT HRS	---LSD LOAD % 0 100 200	NORM HRS (*)	EARL HRS (*)	SURPLUS -- SURPLUS CAP % 0 50 100	PER HRS (*)	UNAVOID CUM HRS (*)	OVERLOAD % 50 100	*SEC LOAD* ESD HRS	LSD HRS
1	1081	5	150	384	272		**********				72	72	**********	0	0
2	1086	5	150	257	111		********					33	*****	0	0
3	1091	5	150	104	65		*****							0	0
4	1096	5	150	143	43		****							0	0
5	1101	10	300	265	142		******							0	0
6	1111	10	300	0	8									0	0
7	1121	10	300	0	2			202	274	**********				0	0
8	1131	10	300	0	36		*	300	300	**********				0	0
9	1141	10	300	36	138		******	264	264	**********				0	0
10	1151	10	300	0	155		****	300	300	**********				0	0
TOTALS		80	2400	1236	885			1065	1137		72			0	0



IBM CAPACITY PLANNING AND INFORMATION REPORTING SYSTEM-CAPREPORT RELEASE 1.1 V7-0 KEY DATE 1154 11.06.21 PAG 0092

CENTRAL MONITORING CLASSIC SYSTEM MICROPROCESSOR FACTORY STORES REQUISITION CAPACITY MATERIAL REQUIRED REPORT

NAME OF AUTHORISER SIGNATURE DELIVERY POINT REQUISITION SIGNATURE SPECIAL ISSUE / BY DOCUMENT NO

CHECKED BY :-

TEL.EXT. TIME IN OUT A3

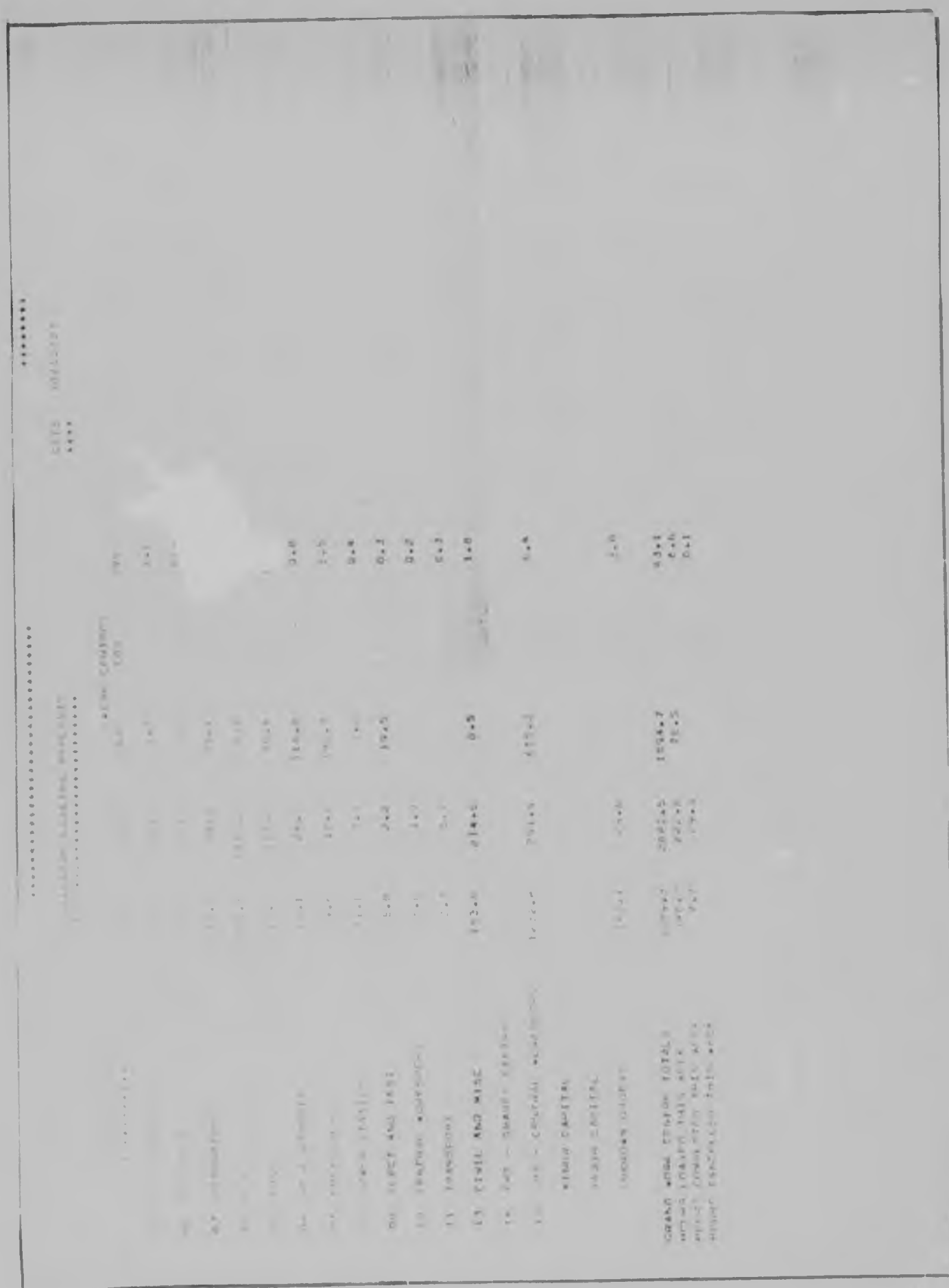
U	REQ.	DATE	COST	ALL	CIR	PRTY	WORK	WORKSHOP	FOR	PLNT	SUFF	ITEM	COMMODITY	QTY		DIN	ISSUE	ISSUE
N	CODE	DUMMY	CENT	NO.	NO	AREA	CHGEA	NUMBER	NO.	CODE	NO.	NO	CODE	REQ	DESCRIPTION	LCO	QTY	UNIT
G	4	13	17	19	21	23	24		33	36	39	40	48				53	58
	****	******	****	**	**	**	******		****	***	***	*	********				*****	*****
	3650			10	T76957	1116177			100		01	11021333	1	EA201 1050MM LONG	J			
	3650			10	T76957	1116177	502		100		02	11321160	1	EA3E 1920MM LONG	J			
	3650			10	T76957	1116177	502		100		03	21010276	20	10MM CAP HEAD SCHE*C				
	3650			10	A14331	1136006	500		100		01	11571512	1	1200MM SQ M/S PL	J			
	3650			10	A14331	1136006	500		100		02	11571552	1	300MM SQ M/S PL	J			
	3650			10	A14331	1136006	500		100		03	11791087	1	1 LENGTH A106 PIPE	J			
	3650			10	A14341	1136006	501		100		01	11571512	1	1200MM SQ M/S PL	J			
	3650			10	A14341	1136006	501		100		02	11571552	1	300MM SQ M/S PLATE	J			
	3650			10	A14341	1136006	501		100		03	11791087	1	1 LENGTH A106 PIPE	J			
	3650			14	C32031	1136037	500		100		01	11327420	1	HEX X 150 LONG	J			
	3650			14	C32034	1136037	501		100		01	62344021	12	S/STEEL CAMS MI 1	C			
	3650			14	C32034	1136037	502		100		02	62344013	12	SHAFT PT 3	C			
	3650			14	C32034	1136037	503		100		03	62344011	12	CAM ARM PT 4	C			
	3650			14	C32034	1136037	504		100		04	21040107	12	CASTLE NUT PT 5	C			
	3650			14	C32034	1136037	505		100		05	21172023	12	BRASS WASHER PT 6	C			
	3650			14	C32034	1136037	506		100		06	62342002	12	S/STEEL BOLTS PT 7	C			
	3650			14	C32034	1136037	507		100		07	62344016	12	CAM FOLLOWER PT8-11	C			
	3650			14	C32034	1136037	508		100		08	62344014	12	BRASS ROLLERS PT 9	C			
	3650			14	C32034	1136037	509		100		09	62344015	12	ROLL COVERS PT 10	C			

MODDENFONTEIN FACTORY

P7-5 AMENDMENT LIST TO THE STORES SYSTEM DELIVERY DATES AND LEAD TIMES

CAPOSS SYSTEM IDENTIFICATION			STORES SYSTEM RECORD TYPE 3626					STORES SYSTEM RECORD TYPE 3603			
WORK ORDER NUMBER	WORK ORDER NUMBER	QTY	INPUT CODE	COMMODITY CODE	ORDER NUMBER	SUFFIX NO	DELIVERY DATE	INPUT CODE		COMMODITY CODE	LEAD TIME
			1 4 ****	8 15 ********	16 23 ********	26 ***	51 56 ******	1 4 ****	9 **	10 17 ********	53 ***
14C2764T	107795803	100	3626	62343091	14C2764T	001	150681	3603	2C	62343091	12
14C2763T	107796802	410	3626	62216214	14C2763T	001	190881	3603	2C	62216214	108
14C2761N	107798800	4	3626	62354141	14C2761N	001	080981	3603	2C	62354141	126
14C2760T	107799800	8	3626	24656405	14C2760T	001	100781	3603	2C	24656405	69
14C2758T	107895800	50	3626	62343062	14C2758T	001	140781	3603	2C	62343062	71
14C2779N	107896800	2	3626	62354096	14C2779N	001	230981	3603	2C	62354096	141
14C2778N	107897800	50	3626	51312503	14C2778N	001	190881	3603	2C	51312503	108
14C2777T	107898800	4	3626	24656303	14C2777T	001	080681	3603	2C	24656303	35
14C2776N	107899800	8	3626	62344503	14C2776N	001	051081	3603	2C	62344503	153

********** END OF REPORT **********



ANALYSIS OF HOURS ARE BEING WORKED ON - SHIFT AND PRIORITY CLASSIFICATION — DATE 300381

SHIFT	TRADE	NORMAL WORK		SYSTEM CHANGES		SHARES		URGENT REQUIREMENT		REWORK		PLANNED SPLIDGE		IMMEDIATE ACTION		TOTAL	
		NO	HOURS	NO	HOURS	NO	HOURS	NO	HOURS	NO	HOURS	NO	HOURS	NO	HOURS	NO	HOURS
01	[illegible]	4	34	0	0	0	81	53	787	0	0	1	1	43	474	102	1367
02	ELECTRICAL	1	1	0	0	0	0	15	74	0	0	9	78	3	44	29	203
03	[illegible]	17	17	1	1	1	42	99	1012	0	0	0	0	16	240	136	1429
04	[illegible]	7	171	0	0	1	180	77	2091	0	0	4	150	24	845	117	3891
05	[illegible]	3	11	0	0	0	0	40	625	0	0	0	0	6	78	49	815
06	[illegible]	1	10	0	0	0	0	30	313	0	0	11	253	1	50	42	760
07	CHEMICALS	10	61	0	0	0	6	25	472	0	0	1	1	0	200	44	740
08	BOWEN STATION	1	4	0	0	0	0	5	18	0	0	4	3	0	0	10	25
09	[illegible]	1	20	0	0	0	0	1	8	0	0	0	0	0	0	3	28
10	CENTRAL WORKSHOPS	0	0	0	0	1	12	4	24	4	15	0	0	6	19	15	80
11	TRANSPORT	1	1	0	0	0	0	4	24	0	0	0	0	6	176	11	201
13	FIRE AND MISC	2	11	0	0	4	100	64	1150	0	0	10	176	6	114	97	1557
14	EMS - SOUTH CENTRE	14	140	0	0	26C	9441	0	0	8	95	1	560	28	200	322	6431
16	EMS - CENTRAL WORKSHOPS	0	182	0	0	136	2198	14	146	0	0	0	0	38	1296	257	4782
	MEDIA CENTRAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RADIO CENTRAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	[illegible]	12	59	0	14	0	35	13	120	0	0	16	258	16	427	64	938
	[illegible]	65	1340	1	15	667	7684	443	7785	12	110	70	1614	261	4177	1360	23327

MCCORMICKS IN CENTRAL WORKSHOPS

ANALYSIS OF [illegible] AND [illegible] BY PLANT AND PRIORITY CLASSIFICATION PER WEEK — DATED 110881

ORIGINATING PLANT AREA	NAME	NORMAL WORK NO	NORMAL WORK HOURS	SYSTEM INCLUDED NO	SYSTEM INCLUDED HOURS	SCRAPES NO	SCRAPES HOURS	PRIORITY CLASSIFICATION: URGENT REQUIREMENT NO	URGENT REQUIREMENT HOURS	REWORK NO	REWORK HOURS	PLANNED SHUTDOWN NO	PLANNED SHUTDOWN HOURS	IMMEDIATE ACTION NO	IMMEDIATE ACTION HOURS	TOTAL NO	TOTAL HOURS
01	NO 2 AMMONIA	0	0	6	186	0	0	20	257	0	0	0	0	21	1540	47	2063
02	NITROGEN	0	0	3	134	0	0	2	22	0	0	4	13	1	10	10	184
03	CARBONATORS	0	0	0	64	0	0	15	211	0	0	0	0	5	17	25	292
04	B E	0	0	0	0	0	0	7	64	0	0	0	0	7	46	14	110
05	FUSC	2	0	2	11	3	0	7	147	0	0	1	1	0	0	11	159
06	NO 1 AMMONIA	0	0	1	8	0	2	1	6	0	0	0	0	2	3	5	17
07	CHEMICALS	0	0	2	6	0	0	5	31	0	0	0	0	9	40	16	76
08	POWER STATION	0	0	1	4	0	0	1	8	0	0	0	0	2	8	4	20
09	FLEET AND INST	0	0	0	0	0	0	1	12	0	0	0	0	0	0	1	12
10	CENTRAL WORKSHOPS	0	0	1	13	0	0	3	72	1	4	0	0	0	0	5	89
11	TRANSPORT	0	0	1	2	0	0	0	0	0	0	0	0	4	18	5	20
13	CIVIL AND MISC	0	0	3	8	0	0	5	93	0	0	0	0	8	44	16	145
14	FMS - SPARES CENTRE	0	0	0	60	0	0	19	308	0	0	0	0	1	207	28	568
14	FMS - CENTRAL WORKSHOPS	0	0	1	12	0	0	14	177	0	0	0	0	2	79	19	204
	MINOR CAPITAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	MAJOR CAPITAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	UNKNOWN ORDERS	0	0	1	16	0	0	0	0	0	0	0	0	0	0	1	16
	GRAND TOTALS	0	0	34	711	0	0	97	1345	1	4	5	14	63	2107	207	3981

		40	60	100	150	200	250	>250	
		17	08	14	14	22	03	172	

LISTING OF ORDERS IN SECOND HIGHEST CATEGORY

				AREA	WORK	WORKSPACE	
			PRIORITY	CODE	NUMBER	NUMBER	PRIORITY
14			3	01		015410508	3
14			3	01		014704202	3
14			3	01		014704200	3
14			3	01		017503508	3
14			3	01		017731208	3
14			3	01		017088508	3
14			3	02		016906108	3
14			3	02		004721208	3
14			3	03	25723	9487508	3
14			3	03		016702508	3
14			3	03		015013508	3
14			3	03		015510508	3
14			3	03		017119508	3
14			3	03		016502208	3
14			3	04		014105308	3
14			3	04		011415508	3
14			3	04		017707208	3
14			3	04		015228308	3
14			3	04		016815508	3
14			3	05		008732308	3
14			3	06		016616208	3
14			3	07		015035508	3
14			3	07		016407308	3
14			3	11		016308108	3
14			3	11		017406208	3
14			3	13		014524208	3
14			3	13		015234508	3
14			3	13		015234508	3
14			3	13		015234508	3
14			3	13		015234508	3
14			3	13		015234508	3
14			3	13		015234508	3

OPERATOR: ******* MODEL/SYSTEM: ********** RUN DATE (CCYYMM): ____ PAGE 2

T U R N A R O U N D T I M E A N A L Y S I S

PRIORITY : 4

EARLY JOBS - DAYS EARLY													LATE JOBS - DAYS OVERDUE											
>-50	-50	-40	-30	-25	-20	-15	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	>6
***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

NO. OF JOBS EARLY = 0 NO. OF JOBS LATE = 0

AVERAGE DEVIATION FROM REQUEST = 0
AVERAGE TURNAROUND TIME = 0
TOTAL JOBS WITH DUE DATE = 0
TOTAL JOBS WITHOUT DUE DATE = 0
TOTAL JOBS = 0

PRIORITY : 5

EARLY JOBS - DAYS EARLY													LATE JOBS - DAYS OVERDUE											
>-50	-50	-40	-30	-25	-20	-15	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	>6
***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
124	18	15	5	5	5	17	7	8	3	5	1	2	11	3	6	4	11	12	6	4	2	7	4	54

NO. OF JOBS EARLY = 208 NO. OF JOBS LATE = 181

AVERAGE DEVIATION FROM REQUEST = 63
AVERAGE TURNAROUND TIME = 84
TOTAL JOBS WITH DUE DATE = 331
TOTAL JOBS WITHOUT DUE DATE = 0
TOTAL JOBS = 331

PRIORITY : 6

EARLY JOBS - DAYS EARLY													LATE JOBS - DAYS OVERDUE											
>-50	-50	-40	-30	-25	-20	-15	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	>6
***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0

NO. OF JOBS EARLY = 5 NO. OF JOBS LATE = 2

AVERAGE DEVIATION FROM REQUEST = 35
AVERAGE TURNAROUND TIME = 40
TOTAL JOBS WITH DUE DATE = 2
TOTAL JOBS WITHOUT DUE DATE = 0
TOTAL JOBS = 2

COMPANY
****

MODEL/OPERATION
****

RUN DATE [illegible] PAGE 3

E X E C U T I O N - T I M E A N A L Y S I S
****

PRIORITY : 7

EARLY JOBS - DAYS EARLY

>-50	-50	-40	-30	-25	-20	-15	-10	-8	-6	-4	-2	0
***	***	***	***	***	***	***	***	***	***	***	***	***
0	0	0	0	0	0	1	0	1	1	2	10	1

LATE JOBS - DAYS OVERDUE

2	4	6	8	10	15	20	25	30	40	50	>50
***	***	***	***	***	***	***	***	***	***	***	***
3	0	0	4	2	4	1	1	2	0	0	2

NO. OF JOBS EARLY = 15

NO. OF JOBS LATE = 17

AVERAGE DEVIATION FROM REQUEST = 10
AVERAGE TURNAROUND TIME = 11
TOTAL JOBS WITH DUE DATE = 32
TOTAL JOBS WITHOUT DUE DATE = 0
TOTAL JOBS = 32

PRIORITY : 8

EARLY JOBS - DAYS EARLY

>-50	-50	-40	-30	-25	-20	-15	-10	-8	-6	-4	-2	0
***	***	***	***	***	***	***	***	***	***	***	***	***
0	0	0	0	0	0	0	0	0	1	3	0	1

LATE JOBS - DAYS OVERDUE

2	4	6	8	10	15	20	25	30	40	50	>50
***	***	***	***	***	***	***	***	***	***	***	***
0	0	0	0	0	0	0	0	0	0	0	0

NO. OF JOBS EARLY = 5

NO. OF JOBS LATE = 0

AVERAGE DEVIATION FROM REQUEST = 0
AVERAGE TURNAROUND TIME = 0
TOTAL JOBS WITH DUE DATE = 5
TOTAL JOBS WITHOUT DUE DATE = 0
TOTAL JOBS = 5

PRIORITY : 9

EARLY JOBS - DAYS EARLY

>-50	-50	-40	-30	-25	-20	-15	-10	-8	-6	-4	-2	0
***	***	***	***	***	***	***	***	***	***	***	***	***
10	3	0	0	1	6	10	30	11	36	72	19	5

LATE JOBS - DAYS OVERDUE

2	4	6	8	10	15	20	25	30	40	50	>50
***	***	***	***	***	***	***	***	***	***	***	***
7	8	8	4	3	5	2	0	1	5	0	1

NO. OF JOBS EARLY = 172

NO. OF JOBS LATE = 44

AVERAGE DEVIATION FROM REQUEST = 11
AVERAGE TURNAROUND TIME = 4
TOTAL JOBS WITH DUE DATE = 225
TOTAL JOBS WITHOUT DUE DATE = 0
TOTAL JOBS = 225

CAMPBELL
****

HOLCOMB/CRAIG
****

SLM DATE CCYYJJJ PAGE 1

TURNAROUND TIME ANALYSIS
.....

GRAND TOTAL

EARLY JCPS - DAYS EARLY

5-9C	-5C	-4C	-3C	-2C	-2C	-1C	-1C	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	15	20	25	30	40	50	25C
***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
134	14	15	5	6	8	28	17	32	42	77	32	12	21	11	12	12	15	21	12	8	4	11	0	59										

LATE JCPS - DAYS OVERDUE

NO. OF JCPS EARLY = 350

NO. OF JCPS LATE = 188

AVERAGE DEVIATION FROM REQUEST	=	48
AVERAGE TURNAROUND TIME	=	27
TOTAL JCPS WITH DUE DATE	=	541
TOTAL JCPS WITHOUT DUE DATE	=	0
TOTAL JCPS	=	541

CAMPUS ******** MODEL/PROTEIN ********** RUN DATE 07/11/91 PAGE 8

TURNAROUND TIME ANALYSIS

PRIORITY : 4

EARLY JOBS - DAYS EARLY | LATE JOBS - DAYS OVERDUE

>-50	-50	-40	-30	-25	-20	-15	-10	-8	-6	-4	-2	0	2	4	6	8	10	15	20	25	30	40	50	350
***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

NO. OF JOBS EARLY = 0 | NO. OF JOBS LATE = 0

AVERAGE DEVIATION FROM PLAN = 0
AVERAGE TURNAROUND TIME = 0
TOTAL JOBS WITH FCF DATE = 0
TOTAL JOBS WITHOUT FCF DATE = 0
TOTAL JOBS = 0

PRIORITY : 5

EARLY JOBS - DAYS EARLY | LATE JOBS - DAYS OVERDUE

>-50	-50	-40	-30	-25	-20	-15	-10	-8	-6	-4	-2	0	2	4	6	8	10	15	20	25	30	40	50	350
***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
30	13	14	14	5	8	13	5	9	13	21	14	42	11	7	12	4	1	16	4	6	2	5	10	49

NO. OF JOBS EARLY = 183 | NO. OF JOBS LATE = 117

AVERAGE DEVIATION FROM PLAN = 22
AVERAGE TURNAROUND TIME = 44
TOTAL JOBS WITH FCF DATE = 300
TOTAL JOBS WITHOUT FCF DATE = 23
TOTAL JOBS = 321

PRIORITY : 9

EARLY JOBS - DAYS EARLY | LATE JOBS - DAYS OVERDUE

>-50	-50	-40	-30	-25	-20	-15	-10	-8	-6	-4	-2	0	2	4	6	8	10	15	20	25	30	40	50	350
***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0

NO. OF JOBS EARLY = 0 | NO. OF JOBS LATE = 2

AVERAGE DEVIATION FROM PLAN = 22
AVERAGE TURNAROUND TIME = 45
TOTAL JOBS WITH FCF DATE = 2
TOTAL JOBS WITHOUT FCF DATE = 0
TOTAL JOBS = 2

CMSTOP ******* MODDEMCENTER ********** RUN DATE 02/15/01 PAGE 7

TURNAROUND TIME ANALYSIS

PRIORITY : F

EARLY JOBS - DAYS EARLY

>=50	-50	-40	-30	-25	-20	-15	-10	-8	-6	-4	-2	0
0	0	0	0	0	0	0	0	0	0	0	0	26

LATE JOBS - DAYS OVERDUE

2	4	6	8	10	15	20	25	30	40	50	350
0	0	0	0	1	4	0	0	1	0	0	1

NO. OF JOBS EARLY = 0 NO. OF JOBS LATE = 7

AVERAGE DEVIATION FROM PLAN = 4
AVERAGE TURNAROUND TIME = 11
TOTAL JOBS WITH ECF DATE = 7
TOTAL JOBS WITHOUT ECF DATE = 26
TOTAL JOBS = 33

PRIORITY 1 F

EARLY JOBS - DAYS EARLY

>=50	-50	-40	-30	-25	-20	-15	-10	-8	-6	-4	-2	0
0	0	0	0	0	0	0	0	0	0	0	0	0

LATE JOBS - DAYS OVERDUE

2	4	6	8	10	15	20	25	30	40	50	350
0	0	0	0	0	0	0	0	0	0	0	0

NO. OF JOBS EARLY = 0 NO. OF JOBS LATE = 0

AVERAGE DEVIATION FROM PLAN = 0
AVERAGE TURNAROUND TIME = 0
TOTAL JOBS WITH ECF DATE = 0
TOTAL JOBS WITHOUT ECF DATE = 0
TOTAL JOBS = 0

PRIORITY 2 0

EARLY JOBS - DAYS EARLY

>=50	-50	-40	-30	-25	-20	-15	-10	-8	-6	-4	-2	0
0	1	1	0	0	0	5	1	3	0	0	0	211

LATE JOBS - DAYS OVERDUE

2	4	6	8	10	15	20	25	30	40	50	350
4	2	0	0	2	1	0	0	0	0	1	1

NO. OF JOBS EARLY = 3 NO. OF JOBS LATE = 11

AVERAGE DEVIATION FROM PLAN = 1
AVERAGE TURNAROUND TIME = 4
TOTAL JOBS WITH ECF DATE = 14
TOTAL JOBS WITHOUT ECF DATE = 211
TOTAL JOBS = 225

TURNAROUND TIME ANALYSIS

PRIORITY : 1

EARLY JOBS - DAYS EARLY													LATE JOBS - DAYS OVERDUE											
>-50	-50	-40	-30	-25	-20	-15	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
0	0	0	0	0	0	0	0	0	1	0	0	0	26	0	0	0	0	1	0	0	1	0	0	1

EARLY JOBS - DAYS EARLY													LATE JOBS - DAYS OVERDUE											
8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	40	>50
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

NO. OF JOBS EARLY = 0 NO. OF JOBS LATE = 7

AVERAGE DEVIATION FROM PLAN = 4
AVERAGE TURNAROUND TIME = 11
TOTAL JOBS WITH PCF DATE = 7
TOTAL JOBS WITHOUT PCF DATE = 26
TOTAL JOBS = 33

PRIORITY : 2

EARLY JOBS - DAYS EARLY													LATE JOBS - DAYS OVERDUE											
>-50	-50	-40	-30	-25	-20	-15	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

EARLY JOBS - DAYS EARLY													LATE JOBS - DAYS OVERDUE											
8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	40	>50
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

NO. OF JOBS EARLY = 0 NO. OF JOBS LATE = 0

AVERAGE DEVIATION FROM PLAN = 0
AVERAGE TURNAROUND TIME = 0
TOTAL JOBS WITH PCF DATE = 0
TOTAL JOBS WITHOUT PCF DATE = 0
TOTAL JOBS = 0

PRIORITY : 3

EARLY JOBS - DAYS EARLY													LATE JOBS - DAYS OVERDUE											
>-50	-50	-40	-30	-25	-20	-15	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
0	1	1	0	0	0	0	1	0	0	0	0	0	211	4	2	0	0	3	1	0	0	0	1	1

EARLY JOBS - DAYS EARLY													LATE JOBS - DAYS OVERDUE											
8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	40	>50
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

NO. OF JOBS EARLY = 1 NO. OF JOBS LATE = 11

AVERAGE DEVIATION FROM PLAN = 1
AVERAGE TURNAROUND TIME = 4
TOTAL JOBS WITH PCF DATE = 14
TOTAL JOBS WITHOUT PCF DATE = 211
TOTAL JOBS = 225

CAPACITY
****

MODIFICATION
****

ALA DATE 02/11/81 PAGE 4

TURNAROUND TIME ANALYSIS
****

DEMAND TOTAL

EARLY JOBS - DAYS EARLY													LATE JOBS - DAYS OVERDUE											
-60	-53	-47	-41	-35	-29	-23	-17	-11	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
30	34	17	24	3	5	13	7	9	11	13	14	274	15	9	12	9	9	12	4	6	3	5	11	51

11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
4	4	22	4	6	2	5	11	51																

NO. OF JOBS EARLY = 105

NO. OF JOBS LATE = 197

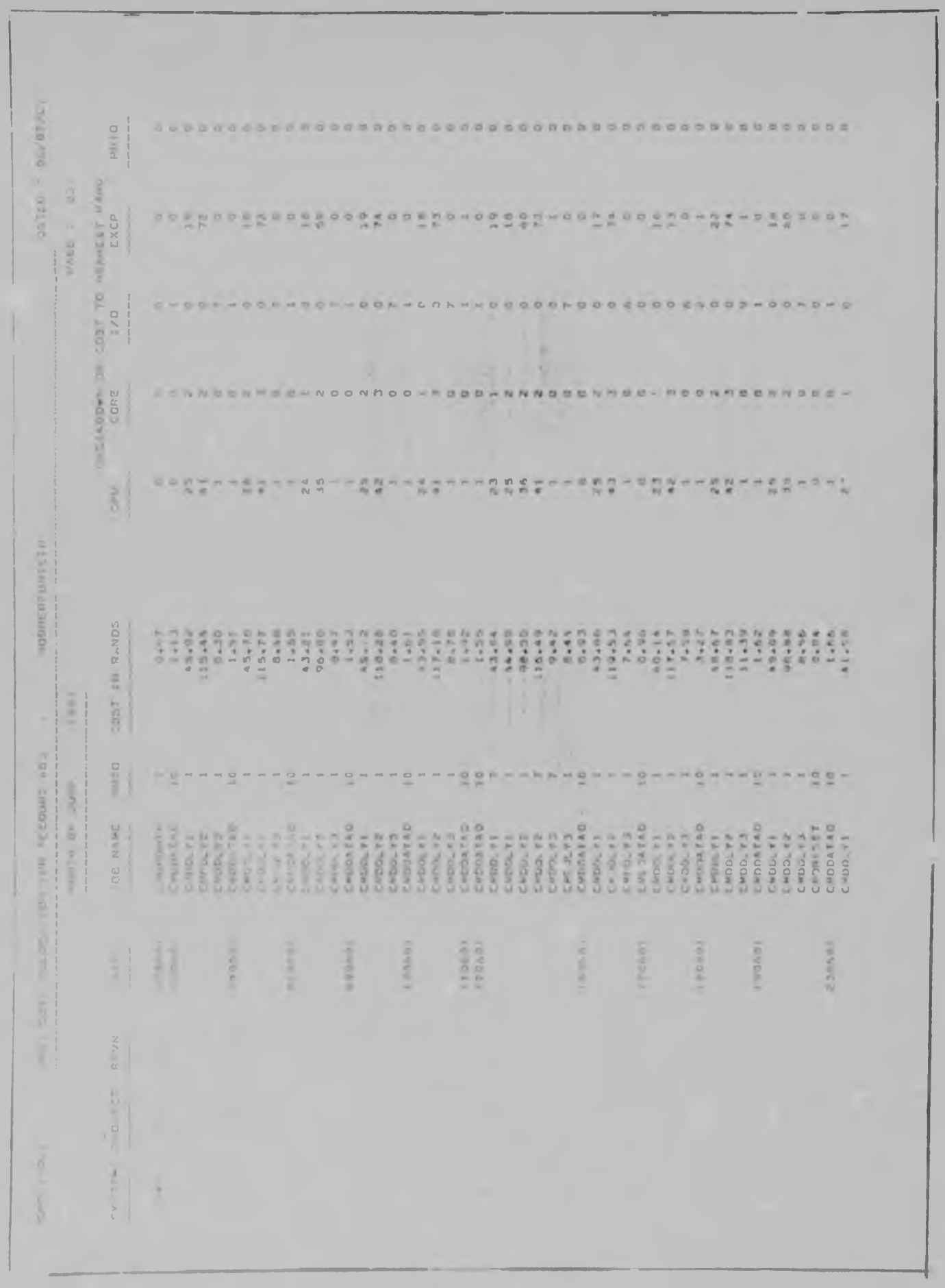
AVERAGE DEVIATION FROM PLAN	=	19
AVERAGE TURNAROUND TIME	=	27
TOTAL JOBS WITH DUE DATE	=	331
TOTAL JOBS WITHOUT DUE DATE	=	300
TOTAL JOBS	=	631

20b

[illegible] JOB SHOP

[illegible] MASTER DATA

MCN	MTC	DESCRIPTION	NO. OF SINGLE MACHINES	EFF. %	QUEUE TIME FACT.	AVERAGE QUEUE TIMES IN HOURS FOR PRIORITY GROUPS 1 2	3	4	ALTERNATE M/C'S 1ST	2ND	3RD
1	[illegible]	[illegible]	15	100	0	5.9	6.5	16.8	8.5		
2	[illegible]	[illegible]	4	100	4	8.1	2.6	24.4	12.5		
3	[illegible]	[illegible]	2	100	7	2.1	5.1	7.3	7.9		
4	[illegible]	[illegible]	3	100	4	3.9	10.1	4.1	8.8		
5	[illegible]	[illegible]	INF	150	1	9.0	6.2	9.0	1.0		
6	[illegible]	[illegible]	1	100	6	6.9	6.8	6.5	6.5		
7	[illegible]	[illegible]	15	100	7	8.1	8.5	8.0	9.9		
8	[illegible]	[illegible]	10	75	7	7.0	6.8	8.2	8.5		
9	[illegible]	[illegible]	6	100	8	12.1	8.0	8.4	8.1		
10	[illegible]	[illegible]	5	75	5	8.5	8.9	5.2	9.2		
11	[illegible]	[illegible]	1	100	7	8.0	8.2	19.5	10.9		
12	[illegible]	[illegible]	1	100	13	16.3	8.4	7.2	9.5		
13	[illegible]	[illegible]	3	100	7	7.1	8.9	15.9	8.8		
14	[illegible]	[illegible]	8	75	8	8.4	8.8	8.5	8.5		
15	[illegible]	[illegible]	1	100	11	12.3	10.8	9.1	7.1		
16	[illegible]	[illegible]	1	100	7	7.3	7.1	7.0	8.6		
17	[illegible]	[illegible]	1	100	10	1.9	8.5	7.4	8.9		
18	[illegible]	[illegible]	3	100	4	8.5	14.8	11.5	7.8		
19	[illegible]	[illegible]	1	100	13	23.1	11.8	13.9	5.5		
20	[illegible]	[illegible]	2	100	2	15.8	4.6	7.8	12.2		
21	[illegible]	[illegible]	INF	100	1	9.0	8.9	1.0	1.0		
22	[illegible]	[illegible]	3	100	8	8.1	8.5	8.9	8.5		
23	[illegible]	[illegible]	2	100	12	4.8	10.5	7.4	8.8		
24	[illegible]	[illegible]	1	100	15	15.8	11.1	11.5	7.5		



CAPOSS INPUT DATA

CARD TYPE: CW 52 OPERATION ADD

CARD TYPE	AREA	WORKS ORDER NUMBER	SHUTDOWN CODE	CAPOSS NUMBER	OPERATION NUMBER	WORK CENTRE	GROUP CODE	OPERATION DESCRIPTION	QUANTITY	STANDARD TIME	INSPECTION	PLANNED M'N	ALT W/C	ASSIST	DELAY
1 2	3	4 5 6 7	12 13 14	15 21	22 25	26 28	29 30	31 63	64 69	70 73	74	75	76	77	78 80
CW	52														

CAPOSS INPUT DATA

CARD TYPE: CW 51 OPERATION CANCEL
CW 53 OPERATION MODIFY

CARD TYPE	AREA	WORKS ORDER NUMBER	SHUTDOWN CODE	CAPOSS NUMBERS	OPERATION NUMBER	WORK CENTRE	GROUP CODE	OPERATION DESCRIPTION	QUANTITY	STANDARD TIME	INSPECTION	PLANNED MEN	ALT W/C	RELATED FAC	DELAY
1 4	5 6	7 12	13 14	15 22	23 27	28 28	29 30	31 65	66 69	70 73	74	75	76	77	78 80
CW53															
CW51															

Processing Description

Figure 36 presents a general data flow of CAPOSS. It is subdivided into eight functional modules. They, in turn, consist of several phases. Most of the functions outlined in the section General Description of Application must be developed in stages through many phases. For example, to be able to allocate split operations in the Operation Sequencer, the data required is prepared by the preceding phases. This applies to all functions.

The Scheduling System

The Run Data Maintenance phases create and maintain the Run Data files which include all program parameters, input/output descriptions, work center data, and capacity event specifications. Several variations can be stored for phase parameters, input file descriptions, and report layouts. Before the scheduling program is executed, a short initialization phase must be executed to determine which variations of the phases are to be used, and to update the key date for the scheduling execution. The Work Center file and Capacity Event file are also created and maintained by this module. All data can be printed by special print options contained in this module.

The objective of the Order Management phases is to create and maintain the Order file. This is the order-dependent Data file used by the scheduling system. It is a permanent file and contains the master order information. For this reason, a forced backup is built into the data flow.

The new Order file, when created, is immediately used and checked by the succeeding phase. As the system is designed for large volume files, tape storage can be used to store the Order file.

The Order Management phases are assumed to be executed in a longer range cycle, e.g., weekly. Therefore, it is necessary to be able to update the Order file with all changes that have been made during the week. This is done either by using the Subset Order file which is maintained in the later phases on a daily basis, or directly into the Order Management module if the Subset Order file is not being maintained as would be common in the early installation period.

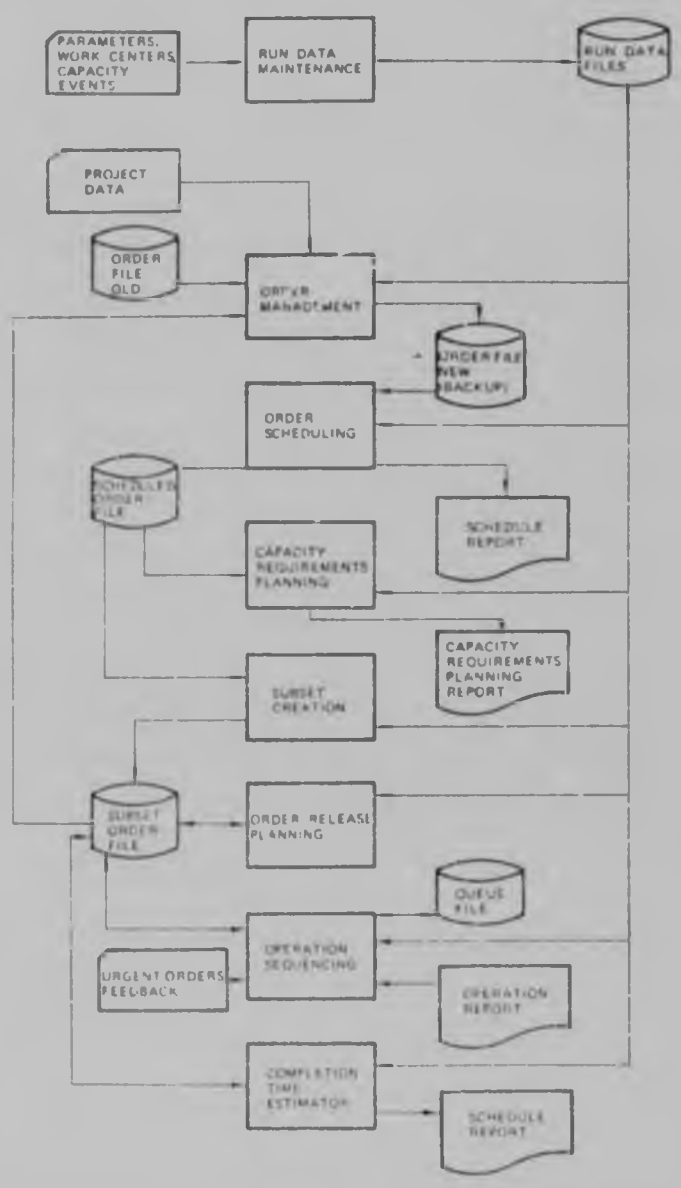


Figure 36. CAPOSS

The logic required to schedule single orders is simpler than that necessary to schedule networks. For this reason, and because in some application areas networks

are not used, the processing of orders and network scheduling have been separated. In Order Scheduling, material records can be used.

If networks are specified, critical path techniques are applied to compute the schedule dates. Orders from different projects may be interconnected within a network.

In Order Scheduling, only those orders are rescheduled for which data has been changed since the last scheduling execution.

The results obtained from Order Scheduling assume that there are no capacity restrictions. They test the feasibility of manufacturing an order by the user-specified due date. The results of this test are reflected in the priority computations used by the loading phases which respect capacity restrictions.

Capacity Requirements Planning evaluates the results of the Order Scheduling phases. It determines the overall latest and earliest start date loads and tries to level these over the available capacity. It also computes the offload possibilities in the event of overloads to alternate work centers if required. Computations such as this give an idea of the real capacity requirements. These computations can be made for all orders held in the Order file.

All modules up to this point process the Order file sequentially. For this reason, disk or tape storage was possible. The remaining modules require the data in direct-access mode and, in terms of a date range, only require the imminent orders. For this reason, the main Order file is subset and this disk file used in the remaining modules. This is achieved using the Subset Creation phases.

Order Release Planning reviews each order to determine whether sufficient capacity is available to produce the order on time. If a bottleneck occurs, the resulting delay is used to influence the release of the order in the Operation Sequencer or to influence the order priority.

The Operation Sequencing phases perform the actual machine loading with regard to all functions outlined in the section General Description of Application. This module of the program is designed to be executed in short-range cycles. In the short-range cycle, e.g., daily, it includes a complete feedback system and allows the insertion of urgent orders and changes. It also supplies the operation report (work-sequence report) which gives the scheduled sequence of operations for each work center or, if required, for each subgroup or single machine. The Operation Sequencer computes the actual queue time for each operation and, therefore, does not use the user input value for the work center.

Based on these results, the Completion Time Estimator determines the probable continuation and completion of all orders in process. In additio , it loads the remaining orders on hand in the Subset Order file. It uses updated queue times considering the experience of the earlier executions of the Operation Sequencer phase.

Programming Systems

The IBM System/360 and System/370 Capacity Planning and Operation Sequencing System is written in Assembler language using the macro language facility. It can operate under the

- IBM Operating System (OS) MFT and MVT, or
- IBM Disk Operating System (DOS).

Both sequential and direct-access data management and access methods are used.

In addition, one of the following service programs is used:

- IBM Operating System, Sort/Merge (Program Product 5734-SM1 or Program Number 360S-SM-023), or
- IBM Disk Operating System, Tape and Disk Sort/Merge (Program Product 5736-SM1), or Disk Sort/Merge (Program Number 360N-SM-450).

The sort program is combined into the relevant CAPOSS mainline programs to ensure full control of the execution sequence of the phases within the data flow.

JOB SHOP PRODUCTION PLANNING & CONTROL - CASE STUDY

(AECI Modderfontein -- Central Workshops)

Part C

Implementation of Overall Management Study Recommendations

Part C

CONTENTS

		Page
INTRODUCTION		1
1.	JOB SHOP PRODUCTION PLANNING & CONTROL - GENERAL	2
2.	SYSTEM ANALYSIS	
2.1.	Recognition and formulation of the problem	2
2.2.	Organization of the project	3
2.3.	Definition of system objectives	3
2.4.	System design	4
2.5.	Modification of the system in order to rectify the situation	7
2.6.	Operation	13
3.	DETERMINATION OF WORK CENTRE CAPACITY	15
4.	PLANNING SECTION	
4.1.	Organization structure	16
4.2.	Key performance areas	16
5.	LONG TERM JOBS	
5.1.	General	18
5.2.	Action taken	18
6.	PLACING OUTSIDE ORDERS	
6.1.	General	20
6.2.	Placing outside material/manufacturing orders - Overall solution	21
6.3.	Order inspection of expediting	21
6.4.	Backlog	22
6.5.	Alternative suppliers	22
7.	QUALITY ASSURANCE	
7.1.	Procedures	23
7.2.	Spoiled Work	23
7.3.	Rejected Work	23
8.	FLOOR MANAGEMENT : PROCEDURES, REGULATIONS & TRAINING	
8.1.	General	25
8.2.	Daily Work List	25
8.3.	Standard times for jobs	27
8.4.	Training & Motivation	28

2/...

		Page
9.	ESTIMATING	
	9.1. General	30
	9.2. Liaison with shop floor	30
	9.3. Feedback	30
	9.4. Specifications and drawings	30
	9.5. Liaison with the planning section	31
10.	BONUS SCHEME	
	10.1. Background	32
	10.2. New bonus scheme	32
	10.3. Summary	35
11.	COSTING	36

APPENDICES

1 : Emergency Jobs Loading into the System

2 : Emergency Jobs

3a : Planning & Control Section Delivery Dates - State
3b : Planning & Control Section Hours Loaded per Work Centre - State

4 : Changes in CFDs due to the new scheduling approach

5 : Amendment List to the Stores System Delivery Dates & Lead Times

6 : Factory Made Spares (Isando)- Capacity requirements (Extracts from memorandum)

7a : Backlog & Incoming Work
7b : Monthly Work Centre Capacities

8 : Planning & Control - Organization Structur

9 : Planning & Control - Key Performance Areas

10 : Jobs Resicence Time

11 : Approved list of Suppliers and Manufacturing Delivery Time

12 : Report 46 - Listing of outstanding orders

13 : Quality Assurance Procedure Standard

14 : Spoiled Work

15 : Illustration - Times Schedule

16a : Engineering Work Order
16b : Engineering Work Order - Check List
16c : Engineering Work Order - Continuation Sheet

17a : Estimator Planner - FMS job request procedure
17b : Estimator Planner - Plant job request procedure

18 : Engineering Time Card

19 : Bonus Scheme - Recommended operation card

INTRODUCTION

This report presents the implementation stage of the October 1980 Overall Management Study, in Central Workshops, from 15.3.81 to 15.10.81.

The first action taken following the recommendations, was to appoint the author as Workshops Planning & Control Engineer.

The report covers the main areas of treatment concerned with the general recommendations of Part A on this project and concentrates mainly on the Planning & Control section: The right approach for Job Shop Production scheduling, re-organization of the section, Floor management training, quality control procedures, recommended Bonus Scheme system and other matters concerning management in the Workshops.

1. JOB SHOP PRODUCTION PLANNING & CONTROL - GENERAL

The first assigned area for in-depth study, was the approach to scheduling in Job Shop Production.

A mandate was given to investigate and implement the right application of CAPOSS or, alternatively, to modify the system so that it suited our needs without eliminating the system entirely. As the latter was the case, we adhered to the CAPOSS approach, i.e. Job Priorities and Due Dates given by the customers.

Generally, the system works as follows:

Based on existing work in the system and on all other factors involved in scheduling, the programme creates a Calculated Finish Date for each job. However, as regards quality of service, it was a total failure, as Finish Dates were being changed frequently.

In the following paragraphs on system analysis, we try to follow the Systems Engineering hard methodology by Jenkins, which is essential when dealing with implementation of a computerised Management Information System. This is done by comparing what was done when CAPOSS was introduced 2 years ago to what should have been done and the manner in which the problems in the Planning & Control system have been rectified.

2. SYSTEM ANALYSIS

2.1. Recognition and formulation of the problem

Fundamentally, the main problems in the Central Workshops were:

- Manual system not functioning proficiently
- Work not being based on a schedule and production programme
- Work centres being overloaded
- Some work centres not being used to their full potential
- Shifting bottlenecks
- Loss of jobs
- Loss of paperwork and drawings
- Low efficiency
- Poor control over jobs and material in process
- Loss of control over outside materials/manufacturing orders
- Inability to determine CAPACITY requirements vs demands
- Average turnaround time of a job into the system being more than 12 days
- Low quality of work

The above are, in brief, the main problems which were identified before the implementation of CAPOSS, and the reason why an Engineer was appointed to carry out an investigation under the heading "Central Workshops - New Planning & Control System" and thereafter, to recommend a comprehensive solution.

3/...

2.2. Organization of the project

The Company has not had a great deal of systems experience.

The team conducting the study consisted of:

i) An Industrial Engineer as team leader
(with no experience in production at all)

ii) A Production Superintendent

iii) 2 Programmers

The allocated budget amount for this project was approximately R100 000.

The team did not include an experienced Systems Analyst or high level Engineers who could have viewed the problem on a wider base and analysed the system correctly.

The investigation was short and included interviews with Customers, shop floor management and personnel in the Planning Office.

From the start, the approach was that Planning & Control should be computerized.

The team leader concentrated more on procedures and control than on the quality of service given by the Workshops.
The programmers were passive at this stage.

No flow charts were drawn up and knowledge concerning the requirements and objectives of the new system was vague.

The second part of the investigation consisted of trying to find a similar Workshop in South Africa, with a computerized Planning & Control System and to try to implement it in Central Workshops.

The team found a working system called "CAPOSS", which was in use at a shipyard in a South African Naval Base. Similarities existed between the two Workshops and in the type of service they offered.

Although the Navy personnel did not have much experience, they recommended the system and AECI decided to implement it in the Central Workshops.

2.3. Definition of system objectives

Due to the lack of knowledge and experience, this stage has not been done at all. The definition had been determined on the Planning & Control of Investigation Sheet (the mandate for the investigation).

A/...

Definition of system objectives is based on a broad study of the system, procedures and any constraints to which the system may be subject to. If the foregoing had been done properly, it would have become apparent that the Production Planning & Control objective is subject to certain constraints, such as:

a) What is the correct philosophy of planning - real queue or system working on job priorities ?

b) Should all jobs pass through the system or not ?

What happens in the event of breakdowns and plant shutdowns ?

How will the system work with the computerized inventory system, which places orders for FMS (Factory Made Spares) work to the Central Workshops.

What are the objectives of the system with regard to Plant Made Spares, which have different problems from that of Central Workshops as regards Production Planning & Control ?

What are the economic criteria in order to make a decision on the chosen system ?

None of these questions were answered, although they are some of the main factors which should have been taken into consideration before deciding to implement CAPOSS.

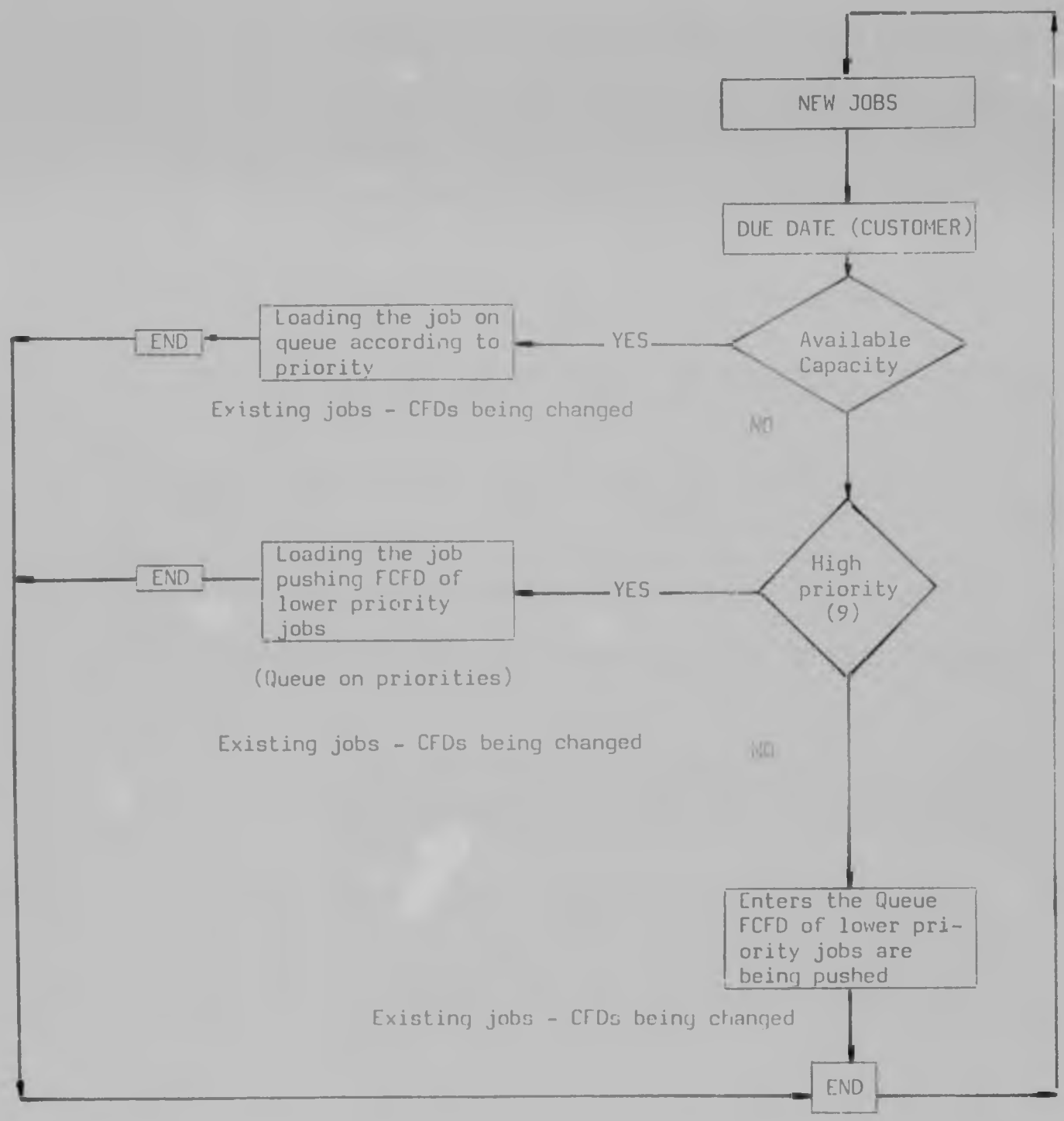
2.4. System design

As mentioned previously, no systems design was used before the decision was made on the type of system required, and the design concentrated on procedures and paper work for the new system.

This chapter does not discuss CAPOSS as it is described in detail in Part B of this project,but it does give the practical results obtained when following the CAPOSS approach.

Actually, the whole priority approach built into CAPOSS can be illustrated schematically, by simplification, as shown on the following page:

5/...



FCFD - First Calculated Finish Date
CFD - Current Finish Date

6/...

2.4.1. Explanation

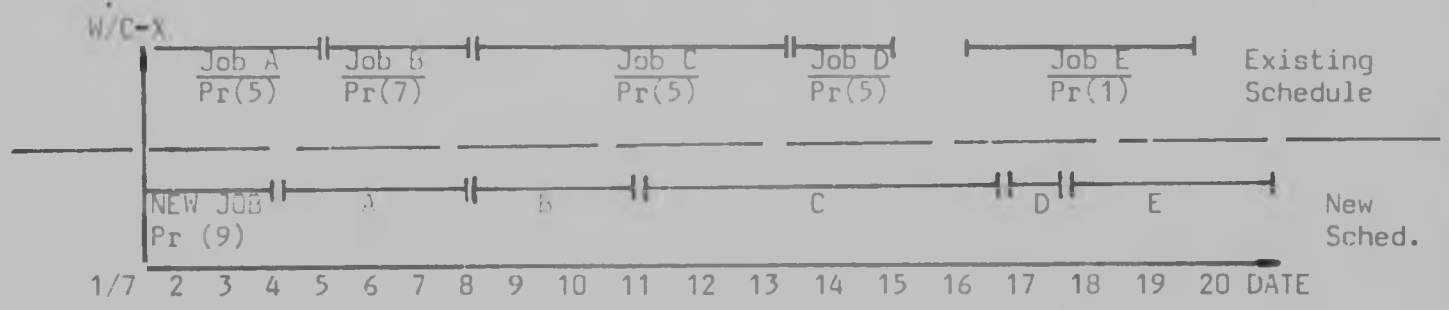
The key factor of the Programme in the process of determining the CURRENT FINISH DATE, is the flexibility.

The First Calculated Finish Date is based on due dates and external priority in the first stage and on operation priority only, in the second stage.

The scheduling programme for the existing jobs is changed depending on job priorities as compared with the new jobs entering the system.

The following figure illustrates what happens practically when such a system is in action:

Assume that the present loading programme in Work Centre X is as follows: (No matter if the W/C is over or under loaded)



Pr = priority

A new job with priority 9 coming in on 3 July and due to be delivered on 4 July, will change the whole schedule, and therefore all the promised First Calculated Finish Dates will be changed.

Now, it must be remembered that not only one job is coming into the system, but many others, and customers (the various plants) are not aware of the requirements of other plants, so the whole schedule for Finish Dates changed many times and there were jobs which were in the system for more than 2 years, simply because the customer was naive and gave priority 3, 2 or 1 for his order.

It was understood very quickly by the customers that, if they wished to get their job done, they had to use priority 9.

However, short jobs which were real emergencies could not appear on the Daily Work List because of the great backlog and automatic load of jobs (superior priority).

7/...

2.4.1. Explanation

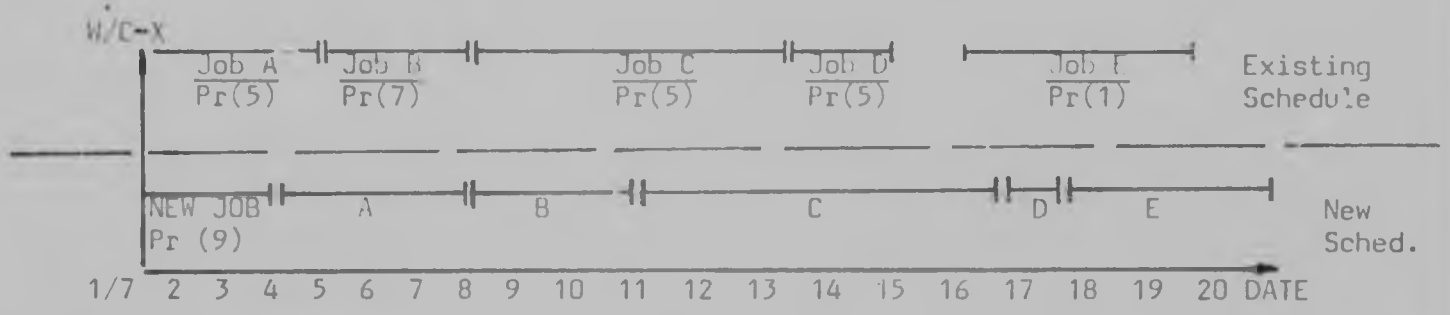
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The First Calculated Finish Date is based on due dates and external priority in the first stage and on operation priority only, in the second stage.

The scheduling programme for the existing jobs is changed depending on job priorities as compared with the new jobs entering the system.

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Pr = priority

A new job with priority 9 coming in on 3 July and due to be delivered on 4 July, will change the whole schedule, and therefore all the promised First Calculated Finish Dates will be changed.

Now, it must be remembered that not only one job is coming into the system, but many others, and customers (the various plants) are not aware of the requirements of other plants, so the whole schedule for Finish Dates changed many times and there were jobs which were in the system for more than 2 years, simply because the customer was naive and gave priority 3, 2 or 1 for his order.

It was understood very quickly by the customers that, if they wished to get their job done, they had to use priority 9.

However, short jobs which were real emergencies could not appear on the Daily Work List because of the great backlog and automatic load of jobs (superior priority).

7/...

The following table depicts what happens, in any one week, to a few jobs in 3 Work Centres, using the priorities approach.

W/C	CAPOSS NUMBER	FCFD	PRIORITY	LAST WEEK		THIS WEEK		CFD HAS BEEN CHANGED (TIMES)
				CSD	CFD	CSD	CFD	
M01	024782800	1012	3	1046	1046	1069	1069	6
	100991800	1024	3	1073	1073	1078	1078	8
	100992800	1030	3	1109	1109	1104	1115	8
	101002200	1009	5	1072	1072	1072	1072	10
	104015900	982	7	1077	1078	1082	1082	6
	104708900	1041	9	1063	1063	1069	1069	4
M11	102106500	898	5	1068	1069	1070	1070	8
	102294800	1062	3	1076	1077	1082	1083	2
	103098801	1043	3	1076	1077	1076	1077	4
	103098802	1041	3	1076	1076	1075	1076	7
C02	103015300	782	1	1116	1117	1032	1033	24
	103018300	812	5	1096	1096	1112	1112	12
	103109800	782	3	1167	1167	1167	1167	16
	103211300	1024	3	1096	1096	1112	1112	8

W/C = Work Centre
FCFD = First Calculated Finish Date
CSD = Current Start Date
CFD = Current Finish Date

2.5. Modification of the system in order to rectify the situation

2.5.1. Analysis

The first step, was to find out the distribution of job priorities, job duration, capacity versus demand, backlogs and meeting of estimated times.

Findings:

a) A significant finding, which contradicted the philosophy of the system, was that one customer was unaware of his job's priority in comparison with those of other customers. It was then decided to appoint a particular person in the Planning and Control Section, to determine the priority and due dates for jobs.

The appointee was an ex-Engineering Superintendent, with more than 30 years experience in the various plants throughout Modderfontein Factory. He undertook this job for more than 3 months. However, the exercise failed totally.

B/...

b) Another finding was that 45% of the total number of incoming jobs per month (500). are real Emergency or short jobs. All the others are Ordinary jobs which can be delivered within two months, or three in the case of awaiting spares.

c) The average capacity required for Emergency jobs is 8% of the total. (For an analysis of Emergency job loading into the system, see Appendix 1).

A real Emergency job by definition is one which affects production. Hence, it must be completed within 24 hours of receipt, provided that problems such as outside ordering of material/manufacturing, quality control rejection, etc do not exist.

If processing Emergency jobs through the system and considering the above findings, means recurring changes to the existing schedule, this became one of the most important factors which upset CAPOSS, in our case.

d) As Emergency jobs are sometimes completed before punching, their existance on the next day's work list means a boosting of waiting time. We found that the amount of waiting time due to this was, on average, 12 , throughout the workshops, whilst the workshops capacity compared to input work was, theoretically, overloaded.

One could say that an on-line system could solve this problem. Theoretically, that would be correct, but as the volume of existing work in our system consumes large amounts of computer time per run, it is done only during the night.

e) From discussions and interchange of ideas between workshops management and various plant engineers, it was clarified that our services are assessed using two factors:

i) Quality of Product : Based on Factory agreed specifications

ii) Quality of Service : Reasonable turnaround time and a constant delivery date with minor deviations (± 3 days)

9/...

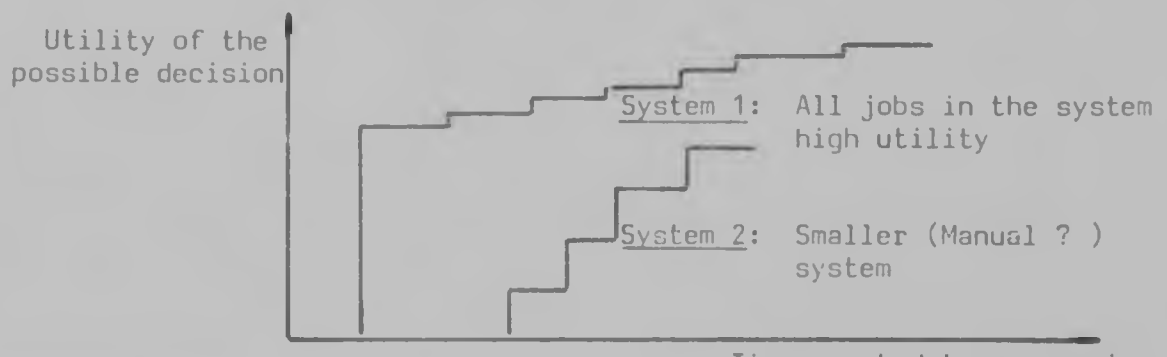
2.5.2. Discussion and decisions

a) Discussion

If the findings mentioned previously were discovered before introducing CAPOSS, it would appear that another system, with a different scheduling approach, was introduced.

As implementation of the 1980 Overall Study Recommendations was subject to the constraint of not eliminating CAPOSS, but modifying as required, a discussion on following a Systems Engineering approach for MIS, was held.

When considering the utility of MIS, the related idea is that different types of MIS cause different utility value as function of time spent for Data Processing. Assuming that CAPOSS is a very sophisticated system in relation to other systems, it can be illustrated as follows:



The idea behind this figure is that, if we can get quick answers in the first case, the more beneficial it will be to us. However, in System 2, we get an improved quality of ideas, in time.

The game is between getting the same suggested answer or quality of information from one system versus the other.

By modifying the system as described in subsequent chapters, we sacrifice gain due to delays but we gain an improved decision making and accurate delivery date system.

b) Decisions

Based on the findings already described and the above discussion, the following decisions were made in order to rectify the scheduling system:

There will be 2 systems:
i) Manual Planning for Emergency jobs
ii) Computerized system for Ordinary jobs

10/...

The actions following this decision were:

i) Allocation of an arbitrary capacity for emergency jobs (10%) and manual management of jobs from this class. (Emergency jobs procedure, paper work, printing into CAPOSS. Performance Measurement and reliability - See Appendix 2)

In future, the allocation of capacity for emergencies will be more accurate, as the new monthly report,"Emergencies per Work Centre", was introduced. (See Part B, Appendix 4). Using methods for forecasting, such as moving average, exponential smoothing, etc, will enable the analysing of hours required for Emergencies, from the data given in this report.

ii) All other jobs will be called "ORDINARY JOBS" from now on. They will have the same priority (5) and the computerized system for these jobs should work on a real queue basis - First Come, First Served. This is done by giving due dates as per work centre and capacity, in the following way:

i) Table 1 - Due Dates - State

ii) Table 2 - Hours loaded per work centre - State

(Tables 1 & 2 - see Appendix 3)

Every operation of a new job coming into the system is allocated to the required work centre and the due date is determined, based on the latest due date of the work centre concerned. The due dates on the list are changed when the amount of hours allocated to the particular work centre is approximately equal to the capacity available in the work centre on a particular date. Figure 1 illustrates how this procedure is carried out:

Table 1 - Due Date State

Work Centre	M01	M02	S01	S02	F05	F06	C03	C04
Sequence	1208	1206	126	1203	1211	1201	1198	1206
	1209		1214				1199	1202
Running	1210							1208
Due Dates								

11/...

Table 2 - Hours Loaded - State

Work Centre	M01	M02	S01	S02	F05	F06	C03	C04	B01	B02
Av. Capacity	49	41	36	72	189	116	38	62	280	
Hours Loaded	16	0,5	38	16	172	24	13	112		
	13	6	(2)	4	16		22	16		
	18	3	13	12	—		(3)			
	44	4								
	3	2								
	17	9								
		8								

Figure 1 - Determination of Due Dates

The data on these tables was extracted from various jobs, which are presented in the table shown in Figure 2. The numbers into the table are the hours required for operation as per work centre.

ORDER NO.	OPERATION - HOURS								DETER-MINED DUE DATE	EXPLANATION
	M01	M02	S01	S02	F05	F06	C03	C04		
1	16	6	-	16	-	-	-	112	1208	M01 on day 1208,M02-1206, S02-1203,C04 required 2 days(1206,1207). New job coming will be on 1208
2	13	3	38	4	172	-	19	-	1211	M01 still on 1208,M02-1206, S01 required more than 1 day(1210,1211). New job on S01 will be on 1211 taki-- into consideration (2` hours consumed alre S02-1203,F05-1211,C
3	18	4	-	12	16	24	-	-	1211	M01-1208 next date w/c will be 1209,M0. 206, S02-1203,F05-1211,F06-1201
4	44	2	-	-	-	-	22	-	1209	M01-1209,M02-1206,C03-1198 (3) hours loaded on 1199)
5	3	9	-	-	-	-	-	-	1209	M01-1209, capacity for this date almost completed Next job will be on 1210 M02 - 1206
6	7	-	-	-	-	-	-	-	1210	M01 - New date 1210
7	-	8	-	-	-	-	-	16	1208	M02 - Still 1206,C04-1208
8	-	-	13	-	-	-	-			S01 new date 1211 (3 hours from previous job already loaded)

Figure 2 - Routing of incoming work

12/...

With this type of scheduling, there are gaps between jobs in the various work centres. An important feature of CAPOSS is that it eliminates these gaps, using the "PULL EARLY PROCEDURE".

By means of this procedure, the system loads the work centres on the basis of Maximum Capacity Utilization, as shown in Figure 3, and, as a result, eliminates waiting time. The Pull Early Procedure can be done up to 99 days.

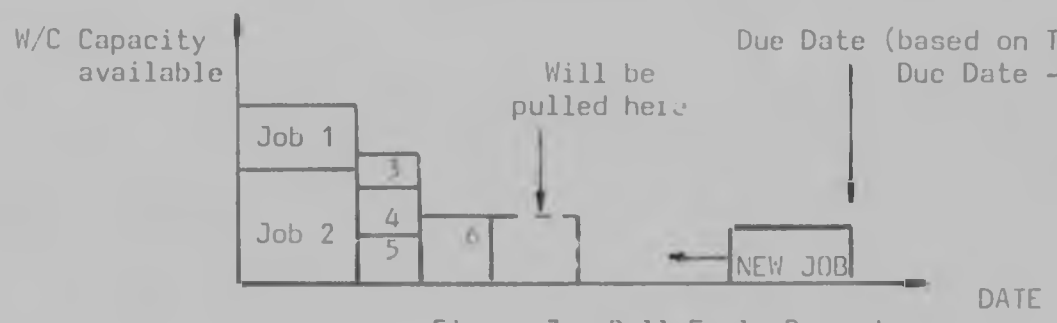


Figure 3 - Pull Early Procedure

SUMMARY:

The methods of scheduling as described above improved the policy of sticking to the First Calculated Delivery Dates significantly.

Nevertheless, there were still jobs with recurring changes to their FCFD, mainly jobs concerned with outside orders, quality control rejection, etc. These are dealt with in items 6 and 7 of this report. (Changes to CFDs due to the new scheduling approach - See Appendix 4).

2.5.3. Performance measurement & control

Control over the performance of the system is being done by the key result areas for the system, which are as follows:

a) Emergency work : 95% of jobs are being delivered within 48 hours of receipt.

3% within 72 hours

2% within 10 days

b) Ordinary work : 95% of jobs are being delivered on Adjusted due date ± 3 days

5% of jobs are being delivered subject to constraints and changes.

c) Daily Production Programme : 99% of jobs on daily work lists should be completed on the same day, even if it will consume overtime.

13/...

d) Master File Accuracy : 99% constant accuracy of data on the file.

e) Punching : 0,1% errors on punching (average).

f) Adjusted Delivery Dates: 0% of weekly errors on this procedure.

g) Average Turnaround Time of Jobs in the System : 95% of total jobs - 5 weeks.

In order to stress the importance of having control over the system, a monthly report, based on these factors, was established.

The report is circulated by the Planning and Control Engineer to the Workshops Management, Engineering Department Management and the Industrial Engineering department.

2.6. Operation

After the system had been re-designed, the following steps were taken:

2.6.1. Initial operation

In order to achieve effective liaison between the Planning personnel and the users (i.e. Floor Management: Superintent, foremen, Leading Hands), training sessions were conducted.

The training included explanation of the layout of the system, procedures, and the importance of having co-operation between Floor Management and Planning personnel.

Co-operation is in practice in the following areas:

a) Completion of all jobs on the daily work list

b) Feedback to Planning on problems regarding completion of the daily work list, such as:

- Material not available
- Waiting for a job from another Work Centre
- Working overtime in the case of overloading because of emergencies
- Strict discipline on meeting of estimated times
- Co-operation with estimating office in order to become acquainted with job layouts, tooling, machine potential and instrumentation.

2.6.2. Retrespective appraisal of the scheduling system and improved operation

Determining delivery dates and adhering to them is the most important factor on deciding whether a system is successful or not.

14/...

A list of jobs was followed up during a few weeks, in order to find out if the CFDs were still being changed significantly.

It was found that the CFDs were being changed in cases where outstanding outside orders were awaited, thus changing the whole schedule.

This problem has been overcome by means of initiating a new procedure of determining due dates for jobs requiring outside orders. Supply Department buyers should adhere to and progress orders based on the new procedure.

Another finding concerned spares. Ordering of spares, not according to the lead time, has caused superfluous re-ordering of items, which affected the planning programme and resulted in excess stocks.

This problem has been solved by initiating a report to stores which included the delivery dates for Spares Orders and the lead time. This enables the stores to balance orders and to control re-ordering levels. (Delivery Dates and Lead Times Report - see Appendix 5).

15/...

3. DETERMINATION OF WORK CENTRE CAPACITY

An important factor on which scheduling is based, is the capacity of the various work centres.

It was found that, since introducing CAPOSS, the parameters for work centres, by the users, had not changed. It would be redundant to say that this is another factor affecting schedule accuracy and, as a result, one of the first activities when commencing implementation was to find out about backlogs, average efficiency per work centre, capacity required for emergency jobs and absence rate.

The analysis was based on available reports for management, which were not in use.

The results of this exercise were:

a) Determining of capacity requirements. (For an example of an analysis in Factory Made Spares plant, see extracts from memorandum in Appendix 6)

b) Allocating capacity to the various work centres, based on:

- men available
- efficiency (Performance Indices- report)
- absence rate
- capacity required for Emergency Jobs - as mentioned before, arbitrarily 10% at the first stage.

(For an example of backlog analysis and determination of monthly work centre available capacities, see Appendix 7)

The task of determining capacity requirements for the various work centres, became an integral part of the responsibility areas of the Planning & Control Engineer, in conjunction with the Production Engineer, as it affects the overall scheduling performance, and, as a result, the quality of service given to the various plants by Central Workshops.

Another essential issue regarding capacity requirements, is the hours required for planned shutdowns.

When we asked what happened in this case, the answer was:

"In shutdown periods, the system is out of control".

However, this is an anti-system approach and we soon found that it is possible, by means of available data from previous shutdowns, to predict the capacity required from each work centre.

The solution is to allocate these known capacities to the Emergencies System as shutdown jobs are dealt with by this system.

16/...

4. PLANNING SECTION

4.1. Organization Structure

A part of the 1980 Overall Management Study Recommendations referred to the Organization Structure of the Planning and Control Section.

Based on the structure envisaged in the above report and the performances required from the Planning Section in particular and Central Workshops generally, a new organization structure was drawn up.

This consists of 2 main units:

a) A Planning unit - responsible for:

- Computer and Data control
- Liaison with estimating office
- Providing work lists and reports
- Materials procurement
- Materials preparation
- Administrative convenience

b) A Progressing unit - responsible for:

- Progress of ordinary work in the various work centr
- Progress and control of emergency work
- Deliveries
- Liaison with Floor Management
- Liaison with customers
- Feedback to planning unit

The idea behind this approach is that Planning deals with pre and post production stage activities and Progressing deals with production stage activities.

(Planning & Control Section - Organization Structure and Function involved - Appendix 9)

4.2. Key Performance Areas

To determine the KPAs for the Planning section, four major factors were considered:

- Meeting of targets as set out in item 2.5.3. of this report
- Quantative measurement of performances
- The performance level aimed at
- Simple enough to control and measure

17...

The format used for this exercise is shown in figure 4 below.

It was carried out in such a way that every incumbent prepared KPAs for his subordinates, from the top to the bottom of the organization structure, with the assistance of the Planning and Control Engineer. The idea behind this was to achieve a commitment to and a better understanding of control and measurement by all Planning Section personnel.

Appendix 9 to this report consists of the key performance areas for all Planning Section personnel.

POSITION TITLE: GRADE: DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARD	WAYS TO MEASURE PERFORMANCE
Performance outputs	Detailed tasks and operations	Quantative achievement of tasks and operation	Quantative as possible target for tasks and ways to measure it: Reports, data, etc.

Figure 4 - Format used for compiling key performance areas

5. LONG TERM JOBS

5.1. General

At the beginning of implementation, there were 216 jobs, out of approximately 1350, which had been in the system more than 90 days. Of these 216, 41 were more than one year in the system.

The distribution of residence time was as follows:

Residence (days)	Quantity	%
0-10	305	22.7
10-20	241	17.9
20-30	154	11.4
30-40	108	8.1
40-50	108	8.1
50-60	83	6.2
60-70	52	3.8
70-80	32	2.3
80-90	49	3.6
90-100	13	0.9
100-125	60	4.6
125-150	30	2.2
150-175	29	2.1
175-200	21	1.6
200-225	16	1.2
225-250	6	0.4
250-300	17	1.3
300-350	15	1.1
350-400	4	0.2
400-450	2	0.1
450-500	1	0.05
500-550	1	0.05
600-700	1	0.05
TOTAL	1348	99.95

(Histogram of residence time - Appendix 10)

As the established target fo turnaround time is 5 weeks (25 work days), action was taken to eliminate the large backlog.

This was done in 3 main stages:

1. Completion of jobs more than 200 days in the system.

2. Completion of jobs more than 90 days in the system.

3. Completion of jobs more than 60 days in the system.

5.2. Action Taken

Stage 1

A few interesting facts were established when taking action in order to eliminate the backlog.

As the first group we dealt with was that of jobs more than 200 days in the system, we asked the Plant Engineers if they still required these jobs:

19 of the total number (41) were unknown or had been ordered by personnel no longer working at the plant

19/...

13 were waiting as a result of partial rejection by Quality Control because there were no procedures in planning to deal with such a problem

9 were waiting on outside orders for more than a year, and in the meantime, the plant had purchased them through an outside contractor

This part of the exercise led to the establishment of Quality Control procedures, spoiled work and placing outside orders by planning, in order to avoid the above phenomena.

Further details on these issues are given in items 6 and 7 of this report.

Stage 2

At this stage, more than 133 jobs with a residence of more than 90 days in the system, were completed. This was done by transferring these jobs from the ordinary system to the emergency system and by working overtime.

We found that, under normal circumstances, this is almost the upper limit of capacity available and we began drawing attention to the manpower problem. This will be dealt with in item 8.

Stage 3

As the constraint of capacity limited us in the number of work hours available, this stage is still being carried out slowly, as the shortage of artisans was too high in the first months of implementation.

An important factor concerning this issue was the use of an "ORDER-RESIDENCE" weekly report (see part B - Appendix 4), which gives a residence range to all the jobs on the list.

It was designed in such a way that, as this report is received, the last 2 groups of jobs should be pulled from the ordinary system and put into the emergency system and completed. However, as said before, difficulties were encountered when coming to jobs more than 60 days in the system.

20/...

6. PLACING OF OUTSIDE ORDERS

6.1. General

One of the reasons for recurring changes in delivery dates promised to the plants, was the long delay in receiving outside orders.

The procedure for placing these orders is shown in figure 5 below.

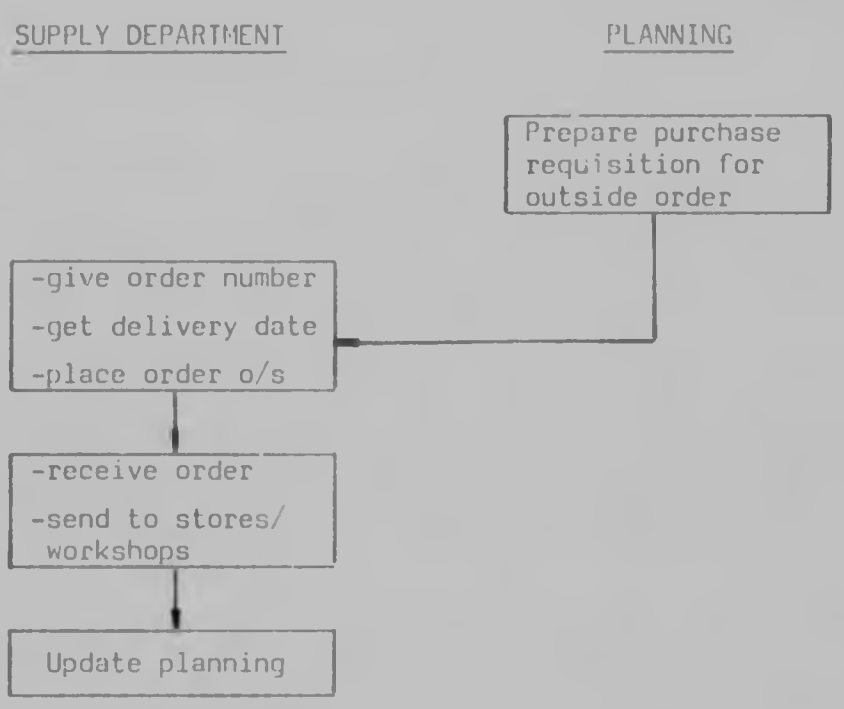


Figure 5 - Placing outside order procedure

The situation was that there was little control over outside orders or the quality of work done outside. Therefore, weekly meetings of the functions involved were held consisting of in-depth discussions on ways of placing outside orders for materials or manufacturing.

These meetings were on behalf of the Planning & Control Engineer and the Supply Department Manager. Those participating were:

- Supply Department Buyers
- Planning personnel from the Workshops
- Stores Manager - Supply Department
- Quality Control Engineer - Workshops

Three major problem areas were discussed and solved:

a) The need to streamline the procurement system, including Quality Control Inspection, expediting and reject control.

b) The need to avoid an "all your eggs in one basket" situation by arranging alternative supplier support.

21/...

c) Backlog situation of materials resulting in upsets in CAPOSS and workshop planning and the ineffective delivery of components to customers.

6.2. Placing outside Material/Manufacturing order - Overall solution

A supplier and manufacturer list has been drawn up giving the estimated delivery periods of all suppliers currently used by Supply, on behalf of the workshops. Supply Department validated this list as being acceptable to them. This list forms the basis of workshops planning - estimating a delivery period for a component prior to advising the customer of the delivery date. For example, a component requiring casting and a pattern, would have delivery as follows:

Pattern making	=	5 weeks
Casting	=	15 weeks
Machining time	=	1 week x Factor of 3 = 3 weeks
Total	=	delivery of 23 weeks

For FMS components, the same system is used but incorporates a 4 week period covering the initial administration period between computer call up of a component and workshop planning receiving the order. The list will be updated quarterly to ensure that realistic delivery times are being maintained and used. (Approved list of supplier and manufacturer delivery time - Appendix 11)

When Supply receives an order, they will negotiate with the supplier to determine actual supplier delivery time and cost. They will inform Quality Control and workshop planning by sending the initiator copy of the order to them giving the negotiated and agreed delivery date. "Order by dates" given by a supplier must be worked according to Report 46 - Listing of outstanding orders - see Appendix 12. Planning controls outside orders according to Report P18 - see Part B Appendix 4.13.

A customer, on being advised of a delivery date, will either accept or reject it. Should rejection be because of the job being an emergency etc., e.g. planned shutdown work being done, Planning and Supply are in a position to perhaps negotiate with the supplier as to an improved delivery - this however, should be the exception not the rule.

6.3. Order inspection of expediting

All orders are subject to Quality Control monitoring. Quality Control advises the Supply and Planning departments,by means of a weekly progress sheet, of orders being manufactured.

Orders which are falling behind schedule are listed on the progress sheet and expedited by Supply department to ensure maintenance of delivery date.

22/...

6.3.1. Rejects

Quality Control, upon determining a reject situation, immediately informs the supplier and advise rework or immediate remake. Rejection notes and order documents are then forwarded to the buyers at Supply department for official notification and action. Planning department is also advised of rejects, in case there are amendments to the planning system. A weekly advice sheet detailing rejections is given to Supply and Planning.

Rejected components, if not collected by the supplier at time of rejection advice, are delivered to supplier by Stores, under the present system.

6.4. Backlog

The first step taken on this subject was to determine new delivery dates using the new procedure for placing outside orders. As it was a special effort, notice was given to the various suppliers. They collaborated and all outstanding orders were delivered within 6 weeks.

6.5. Alternative suppliers

As there were suppliers with long delivery periods and deteriorating quality of product, it was decided that:

A concentrated effort will be initiated to determine alternative suitable sources of supply. Supply Department shall undertake to approach such suppliers and submit names to Quality Control Engineering for assessment and audit.

Before this commences, supplier specification sheets, detailing supply requirements,shall be prepared, covering the various aspects of supply, i.e. quality, cost, delivery.

Specification sheets shall be prepared as follows:

1. Quality Assurance Criteria
2. Cost Criteria
3. Delivery Criteria

Completion of these sheets by a prospective supplier shall form the initial audit of the supplier. Quality Control Engineering, with support from other specialist sections as required, shall conduct the supplier audit and shall advise, in writing, acceptance or rejection of the supplier to Supply Department.

23/...

7. QUALITY ASSURANCE

7.1. Procedures

As mentioned before, not having set Quality Control procedures, led to such situations as rejected work and work under inspection lying on the shop floor for a considerable time without anyone being aware of their existance.

There was full participation in the preparation of this procedure by the Planning & Control Engineer and the Production Engineer, as it affects their shop's performance.

The factors taken into consideration were; responsibility areas, inspection control in the shop and on-site, batch inspection, non-batch inspection, reject control, equipment calibration and reports required for various management levels in the shop and in the Engineering department. (Quality Assurance Standard-Appendix 13)

7.2. Spoiled Work

When dealing with spoiled work, we found that jobs were being "stacked" on the work lists and in the system for a considerable time because Planning personnel did not know what to do when this happened.

There are three possible reasons for spoiled work:

a) Scrapped after intermediate operation

b) Scrapped after final inspection

c) Partial batch being rejected

A detailed procedure for dealing with spoiled work from a computerised system point of view, was written and, as a result, these jobs are identified on the master file, controlled and progressed. (Spoiled Work Procedure - Appendix 14)

7.3. Rejected Work

As Quality Assurance operations improved, the quality of work done by the workshops improved as well.

Comparing figures of rejected work in 1980 to those for 1981 gives the following results:

24/...

	1980	1981
Machine Shop		
Standard hours worked*	21690	36890
Average % rejected work	9,36	',2
% required remake	5,52	2,1
% accepted as substandaid	3,84	2,1
% production time fur remake	1,24	0,72
Fitting Shop		
Standard hours worked*	14381	25860
Average % rejected work	5,77	4,3
% required remake	2,44	3,1
% accepted as substandard	3,33	1,2
% production time for remake	-	0,4
Factory Made Spares		
Standard hours worked*	31112	33200
Average % rejected work	4,88	2,9
% required remake	3,56	1,1
% accepted as substandard	1,32	1,8
% production time for remake	-	-

* only skilled artisans due to the accounting system/method used

There is indeed an improvement in quality of product, although the large number of artisans,of various disciplines, recruited during the second half of 1981, may have added to the problem.

25/...

8. FLOOR MANAGEMENT : PROCEDURES, REGULATIONS AND TRAINING

8.1. General

When dealing with shop floor Management, irregularities regarding management method, discipline and reporting procedures were found.

Most significant were:

- No commitment to the work lists by the Foremen
- Plant personnel pushing jobs forward by virtue of their personal relations with Foremen
- Foremen doing jobs which did not appear on the Order File
- False reporting of hours invested for manipulating the Bonus Scheme
- No feedback to Planning on completed jobs
- High ratio of scrapped work in certain work centres
- Jobs on first day of the work list (Times Schedule) for more than 99 days and sometimes, even longer, without being done (See Appendix 15)

It is difficult to change work habits of a Foreman after many years of working in a certain way, but obviously, in our case, it was essential.

We attempted to do so by means of meetings, explanations, extra training, etc., but resistance to change was high. It must be remembered that the pride in their work once felt by tradesmen in this country (and all over the world), is lost and, as a result it is very difficult to motivate these people. We decided to do this through upgrading one of the Foremen. This exercise was very successful. The will to prove ability and gain upgrading motiviated floor management to collaborate and from this stage, things began to move smoothly.

8.2. Daily Work List

As it is essential for the workshop not to deviate from promised delivery dates, work lists should be completed, as per schedule, every day.

The regulations we established regarding work lists are as follows:

8.2.1. Work Lists

a) Work lists will be issued to all leading hands/ foremen by 8 a.m. daily.

b) The jobs shown on the work list will be commenced in the sequence shown on the list.

c) The system of marking progress will be as follows:

i) Artisan's job card received: Underline the operation in red with a ballpoint pen, from the beginning of the line to the "quantity" column.

ii) Job in progress: Underline from "quantity" column to "Insp" column.

iii) Job completed: Underline from "Insp" column to the right hand margin.

d) Problem jobs must be sorted out immediately. If the leading hand or foreman cannot solve the problem, it must be handed to the Planning department immediately.

e) All work lists for the previous day must be sent, by messenger, to the Production Engineer by 10.00 a.m. daily. They must be correctly marked up. Problem jobs must have a brief explanation.

f) Planning receives the marked work lists, checks and identifies problem areas, correct errors and checks if feedback cards were sent.

The above regulations help Planning a great deal in the accuracy of the Master File and various reports, as the following activities are done:

a) Jobs which are scheduled but are still in a previous work centre (including inspection work centres) must be progressed by the progressor.

b) Jobs with wrong material or a shortage of material are dealt with by the loader or material procurer, and results in updating of data.

c) Jobs with routing/specification problems are referred to Estimating for immediate action.

d) Jobs which are rejected but may be acceptable to the plant, are dealt with by Quality Control as quickly as possible.

e) Jobs with drawing problems are referred to Quality Control for immediate action.

f) Problem jobs which cannot be continued within 24 hours are re-programmed by Planning. Foremen notify Planning so that this can be done.

B.2.2. Partial feedback

It was found that one of the reasons for excess booking of waiting time was that there was no partial feedback on jobs requiring longer than 1 day's work. The system continued scheduling, based on the original duration of the job. In many cases, when a job required more than the daily capacity of the work centre, this was the only job on the work list, while the capacity could be utilized for more work.

Nevertheless, before implementing the Real Queue approach, having no partial feedback could result in work already started being pushed backward in the ueue. Partial feedback gives the operation the highest priority (99) on the work centre's queue. The basic rules regarding partial feedback are as follows:

27/...

a) Partial feedback information must be completed and sent to Planning by 3 p.m. each day, as the system is run every night.

b) Any operation in progress at 3 p.m. and will definitely be completed the same day, will be considered as complete and a copy of the job card sent to Planning. Planning submit the feedback card,as the job should not appear on the next day's work list.

c) Any operation which has up to 5 hours work remaining to be completed the next day, does not require partial feedback.

d) Any operation which has over 5 hours work remaining to be completed the next day, does require partial feedback information.

8.2.3. Jobs appearing on first day's work list not being done

The importance of adhering to the daily work lists was stressed at all the weekly Foremen's Meetings.

The percentage of jobs in each work centre which are scheduled 1x, 2x, 3x and "4x and over", are used as one of the measures of each foreman's performance. The calculation is done, approximately, monthly.

The objective is to maximise the number of jobs which are done the first time they are scheduled (1x).

Before introducing this measure of performance, the overall figures for the workshops were as follows:

Times Scheduled:	01	02	03	04 & over
May	13%	12%	10%	65%
June	25%	20%	11%	44%

There were two target stages in the implementation of this issue:

	01	02	03	04 & over
Initial	60%	20%	10%	10%
Final	70%	25%	4%	1%

When judging performance, allowances are made for:

a) Long jobs which accumulate the time scheduled.

b) Volume of emergency jobs which will delay planned jobs.

8.3. Standard Times for Jobs

It is important that the Standard Time for a job is a fair time. If problems are encountered in achieving the time shown on the job card, then the estimator must be consulted in order to check the time.

28/...

The following are the most common reasons for not achieving standard time:

a) The method has changed. This may be a justified change (in which case, additional time will be allowed), or it may be that the wrong method is being used, in which case, no additional time will be given.

b) Extra work is required, which could not be forecast. Extra time should be given.

c) The man is inexperienced, resulting in a longer time being taken. No extra time will be given.

d) The job is more difficult than was estimated. The estimated time will be corrected.

e) An error in estimating. The estimate will be corrected.

We stressed that it is wrong to assume that because a department is not on bonus, the standard time does not matter. Performance Indices are calculated and should show the time OPs and DPs for department. If the standard times are corrected, it will probably show th[illegible]he men will earn bonuses.

It is also [illegible] to say that a job can be allowed to take longer because the man will be on waiting time if he finishes the job earlier. This is overcharging the customer. It also lowers the [illegible] and DPs.

The solution to the above problems is achieved through the following:

- Increasing the frequency of shop floor visits by estimators to check standard times.
- Foreman and leading hands to check if the standard times are being achieved by job basis and to get the estimator to check the problem jobs.

8.4. Training and Motivation

On looking into the training services offered by the Company, it was found very necessary that training should be improved within the Central Workshops.

Training was given mainly to two groups:

a) Artisans

b) Foremen

8.4.1. Artisans

A Training Officer was appointed and training programmes were drawn up. These consisted of:

- Refresher courses
- New tooling and fixtures

  Exercises
- Examinations

The action programme is being carried out in conjunction with the Foremen, based on requirements and identified weak areas in the various work centres.

8.4.2. Foremen

Training consists of courses on development of management skills outside the Company, Estimating, Planning & Control, simple applications of computers in production, costing and technical courses as per request and recognition of needs by the Company.

8.4.3. Summary

A great deal of work was done with the shop floor personnel in order to increase motivation and consequently, improve performances and the service given by the workshops. We tried to devise a merit scheme for artisans but encountered resistance from high level management in the Company. However, they accepted the alternative, which was a special increment of more than 10% to all Engineering and Maintenance personnel, including staff personnel such as Superintendents and Foremen.

Indeed, this, together with the introduction of the Bonus Scheme described in item 10, helped considerably in improving performances and in the recruitment of artisans.

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9. ESTIMATING

9.1. General

As scheduling is based on estimated time, it is redundant to say how important the role of estimating personnel is in the execution of the Planning & Control system.

In the beginning, we investigated, through work study techniques, estimating accuracy. Having foun that this was reasonably accurate, we then investigated the possibility of introducing a computer into the estimating section or introducing quick estimating systems such coding and slotting.

The main area we concentrated on were:

a) Liaison with the shop floor

b) Feedback

c) Specification and drawings

d) Liaison with Planning

9.2. Liaison with shop floor

Every estimate should be reviewed and studied by the Foreman/Leading Hand in order to become familiar with the layout used by the estimator, machine feed and speed, tooling required, jigs, fixtures and timing. This means that shop floor management is responsible for artisans working to the estimate method under prescribed conditions.

If the Foreman/Leading Hand feels that the operation's estimated time is too tight or vice versa, it is his responsibility to bring it to the attention of the estimator and reach some sort of agreement.

9.3. Feedback

The best way for estimators to check their performance is to go the shop floor more frequently.

A random schedule for carrying out work studies, work sampling and watching the artisan actually doing the job is practised and used to verify estimates, updating times and methods and gives an indication to workshop management of efficiencies/performances on the floor.

9.4. Specifications and drawings

It was found that, in many cases, the wrong item was estimated and produced as a result of vague specification by the plant and insufficient space on the Engineering Work Order. Since this problem lies outside the boundaries of Central Workshops, we found it useful to introduce a CHECK LIST for the originator in the plant, in order to verify that all the required data, drawings, sketched and descriptions are available, before submitting the order.

31/...

If there is insufficient space on the Engineering Work Order or a drawing is not available, the originator can use a continuation sheet. (Engineering Work Order, Check List and Continuation Sheet - Appendix 16)

9.5. Liaison with planning section

The major work groups for estimating are:

a) Repeat work, spares

b) Emergency

c) Projects

d) Development

As repeat job estimates are filed and maintained, we found that a more useful and efficient way of getting the card in the planning section can be done by transferring 4 estimators (one for each trade) to the planning section.

They are entitled to deal with repeat work, short jobs, spares and emergency jobs.

Another benefit gained by doing this, is the technical ability required by the planning section on receipt of orders and negotiating with customers. A detailed report for re-organization of the estimating function with job layout was prepared and this is being implemented at present.

Appendix 17 to this report consists of the procedure followed by FMS-estimator planner and plant job-estimator planner.

10. BONUS SCHEME

10.1. Background

On investigating Central Workshops history regarding bonus schemes, we found that, for many years, it had not been done properly, but consisted of ad hoc systems and schemes for different work centres.

The systems were establish mainly to prevent unrest in industrial relations and, as such, were often eliminated and re-introduced.

All of these systems were managed manually by non-qualified personnel as a result of the high turnover rate in the Work Study department.

When the new costing system was introduced, a part consisted of a new computerized bonus scheme. The system is computer based but the Inputs are derived from Engineering Time Cards coded by the artisan. (Engineering Time Card - Appendix 18) It's apparent however, that if an artisan has to feed the system with data such as standard time, time taken, work order number, cost centre, etc., it will result in total failure. We found that artisans in some cases were getting more than 9 times their basic salary as a monthly bonus. Other severe malpractices were found, thus we quickly abolished the scheme, without even trying to explain is to the Factory Industrial Relations Officer.

10.2. New bonus scheme

As the work input increases continuously because of new plants being put on-line and expansion of existing plants, we aimed at increasing productivity by 15 - 20%. This can be done by a "true" incentive scheme, based on 100 - 133% approach, as shown in figure 6.

This type of system is in use in Israel and the USA and forces the participants to increase productivity in order to earn more money. With this system, a bonus of more than 33% means that something is wrong with the standard time. The scheme is different from any others being applied at Modderfontein and, as a result, we had to discuss it with the Industrial Relations department. We succeeded in selling the scheme because we had support from high level management in the Factory and also because the timing was right, i.e. immediately after a high increment had been given to the artisans.

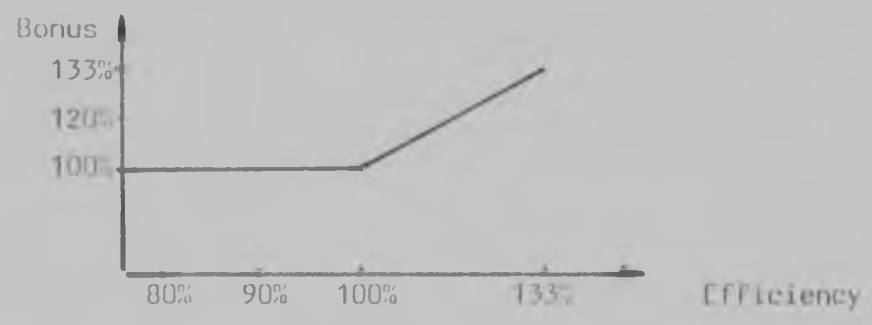


Figure 6 - 100% - 133% incentive scheme

33/...

10.2.1. Principles

The implemented scheme does not have manual interference on inputs. CAPOSS as a planning system has as one of it's tasks, the preparation of work list print operation cards, based on the daily work list, for bonus scheme purposes.

The operation card consists of all data available for bonus computation, except the time taken, which is done by clocking the card. (Recommended Operation Card - Appendix 19) A timekeeper has been appointed in the workshops to control the system.

The procedure is as follows:

a) When a man wants to start a job, he goes to the timekeeper, takes the appropriate operation card and fills in his name and check number.

b) The man clocks the card on commencement and completion of a job.

c) Upon completion of a job, a new operation card is taken and the same procedure applied.

d) At the end of the day, the timekeeper extracts from the cards the time taken for each operation. If the total time taken is less than the duration of the shift, he will add 00 operation card - non-measured time, for the time required to complete shift duration.

e) After all the cards have been collected and checked by the timekeeper, they are sent for punching.

f) The basic data on the operation card is stored on diskettes, thus the only punching done is that of check number, status and times.

g) The next morning, a printout of bonus percentages as per completed operation cards, for each artisan, is available.

h) Uncompleted operations will be calculated as soon as the appropriate coding is written on the operation card by the timekeeper.

i) Copies of the Incentive Scheme Report is sent to Wages department, who then pay the bonus amount shown.

10.2.2. Operation Card - Explanation

This item gives a brief description of the operation card, parameters considered and factors involved in the scheme.

34/...

SPACE	DESCRIPTION	EXPLANATION	INPUT SOURCE
1-9	CAPOSS No.		Route Card/CAPOSS
10-13	OPERATION		"
11-16	W/C		"
17-50	Description		"
51	T	Type of job: Ordinary, Emergency, unmeasured, overtime, evening shift, night shift	"
52	P	Number of people planned to do the job	"
53-56	S. Time	Standard time	"
57-60	T. Taken	Time taken: Coded for punching by timekeeper	Clock/Timekeeper
61-64	O. Time	Overtime	"
65	C	Call out, weekend	Timekeeper
66-71	Check No.	Artisan's Co. No.	Artisan
72	S	Status: Artisan, Leading Hand, Apprentice, Adult Trainee	Timekeeper

We see from the above table that, in contrast to the previous system, only one input is given by the artisan under this system, namely his check number. Moreover, the operation card is designed in such a way that the Foremen/Leading Hand will insert the data on time taken, overtime code, check number and status, and will then sign the card for his control and these will be checked by the timekeeper who inserts the data on the upper row, from where punching is done.

10.2.3. Reports

These are still being worked on at present. In general, the major reports will be as shown in figure 7 on the following page. The reports will give the efficiency percentage and hours gained and Wages department will give them monetary values.

35/...

FREQUENCY	REPORT	MARK	INDEX-BASED	FOR USE BY							REMARKS
				FMN	FST	PLN	MGT	WAG	ARN	IE	
Daily	Bonus hours per operation	BD1	Check number	X				X			Total summaries derived from these reports.
	Efficiency % per operation	BD2	CAPOSS Op. No.	X	X	X					
	Efficiency % per work centre	BD3	Work Centre	X	X		X				
	Unmeasured hours	BD4	Work centre	X							
Weekly	Bonus hours per operation	BW1	Check number					X	X		
	Daily unmeasured hours	BW2	Check number			X			X		"
Monthly	Average efficiency % per operation	BM1	CAPOSS Op. No.		X		X			X	
	Average efficiency % per work centre	BM2	Work Centre	X	X	X	X			X	"
	Total bonus hours per operation	BM3	Check number	X			X			X	

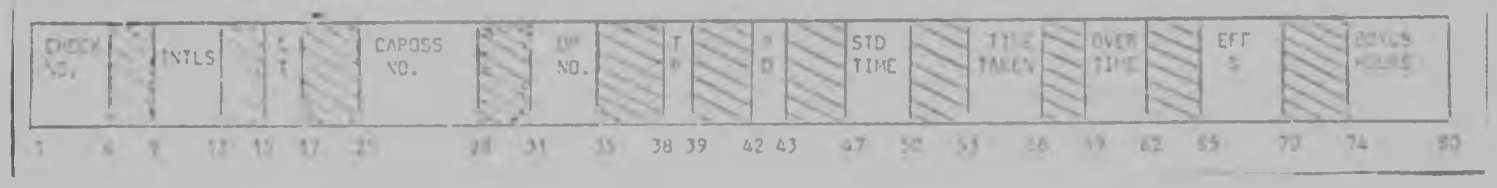
KEY

FMN - Foreman
EST - Estimating
PLN - Planning
MGT - Workshops Management
WAG - Wages
ARN - Artisan
IE - Industrial Engineering

Figure 7 - Recommended Reports

The basic format used for reports is shown in figure 8 with insignificant differences between the various reports as a result of different Index-Basis.

Work Centre:------- Date: -------



INDEX:

ST - Status
TP - Type of work
PD - Planned number of men
EFF- Efficiency

Figure 8 - Basis format for reports

10.3. Summary

The main reason for adopting a 100%-133% scheme is to increase productivity rather than awarding increments. Under the 75%-100% scheme every standard time was reduced by 1/3, resulting in reduction of available capacity by 1/3, or paying 33% more for capacity available. The idea behind implementing our approach is that, we believe for basic salary basic output should be produced and standard times, as they consist of relaxation allowances up to a maximum of 22% (in our workshop), present basic output required to be produced.

36/...

11. COSTING

In order to obtain a true picture of workshops Management in money terms, a new costing system was introduced into the workshops at the end of 1980. This system is part of an overall computerized costing system in use throughout the Factory.

The actual costs of a job, i.e. labour, materials and overheads, are collected against the workshops work order number. On completion of the job, the cost is charged to the plant as an actual "contract services" cost.

The introduction of the system was phased as follows:

December 1980:
a) No overheads charged
b) Materials debited directly to the plant's work order number

January 1981:
a) Overheads charged
b) Materials collected against workshops work order number and recovered on completion of job

April 1981:
a) Actual charges to plant are the estimated cost of the job rather than the actual cost

Working subject to the final phase, required each work centre to meet times given by the estimators, minimum of waiting time, true picture of materials used, and monitoring of all orders placed outside by Central Workshops. However, costing using estimated times, could only be started by the end of November 1981, and problems are being experienced on true materials costing.

The reasons for not having qualified materials costing procedures are due to the following:

- Manufacturing orders being placed outside by 2 functions, namely Planning & Control and Spares Co-ordinator.
- Spares costing system being managed for both shops by Factory Made Spares, thus complicating the system and resulted in many of the Central Workshop jobs not being credited.
- Tailoring the system to a shortage of manpower situation in the costing department.

Temporary arrangements and procedures for placing outside orders and costing were prepared in order to collect all costs and overcome short-falls. However, it was emphasized that the costing system should be revised and re-organized throughout the whole Engineering department of the Factory.

From the point of view of Central Workshops, we envisage that as Planning allocates jobs to Factory Made Spares and places outside orders, all costs should be credited to us as the costing centre and we will credit the various outside suppliers, manufacturers,as well as Factory Made Spares.

This principle was agreed to by the Chief Engineer and Costing Department and is being implemented at present.

A P P E N D I C E S

1 : Emergency Jobs Loading into the System

2 : Emergency Jobs

3a : Planning & Control Section Delivery Dates - State
3b : Planning & Control Section Hours Loaded per Work Centre - State

4 : Changes in CFDs due to the new scheduling approach

5 : Amendment List to the Stores System Delivery Dates & Lead Times

6 : Factory Made Spares (Isando) - Capacity requirements (Extracts from memorandum)

7a : Backlog & Incoming Work
7b : Monthly Work Centre Capacities

8 : Planning & Control - Organization Structure

9 : Planning & Control - Key Performance Areas

10 : Jobs Residence Time

11 : Approved list of Suppliers and Manufacturing Delivery Time

12 : Report 46 - Listing of outstanding orders

13 : Quality Assurance Procedure Standard

14 : Spoiled Work

15 : Illustration - Times Schedule

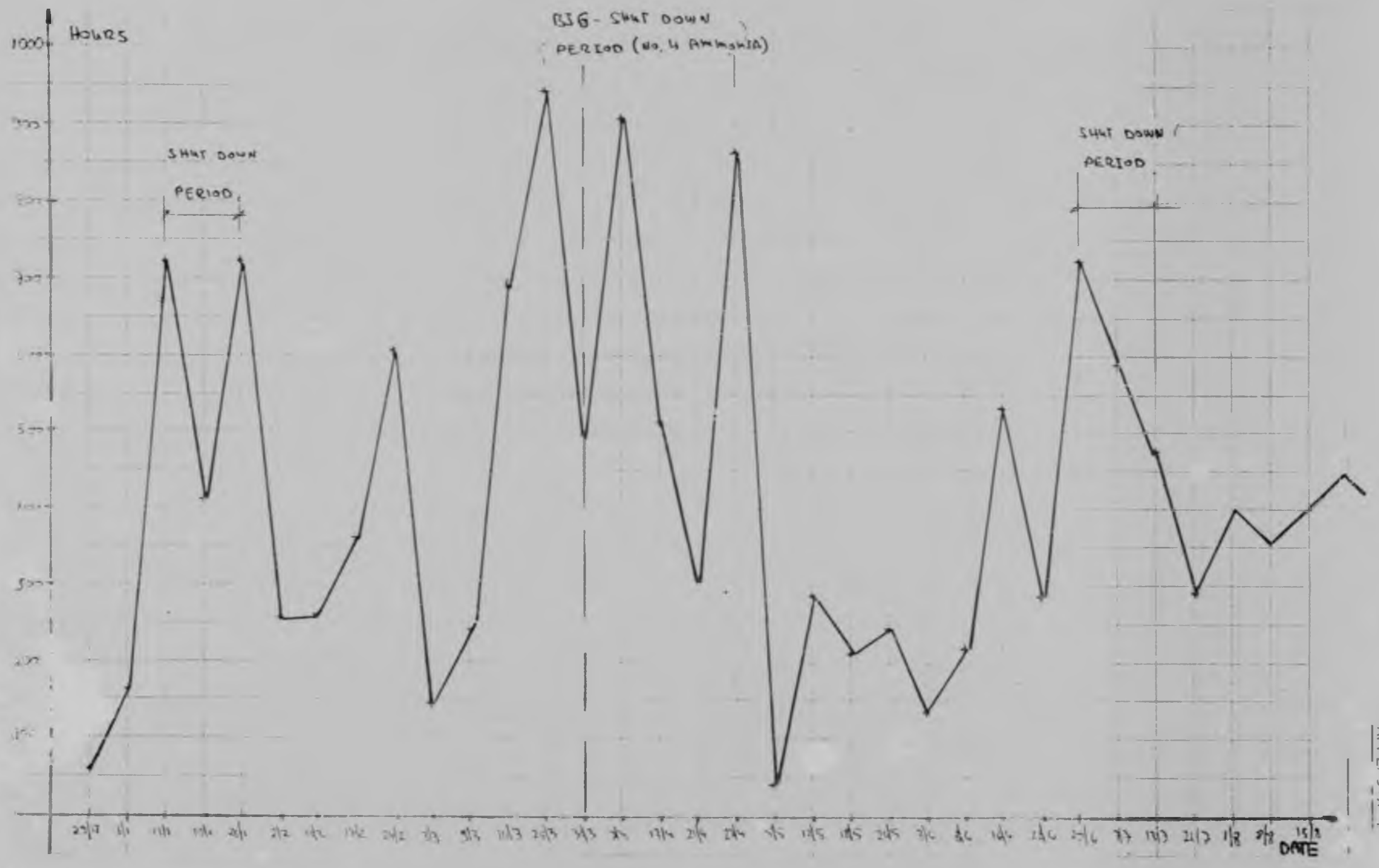
16a : Engineering Work Order
16b : Engineering Work Order - Check List
16c : Engineering Work Order - Continuation Sheet

17a : Estimator Planner - FMS job request procedure
17b : Estimator Planner - Plant job request procedure

18 : Engineering Time Card

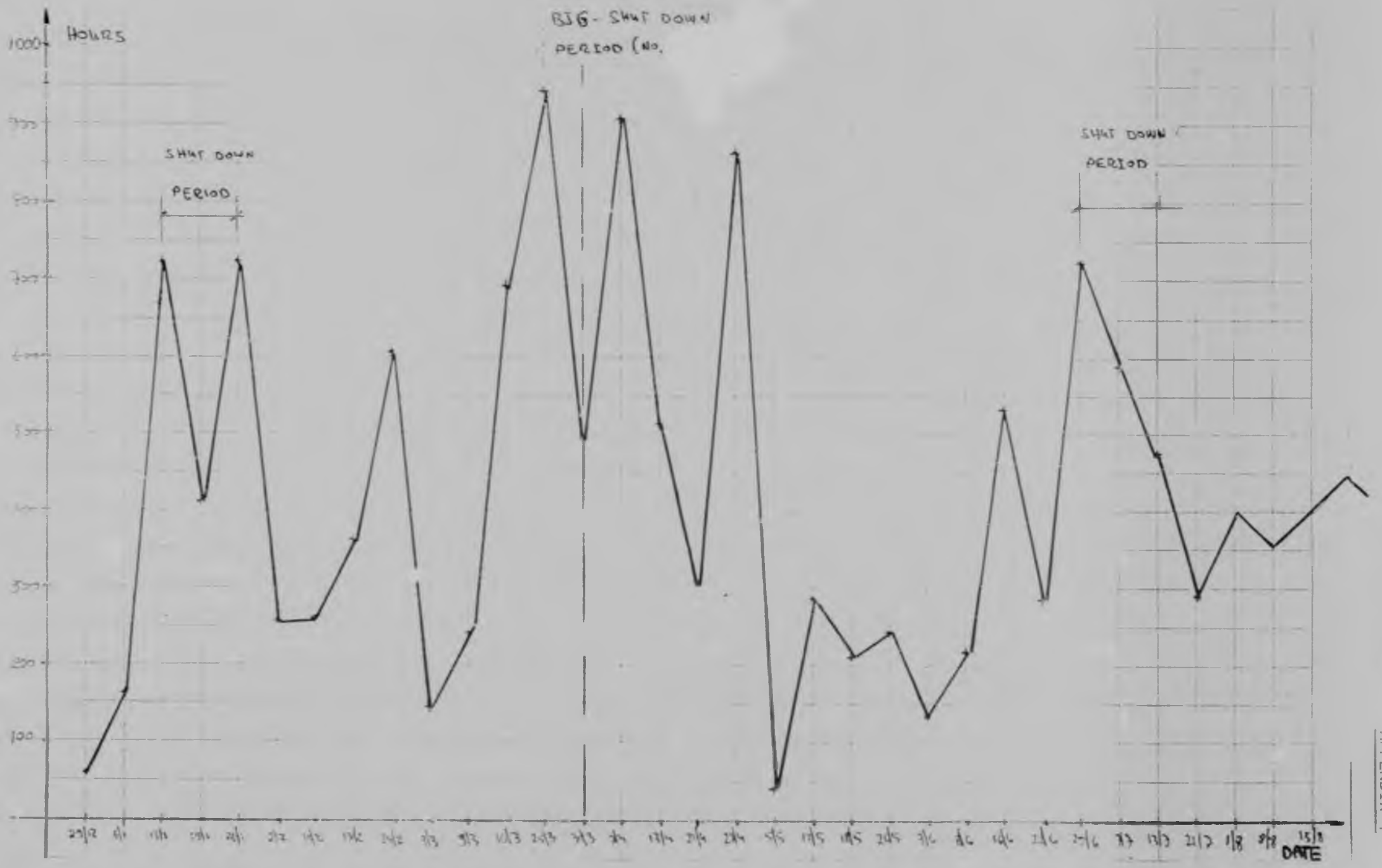
19 : Bonus Scheme - Recommended operation card

EMERGENCY JOBS LOADING INTO THE SYSTEM



ATTACHMENT 1

EMERGENCY JOBS LOADING INTO THE SYSTEM



APPENDIX I

EMERGENCY JOBS LOADING INTO THE SYSTEM

	2/7	15/7	4/8	22/8	22/8	29/8	5/9	5/9	23/5	12/5	12/5	5/5	21/4	21/4	13/4	7/4	5/3	25/3	25/3	16/3	30/3	3/3	24/2	17/2	10/2	24/2	26/1	17/1	31/1	5/1	20/12
2 AMMONIA	16	87	127	39	33	52	42	4	24	112	78	2	637	40	69	375	341	103	205	126	42	138	113	99	40	88	51	233	43	0	
NITROGEN	11	3	43	3	29	0	2	0	3	3	33	7	1	0	5	34	0	27	39	4	2	2	5	46	2	7	86	43	0	2	
DETONATORS	26	27	15	11	0	15	0	3	8	0	15	0	2	46	2	14	0	67	109	10	0	15	9	28	11	3	19	45	0	7	
BLASTING EXPLOSIVES	28	3	9	28	40	11	41	17	43	31	30	4	26	36	118	47	58	200	39	15	28	5	13	25	80	41	19	30	0	11	
FUSE	1	0	39	30	17	0	6	66	0	0	6	0	0	0	9	0	0	34	0	1	36	68	8	16	12	64	42	117	7	0	
4 AMMONIA	2	29	13	8	0	0	0	1	8	14	21	4	36	26	13	64	10	30	2	34	4	0	0	23	0	18	5	20	5	13	
CHEMICALS	53	46	53	32	27	41	27	13	11	8	9	5	18	4	53	68	7	113	3	2	6	120	70	7	29	0	12	38	35	0	
POWER STATION	32	0	0	11	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	21	4	11	0	0	13	
ELECTRICAL INSTALLAT.	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	
CENTRAL WORKSHOPS	3	0	14	0	0	10	0	3	8	0	0	3	0	0	0	16	20	3	19	10	0	0	0	0	10	6	16	26	0	0	
TRANSPORT	4	20	103	0	12	2	26	10	25	21	21	0	3	23	22	3	0	172	11	0	2	29	2	1	13	33	7	8	0	2	
CIVIL AND MISCELLAN.	64	215	95	124	76	160	67	0	50	12	4	0	60	38	0	6	29	0	42	24	25	4	4	0	1	28	3	12	1	0	
F.W.S. SPARES	0	0	36	15	30	23	0	9	9	12	0	5	38	25	225	32	17	50	9	3	0	155	57	0	30	43	19	20	33	12	
F.W.S. CENTRAL WS	0	40	27	0	0	0	0	0	52	0	0	12	0	0	0	244	5	52	172	10	0	0	80	15	0	101	133	71	40	0	
TOTAL	293	470	581	715	280	533	219	131	241	213	276	43	867	305	516	904	487	947	681	240	145	605	363	260	255	722			162	60	

APPENDIX 2

EMERGENCY JOBS

1. DEFINITION

An emergency job, by definition, is one which affects production and, as such, should be completed within 24 hours, provided that no problems exist, e.g. drawings, materials, samples or outside manufacturing.

2. TREATMENT OF EMERGENCY JOBS

2.1. Receipt

a) An Engineering Work Order (EWO) for emergency jobs (Priority 9), must be signed by the Plant Engineer or his deputy.

b) The EWO must be delivered by the Foreman or Leading Hand, to the Progress Supervisor of the Planning Section in Central Workshops. Direct conctact with a Shop Foreman is not acceptable.

c) The Plant Foreman should discuss the job until both he and the Progress Supervisor are satisfied that the requirements are clear. At this point, an approximate completion time should be given to the Plant Foreman.

If problems with materials or drawings exist, then the Plant Foreman will, through discussion, become aware of them at an early stage and could possible assist in resolving them.

2.2. Workshops emergency treatment

The Workshops will treat emergency jobs as follows:

a) Emergency jobs will not be processed on CAPOSS. On receiving the order, Planning will only register the order until the route card is received from the Estimators. Planning and Progressing will be done manually.

b) Jobs will be commenced immediately unless there are exceptional circumstances preventing this.

c) Jobs will be worked on continuously if required. This will be established in discussions with the Plant Foreman.

d) Whilst the job is being processed, an estimate will be prepared immediately (as soon as possible), and sent to Planning.

e) Planning, on receiving the route card, will feed it into CAPOSS and close it off at the same time.

2/...

2.3. Control

Manual control will be done by the Emergency Progressor. He will maintain the route card and register of jobs in process. The register will look like this:

PLANT	CAPOSS NO.	WORK CENTRE											DATE IN	DATE OUT	REMARKS
		M01	M02	M03	M04	M05	M06	M07	M11	M14	M15	M16			
Chemicals	106002300		X						X			X	12/4	14/4	

The date under date in/out will be used for performance measuring.

When the Emergency Progressor gives the job to the work centre concerned, he will add the new job to the emergency list of the work centre Progressor. The emergency work list and the daily work list are for use by the Foremen and both of them should be completed on the same day, provided no problems exist.

The emergency work list per work centre will look like this:

PLANT	CAPOSS NO.	FROM W/C	TO W/C	DATE IN	DATE OUT	REMARKS
Chemicals	106002300	M02	M11	12/4		

The same rule for ordinary jobs applies to the emergency work list. Completed jobs should be underlined so that the Production Engineer gets the right load picture of the work centre in his daily round.

When completing the operation, notice should be given immediately to the Emergency Progressor, so that the job can be moved to the next work centre.

2.4. Capacity requirements

At the end of each month, the Progress Supervisor in conjunction with the Planning & Control Engineer, will analyse demands for emergency capacity by means of the various reports produced by CAPOSS. Trends and forthcoming jobs will be charted, in order to enable accurate allocation of capacity for emergencies without upsetting the computerized ordinary jobs system.

PLANNING & CONTROL SECTION - DELIVERY DATES STATE

F01	F02	F03	F05	F06	F11	F13	F15	F16	F17	F19	M01	M02	M04	M06	M10	M11	M13	M14	M16	M17	M18	M20	M21	M25	M26	C02	C03	C04	C05

PLANNING & CONTROL SECTION - HOURS LOADED PER WORK CENTRE - STATE

1	F02	F03	F05	F06	F11	F13	F15	F16	F17	F19	M01	M02	M04	M06	M10	M11	M13	M14	M16	M17	M18	M20	M21	M25	M26	C02	C03	C04	C05						
-																																			

APPENDIX 3b

APPENDIX 4

CHANGES IN CFDs DUE TO THE NEW SCHEDULING APPROACH

CAPOSS NO	REQUEST DEL DATE	ADJUST DUE DATE	FCFD	CFD1	CFD2	CFD3	CFD4	CFD5	CFD6
113825300	1146	2005	1213	1213	1208	1204	1208	1223	
113906100	1158	1175	1171	1171	1175	1181	1187	1191	
113912200	1140	1150	1154	1154	1159	1164	Comp	1158	
113915300	1162	2006	1203	1203	1211	1211	1202	1209	
114107300	1146	2007	1207	1207	1209	1209	1209	1209	
114115900	1145	1166	1162	1162	1166	1172	1165	Comp	
114117200	1157	1150	1150	1150	1151	1160	Comp	1156	
114205200	1150	1169	1166	1166	1151	1161	Comp	1154	
114303300	1162	2009	1206	1206	1206	1206	1206	1210	
114328200	1155	1190	1169	1169	1169	1169	1174	1179	
114406300	1155	2008	1209	1209	1209	1209	1205	Comp	
114425500	1165	1206	1165	1165		1160	Comp	1157	
114501900	1153	1182	1168	1168		1165	1168	1172	
114501901	1153	1181	1177	1177		1165	1169	1171	
114507300	1147	2008	1206	1206	1206	1206	1206	Comp	
114508900	1187	1208	1178			1178	1171	1174	
114508901		1205	1178			1178	1170	1174	
114518900	1163	2022	1234			1234	Comp	1155	Emergency
114608000	1161	1192	1187			1187	1173	1178	
114609900	1168	1183	1170			1170	1166	Comp	
114609902	1168	1184	1170			1170	1166	Comp	
114609903	1168	1185	1173			1173	1178	1172	
114616400	1161	1182	1157	1157		1162	1167	1190	
114619500	1168	1180	1156	1156		1160	1165	1170	
114702500	1169	1217	1173			1173	1168	1173	
114704700	1152	2022	1220			1220	1220	1220	
114705300	1148	2011	1211			1211	1211	1214	
114707900	1157	1176	1163			1163	Comp	1158	
114709300	1167	2021	1223			1223	1224	1224	
114710700	1158	1220	1177			1177	1178	1183	
114727000	ASAP	1191	1169	1169		1159	Comp	1157	
114803300	1167	2010	1213			1213	1210	Comp	Emergency

AMENDMENT LIST TO THE STORES SYSTEM DELIVERY DATES & LEAD TIMES

MODDERFONTEIN FACTORY

P7-5 AMENDMENT LIST TO THE STORES SYSTEM DELIVERY DATES AND LEAD TIMES

CROSS IDENTIFICATION WORK ORDER NUMBER	SYSTEM WORKSHOP	CTY	STORES SYSTEM RECORD TYPE 3626 INPUT CODE	COMMODITY CODE	ORDER NUMBER	SUFFIX NO	DELIVERY DATE	STORES SYSTEM RECORD TYPE 3603 INPUT CODE		COMMODITY CODE	LEAD TIME
1 4	5 8	9 11	12 15	16 23	24	25 26	27 32	33 36	37	38 45	46 48
14C27647	107395C00	ICO	3626	62343051	14C27647	001	150681	3603	2C	62343551	42
14C27683	107396800	A10	3626	62216214	14C27683	001	190881	3603	2C	62216214	108
14C27615	107398C00	A	3626	62354141	14C27615	001	080981	3603	2C	62354141	126
14C27607	107349800	B	3626	24656405	14C27607	001	100781	3603	2C	24656405	69
14C27807	107346C00	50	3626	62343062	14C27807	001	140781	3603	2C	62343062	71
14C27704	107340800	2	3626	62354096	14C27704	001	230981	3603	2C	62354096	141
14C27784	107347C00	50	3626	51312503	14C27784	001	190881	3603	2C	51312503	109
14C27737	107349800	A	3626	24655383	14C27737	001	080681	3603	2C	24656383	35
14C27784	107349800	B	3626	62344503	14C27784	001	051981	3603	2C	62344503	153

END OF REPORT

APPENDIX 5

APPENDIX 6

FACTORY MADE SPARES (ISANDO - CAPACITY REQUIREMENTS (EXTRACTS FROM MEMORANDUM)

The following tables represent the Analysis of Isando Capacity based on data of the last 18 months.

1. Average Backlog last 18 months (Monthly)

W/C	S01	S02	S04	S06	S10	S11	S12	S15	S16	S17	S18	S21	S26	S31
HOURS	472	601	141	998	912	376	596	7	586	92	1321	1707	709	1040

2. Capacity (including overtime)

HOURS	480	72	240	400[1]	400	200[2]	200[3]	200	800	200	1400	1400	192	400

1. Could be 600 hours - (only 2 from 3 machines are being manned)
2. Could be more - (2 small Punch Grinders are not being manned)
3. Could be 400 hours -(only 1 from 2 Machines is being manned)

3. Capacity - Shortage

The following table represents the Capacity Shortage in the Shop.

The results are based on the above tables assuming there is proper manning, and subject to the constraint of 4 weeks maximum jobs Turnaround Time in the Shop.

WORK CENTRE	SHORTAGE HOURS	MACHINE/MEN	WORK CENTRE'S NAME
S06	-	1-Man	CYLINDRICAL GRINDER-1
S10	512	1-Machine	TOOL AND CUTTER
S11	176	2-Men	SURFACE GRINDER -1
S12	196	1-Machine	PUNCH GRINDER
[illegible]	307	2-Machines	MILLING MACHINE-1
S26	[illegible]17	3-Machines	DRILLING MACHINE
S31	640	3-Men	FITTING BAY

4. For your action.

APPENDIX 7b

CENTRAL WORKSHOPS-MONTHLY WORK CENTRE CAPACITIES

JULY 1981

W/C	NAME	Available Hours*	Efficiency	M/P M/C	Regular Capacity	Emergency Capacity
C02	Carp. Mac.	6.1	85%	4	439.2	48.8
C03	Carp. Benc.	6.1		4	439.2	48.8
C04	Carp. Saddler	6.1		1	72.0	8.0
C05	Timber Drying	9.2		1	165.6	18.4
C99	Inspection	9.2		1	165.6	18.4
F01	Welders shop	5.5	77%	15	148.5	165.0
F02	Welders plant	5.5		10	99.0	110.0
F05	B/Makers shop	8.6	121%	5	77.4	86.0
F06	B/Makers plant	8.6	121%	6	928.8	103.2
F11	Blacksmiths	5.9	82%	2	212.4	23.0
F13	Heat treat B/S	9.2	100%	1	165.6	18.4
F15	Plumbing	5.9	82%	3	318.6	35.4
F19	Rigging		100%	8	1324.	147.11
I98	Mech Final Inspection	9.2	100%	1	165.6	18.4
I99	Fab Final Inspection	9.2	100%	1	165.6	18.4
M01	Lathes	5.4	75%	6	583.2	64.8
M02	Lathes	5.4		8	777.6	86.4
M04	Lathes	9.2		1	165.6	18.4
M06	Turret	5.4		2	194.4	21.6
M10	Vertical Borer	5.4		1	97.2	10.8
M11	Milling (1)	5.4		4	388.8	43.2
M12	Milling (2)	5.4		3	291.6	32.4
M13	Slotter	5.4		1	97.2	10.8
M14	Horizontal Boring	5.4		1	97.2	10.8
M16	Grinder 1	5.4		1	97.2	10.8
M17	Grinder 2	5.4		1	97.2	10.8
M18	Grinder 3	5.4		1	97.2	10.8
M20	Horstmann Lath	5.4		1	97.2	10.8
M21	C/F Drilling	5.4	100%	3	291.6	32.4
M25	Fitter Assembly	7.2		3	388.8	43.2
M26	Central Fitters	7.2		6	777.6	86.4
M28	Heat Treat	7.2		1	129.6	14.4
P01	Mater M/C	9.2	100%	1	184.	—
P02	Mater Fab.	9.2		1	184.	—
P13	Spares Prob.	9.2		1	184.	—
P18	Outside orders	9.2		1	184.	—
P21	Materials	9.2		1	184.	—

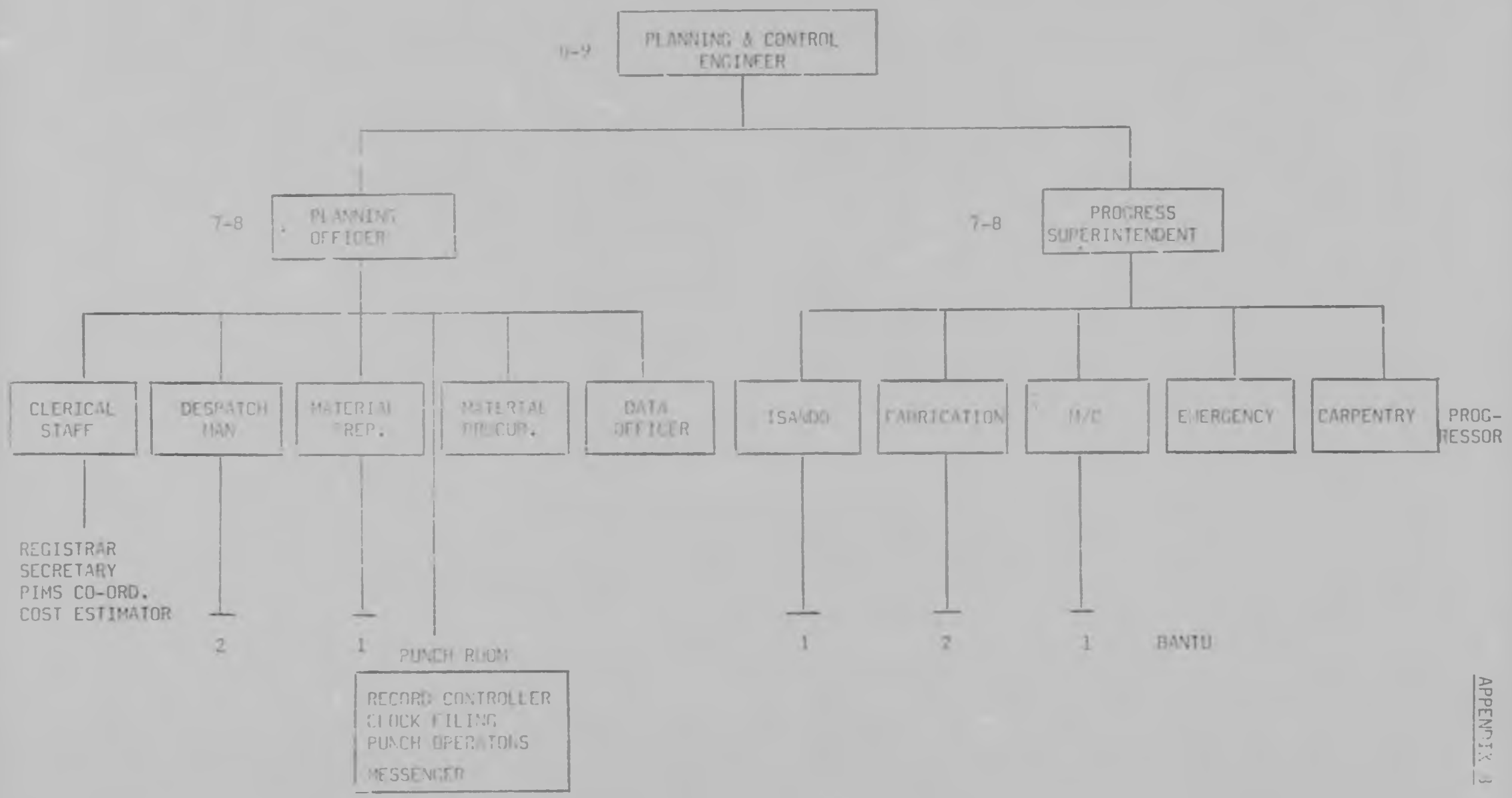
W/C	NAME	Available Hours*	Efficiency	M/P M/C	Regular Capacity	Emergency Capacity
P23	Problem Solver	9.2	100%	1	184.	—
P98	Delivery Note	9.2		1	184.	—
P99	Job Closure	9.2		1	184.	—
S01	NC Cent. Lath	12		2	432.	48.0
S02	NC Turret Lath	12		3	648	72.0
S03	Program NC	9.2		1	165.6	18.4
S04	Drill. Mach	10		1	180.	20.
S06	Grind. Cylinder	10		3	540.	60.
S10	Tool and cutter			2	360.	40.
S11	Grind. Surface	10		1	180.	20.
S12	Punch Grinder	10		1	180.	20.
S15	Turret small	10		1	180.	20.
S16	Turret Small	10		4	720.	80.
S17	Punch Turret	10		1	180.	20.
S18	Center Lath	10		7	1260	140
S21	Milling Mach	10		5	900	100
S26	Drilling Mach	9.2		1	1656	184
S31	Fitting Bay	10		2	360	40
ZZZ	Dummy Error	9.2		1	165.6	18.4

* Available Hours = Full Hours available x W/C efficienc x (1 - 0.1 (absence Rate)) x 0.9

MODDERFONTEIN FACTORY

CENTRAL WORKSHOP - PLANNING & CONTROL SECTION

ORGANISATION STRUCTURE



APPENDIX 3

PLANNING & CONTROL SECTION - KEY PERFORMANCE AREAS

POSITION SPECIFICATION

POSITION TITLE: PLANNING & CONTROL ENGINEER GRADE: DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
A. PLANNING					
1. Manage [illegible] subordinates	1. Plan, lead, organise and control the activities of subordinates [illegible] personnel to monitor the total planning, programme and control system as it [illegible] times.	1.1. Job specifications for each job in the section is completed. Planning Officer, Control Supervisors and Clerk Coordinator are fully trained to maintain effectively total Planning & Control system.	1.1. 0% of discrepancies in subordinates job's definition. Will be controlled by PMC.		
		1.2. Procedures to maintain the total Planning & Control section consisting of: - Comms(Planning) - Input/Output - Programming - Material Procurement - Deliveries - Reports and analysis - Decision making are developed and being maintained at high level.	1.2. 100% of jobs are scheduled. 0.1% errors re serious remarks and files. 95% of jobs being delivered within - 2 days from adjusted deliver. date		
		1.3. A succ-cour for every Supervisory and Specialist job is identified and trained to take over such a job as and when necessary.	1.3. Subordinates on leave: his job is being done properly by others. Will be checked by PMC.		
		1.4. Specific objectives for the section are developed, understood and pursued by every incumbent.	1.4. 100% of accomplishment. Will be checked by PMC, who will determine from time to time special objectives for the section.		
		1.5. Competent personnel are doing the work allocated to them in a disciplined manner. Personnel are highly motivated to achieve the objectives of the section.	1.5. Will be checked qualitatively, based on the various criteria which have been established for the various incumbents		

APPENDIX 9

POSITION SPECIFICATION

POSITION TITLE : PLANNING & CONTROL ENGINEER

GRADE:

DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
2. Work lists, reports, files, materials and tools.	2. Ensure that all required work lists, reports and files are being distributed to PE, foremen and appropriate customers of the planning services	2. Accurate work lists and work packs, material requirements plan and tools are issued to the various work centres.	2. 0% deviation on all procedures involved under this subject.		
3. Problem solving. (Planning)	3. Carrying out special programmes for completing long term jobs. - Progressing outstanding material orders - Progressing outside jobs being done by outside firms.	3. - No more than 20 jobs longer than 120 days into the system. - No more than 5% of outside orders are delayed more than 3 days. - Outside firms are delivering jobs based on schedule.	2. - FWE to check monthly By Job residence report. - Outstanding Materials orders - Report to be used. - 0% deviation on this procedure.		
B. MANAGEMENT					
1. Manpower & Resources.	1. - Training & development programmes are initiated and carried out.	1. No failures in successions of training programmes and promotio	1. Qualitatively. Will be controlled by FWE.		
2. System & Management Development.	2. Continuously investigate, improve use of computer system and better shop floor management.	2. Additional systems, reports and procedures are being established as required.	2. Qualitatively in general. Effectiveness will be checked by concerned subjects.		
3. Prepartion & control of annual budget.	3. - Accurate budget is being identified. - All the budget require ments are itemised. - Saving programmes are being carried out. - Budget controls are being operated.	3. - No inexplicable excess expenditure. - Monetary quantitative indications for expenditure are identified.	3. + 2,5 % maximum excess from budget.		

POSITION SPECIFICATION

POSITION TITLE: PLANNING & CONTROL ENGINEER

GRADE:

DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
4. Workshop facilities, development and infrastructure.	4. Continuously investigate capacity requirements, machinery and shop floor procedures.	4. Agreed turnaround time on the floor is constant or becoming of shorter duration. Demand is growing.	4. Will be derived from the various performance indices.		
5. Relief - PE & FWE	5. As required	5. No discrepancies on agreed standard of general management & decision making.	5. Qualitatively.		

POSITION SPECIFICATION

POSITION TITLE: PLANNING OFFICER — GRADE: — DATE COMPILED:

KEY AREAS	DAILY ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	MEANS OF IDENTIFYING DEVIATIONS	ACTION	INFORM
1. Manage KPA's of subordinates	[illegible] activities of subordinates [illegible] personnel to monitor the total system at all [illegible]	1.1. Job specification for each job in the section is completed. Subordinates are fully trained to maintain effectively total planning system.	1.1. 0% of discrepancies in subordinates job's definition will be controlled managerially			
		1.2. Procedures to maintain the total planning system consists of: -Materials Procurement -CAPOSS scheduling -Management information system -CAPOSS progress are developed and recorded.	1.2. 5% deviation in dates of materials supply will be controlled from receipt of orders. -100% of jobs are scheduled -All reports and programmes are used.			
		1.3. A successor for every supervisory and specialist job is identified and trained to take over such a job as and when necessary.	1.3. Subordinate on leave: his job being done properly by others.			
		1.4. Specific objectives for the section are developed and understood and perused by every incumbent.	1.4. Qualitatively			
		1.5. Competent personnel are doing the work allocated to them in a disciplined manner. Personnel are highly motivated to achieve the objectives of the planning Department.	1.5. Qualitatively			
2. Accurate Input Data	2. Analyse output data and compile management information necessary to control work being done in Work Centres.	2.1. No transcription errors are entered to the computer. The errors report is investigated and all errors corrected within 1 hour after receipt of the error report.	2.1. 0.1% of errors per year in the various programmes and reports.			
		2.2. Inform concerned foreman about errors immediately. Update production programmes and reports.	2.2. 0.1% of errors per year in the various programmes and reports.			

POSITION SPECIFICATION

POSITION TITLE: PLANNING OFFICER — GRADE: — DATE COMPILED:

K.P.A.'s	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	MEANS OF IDENTIFYING DEVIATIONS	ACTION	
3. Daily Work Programme	3. Ensure that all required reports are distributed to appropriate foremen.	3.1. An accurate daily work plan depicting work to be carried out at every work centre is issued to the various progressmen before 8 o'clock every morning.	3.1. 0.1% of errors per year in the various programmes and reports.			
		3.2. An applicable job packet for each job listed on the daily plan is issued with the plan to every work centre.	3.2. 0% deviation on this procedure.			
4. Procurement of Materials.	4. Ensure that all required materials according to daily production programme are available.	4.1. A materials requirements plan is in operation and is being actively expedited.	4.1. 0.1% deviation on despatching of materials based on programme.			
		4.2. Under no circumstances is the start of a job delayed for more than 3 months as a result of non-availability of materials.	4.2. 1% of material ordered being delivered later than 3 months after schedule. Controlled from register of orders.			
5. Problem solving.	5.1. Preparing list of long term jobs and promoting them.	5.1. No more than 20 jobs longer than 120 days into the system.	5.1. Controlling of the Master File. 0% of deviations in this KPA.			
	5.2. Progressing outstanding material orders which are being delayed.	5.2. As above	5.2. As above			
	5.3. Sorting out Master File's programme problems.	5.3. 'Clean' Master File.	5.3. 0.1% errors.			
6. Relieve P & CE	6. Relieve P & CE when required.	6.1. All reports required by Workshop Management and issued on time. Information is being checked and applicability ensured.	6.1. Quality and quantity based on the above mentioned factors.			
		6.2. Management is actively informed of information reports available to assist them.	6.2. 0% deviation.			

POSITION SPECIFICATION

POSITION TITLE: TRANSFUSE OFFICER GRADE: DATE COMPILED:

K.P.A.'s	MAIN ACTIVITIES	PERFORMANCE STANDARD	WAYS TO MEASURE PERFORMANCE	MEANS OF IDENTIFYING DEVIATIONS	ACTION	INFLU-
		6.1. A deviation reporting system is developed and applicable supervision and management are informed accordingly on time.	6.1. Quality will be measured by customers.			

POSITION SPECIFICATION

POSITION TITLE : DATA CONTROLLER

GRADE:

DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
1. Control computer input of information on completed operations.	1. Receive 'feedback' from shop floor. Draw punch cards or code details as necessary.	1. 0.1 % deviation from actual completed job and computer output.	1. Sampling by Planning Officer on a weekly basis.		
	2. Submits cards for nightly computer run.	2. 0 % deviation.	2. Controlling by checking against feedback forms from Foreman.		
2. Updates and maintains Master File	3. Note completed operations in Master File	3. 0.1 % deviation.	3. Weekly sampling.		
	4. Maintain continuous audit of Master File by sampling of chosen cards.	4. 0 % deviation.	4. Weekly sampling.		

POSITION SPECIFICATION

POSITION TITLE: MATERIAL CO-ORDINATOR

GRADE:

DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
1. Control and expedite the procurement of such commodities that are not available ex stores.	1. Vet purchase requisitions, ensuring correct details before placing in Supply Dept. 2. Processes orders in accordance with delivery dates. 3. Arranges delivery of urgent materials. 4. Sub-contracting of works. 5. Provide feedback on delivery of materials.	1. 0 % delays in the starting of a job on time because of material shortages. 2. The incumbent is however dependent on the service given to him by the Supply Dept. Under these circumstances delays in 5 % of the jobs is acceptable. (He is notified any time on such cases)	1. Registration and control by Planning Officer. 2. Registration of failures occurs because of Supply Dept. and giving notice to Planning Officer. Not more than 5 %.		

POSITION SPECIFICATION

POSITION TITLE: MATERIAL PROGRESSOR GRADE: DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
1. Procure raw materials from Factory Stores.	1. Checks requisitions to ensure that material asked for is correct and not in excess stores. Arranges delivery from store and cutting if required. Checks deliveries for correct sizes and quantities.	1. 0,1 % delays in the starting of jobs on time because of material shortages. (The increment is however dependent on availability of material ex stores) Feedback to Planning Office who will control it in writing.	1. Planning Officer will monitor daily performance based on the production programme.		
2. Monitor 'stock out' situation.	2. Progress stock outs or arrange for alternate materials. Deliver materials and route cards to material box and ensure Closed feedback. The above all done for emergencies as and when they arise.	2. Under these circumstances delays in ½ % of the jobs is acceptable.			
3. Manage KPA's of subordinates.	3. Plan, lead, organise the activities of subordinates.	3. Subordinates are fully trained and disciplined to do their job properly.	3. Qualitively.		

POSITION SPECIFICATION

POSITION TITLE: ASSISTANT MATERIAL PROGRESSOR GRADE: DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
1. Assist in the procurement of materials from Factory Stores.	1. Prepare computer produced requisitions. Take to stores. Ensure receipt of material with correct paperwork.	1. 1 % stock-outs at any one time is an acceptable level.	1. Spot checking by Material Progressor of all paperwork.		
2. Monitor stock-outs situation .	2. Keep watch on re stock items and re-requisition regularly, route cards are filed.	2. 1 % stock outs at any one time is an acceptable level.			
3. Receive goods at Workshops delivery point.	3. Check all items and signs waybill for received from stores and outside suppliers and ensure copy is retained of the receipt thereof.	3. Material receiving bay always clean.			

POSITION SPECIFICATION

POSITION TITLE: MATERIALS BAY KEEPER

GRADE:

DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
Ensure that raw material and semi finished products are always available when required.	Bin raw material with complete mini-pack ensuring accuracy and valid Copiss input. Ensure semi-product correctly re-binned after each operation. Conduct regular bin audits in conjunction with the computer bin listing.	Pre-Binning area always clear. No errors in bin numbers reflected in the Master File There is no room for error in this area.	Spot checks. Spot checks by Progressor.		

POSITION SPECIFICATION

POSITION TITLE: RECORD CONTR..ER GRADE: DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
Maintains a library consisting of: Job packs Completed job cards Master filing system by commodities code and drawing numbers	Ensures validity of filing system. Draws and refiles various documents from files as required. Maintains history on file by recording new jobs and their completion on the envelope. Ensures live job file up-to-date. Ensures that completed jobs filed correctly.	0.1 % of misfiling is acceptable.	Control by weekly sampling and three monthly audits. 0.1 % variation is acceptable.		

POSITION SPECIFICATION

POSITION TITLE : PUNCH OPERATOR(S) GRADE: DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
1. Prepare computer input punch cards ensuring that there are no errors and the daily deadlines are met.	1. Punch computer input for all jobs requisioned.	1. 0.1 % allowable errors in the daily punching programme.	1. Regular checks of daily error listing by Planning Officer.		
	2. Punch parameter up dates as required.	2. 0.1 % allowable errors in the daily punching programme.			
	3. Rectify all errors by re-punching various types of input data.				
	4. Re-punch cards as rectified by the Planning Officer.				

POSITION SPECIFICATION

POSITION TITLE: PROGRESS SUPERVISOR GRADE: DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAY TO MEASURE PERFORMANCE	ACTIONS	INFORM
1. Manage KPA's of subordinates.	1.1.Plan, lead, organise and control the activities of subordinates. Develop competent personnel to monitor the total system of all received items.	1.1.1.Job specifications for each job in the section is completed. Incumbents are fully trained to monitor total progressing system.	1.1.1. 0% deviation from KPA's is accepted. Will be controlled qualitively.		
		1.1.2.A successor for every job in the section is identified and trained to take over such a job when necessary.	1.1.2. People on leave - Job will be done properly by successor. Will be controlled with respect to quality.		
		1.1.3.Special objectives for the section are developed.	1.1.3. Achievements will be as equal in terms of quantity. 95% achievement is required.		
		1.1.4.Job is being done in a disciplined manner. Personnel are highly motivated to achieve the objectives of the progress supervisor.	1.1.4. Will be controlled according to quality.		
	1.2.Control the loading programmes and delivery of all jobs.	1.2.1.Procedures to maintain the progressing system, consisting of: - Materials allocation - Tools are available - Papers and reports are updated - Emergency jobs are progressed and delivered on time - Ordinary jobs are being progressed - Control reports are updated.	1.2.1. 0.1% deviation from daily production programme. Deviations will be controlled daily. Report to P & CC will be weekly based.		
2. Determine delivery dates for ordinary jobs.	2.1.Determine delivery dates based on load chart and available capacity.	2.1. Rational delivery dates based on capacity and ± 2% of deviation.	2.1. 95% of jobs with ± 2 days deviation from CDD.		
	2.2.Advise P & CC when overtime is required.	2.2. Overtime is being controlled.	2.2. 5% deviation on assessments of overtime required.		

POSITION SPECIFICATION

2

POSITION TITLE : PROGRESS SUPERVISOR

GRADE:

DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM	
		2.3. Correct method and procedures in production are being used.	2.3. 1% of scrap. (Will be controlled in conjunction with foreman)			
3. Decide on inhouse versus external manufacturing.	3.1. Based on production programme, make decision if job will be done inhouse or externally.	3.1. A job will only be sent outside when impossible to meet the delivery date. Indications about short term and long term shortages of capacity will be given to P & PC.	3.1. 2.5% of machines' waiting time freaking.			
	3.2. Negotiate with outside manufacturers on required delivery dates.	3.2. Jobs being done outside are delivered on time.	3.2. 0% deviation.			
	3.3. Progress and control outside manufacturers	3.3. Job is being done properly by manufacturers and conforms to the required standards.	3.3. 0% scrap.			
4. Emergency jobs.	4.1. Make decision whether emergency job or ordinary job.	4.1. Each emergency job is planned in conjunction with the originator, the applicable foreman/ foreman, the applicable Estimator and the Materials Procurer, within 1 hour after registration of such a job.	4.1. 0% delay of customers in planning.			
	4.2. Apply emergency procedure ensure availability of materials, tools and capacity.	4.2. No emergency job is delivered late to the customer.	4.2. 1% deviation on delivery dates.			
5. Relieve PO and P & CE.		5.1. System is working at high performance.	5.1. According to quality (will affect PO and P & CE measured performances)			

POSITION SPECIFICATION

POSITION TITLE : PROGRESSOR GRADE: DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
1. Progress daily work list	1.1. Obtain daily work list with all required materials and items.	1.1. All jobs on daily work list completed. - Uncompleted jobs can be explained.	1.1. 0% of uncompleted jobs for every day will be measured on a daily basis by the Progress Supervisor when obtaining the work list back.		
	1.2. Allocate jobs based on daily work list to foremen.	1.2. Required facilities, materials and tools are available, based on programme.	1.2. 0% deviation.		
	1.3. Control jobs in process and ensure completion of work list.	1.3. All jobs are meeting delivery dates as per programme.	1.3. 95% of jobs within ± 2 days of planned delivery date. Will be measured by P & CE.		
	1.4. Inform Progress Supervisor of errors and discrepancies on work lists.	1.4. All errors and discrepancies are sorted out by 7 o'clock every morning.	1.4. 0% of errors on work lists. Will be measured daily by the Progress Supervisor.		
	1.5. Follow up completed jobs on quality control and ensure that deliveries are made on time.	1.5. Completed jobs are not more than 8 hours in quality control bay.	1.5. 0% deviation.		
	1.6. Ensure that completed operation/jobs feedback is given to the Data Controller in time.	1.6. Daily feedbacks are given to the Data Controller every day before 3 o' clock.	1.6. 0% deviation.		
2. Liaison between Foremen and Planning & Control.	2.1. Rectify errors on D.P. reports.	2.1. All required operations in order to have applicable work list and jobs are done as per Foremen request.	2.1. 0% deviation.		
	2.2. Update Master File.				
	2.3. Progress jobs.				

POSITION SPECIFICATION 2

POSITION TITLE : PROGRESSOR GRADE: DATE COMPILED:

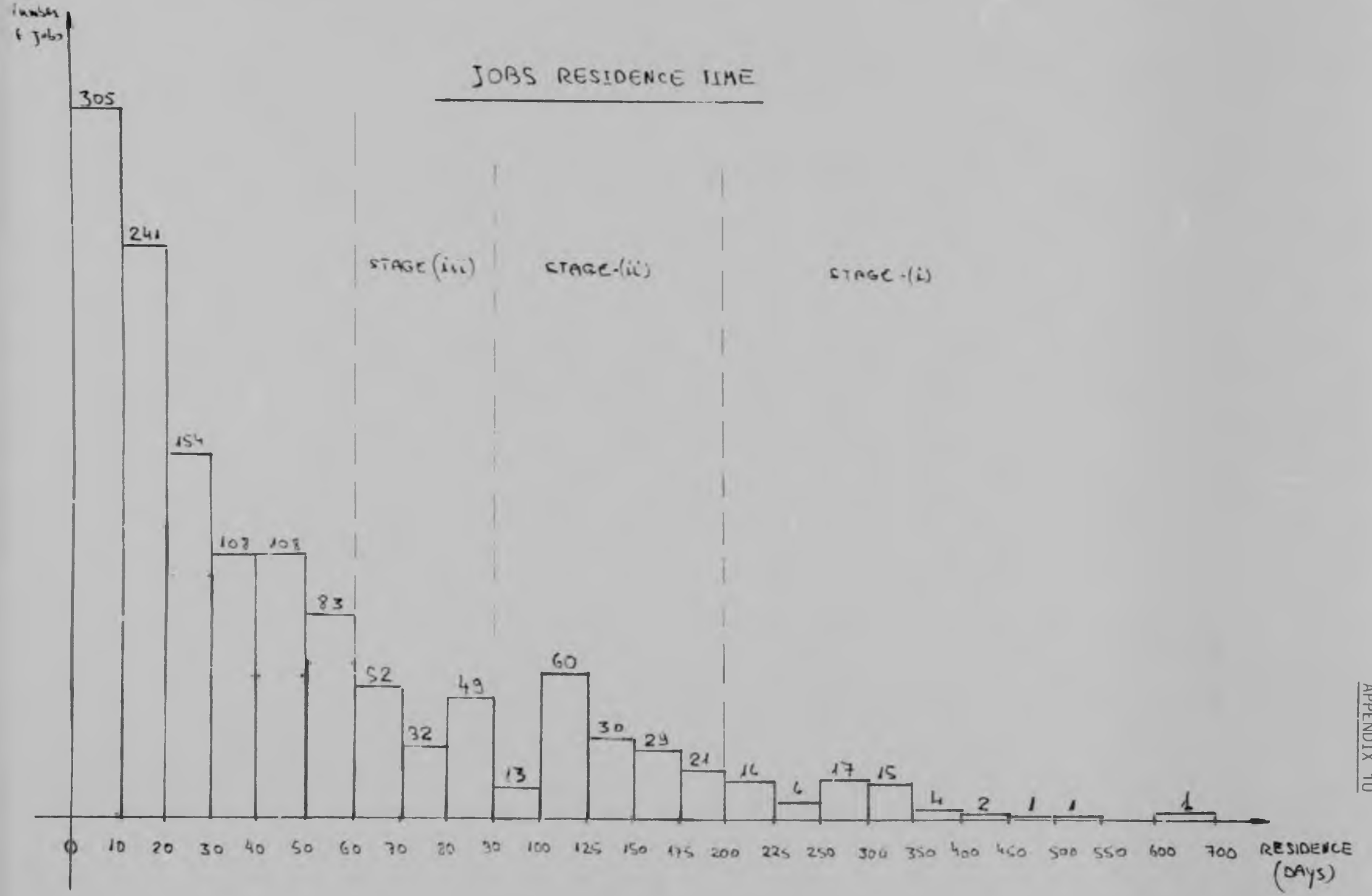
KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARD	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
3. Progress special job lists as per Progress Supervisor request.	3. Make all required preparations to meet completion of jobs.	3. Required facilities, materials and tools are available.	3. 0% deviation.		
4. Update Progress Supervisor.	4. Give daily feedback to Progress Supervisor regarding work list, work in process and work in progress.	4. Progress Supervisor is updated with all the work lists. Action is being taken to sort out problems ie. outstanding orders, lack of materials, work packs, drawings and tools.	4. 100% of jobs or operations being effected perfectly.		

POSITION SPECIFICATION

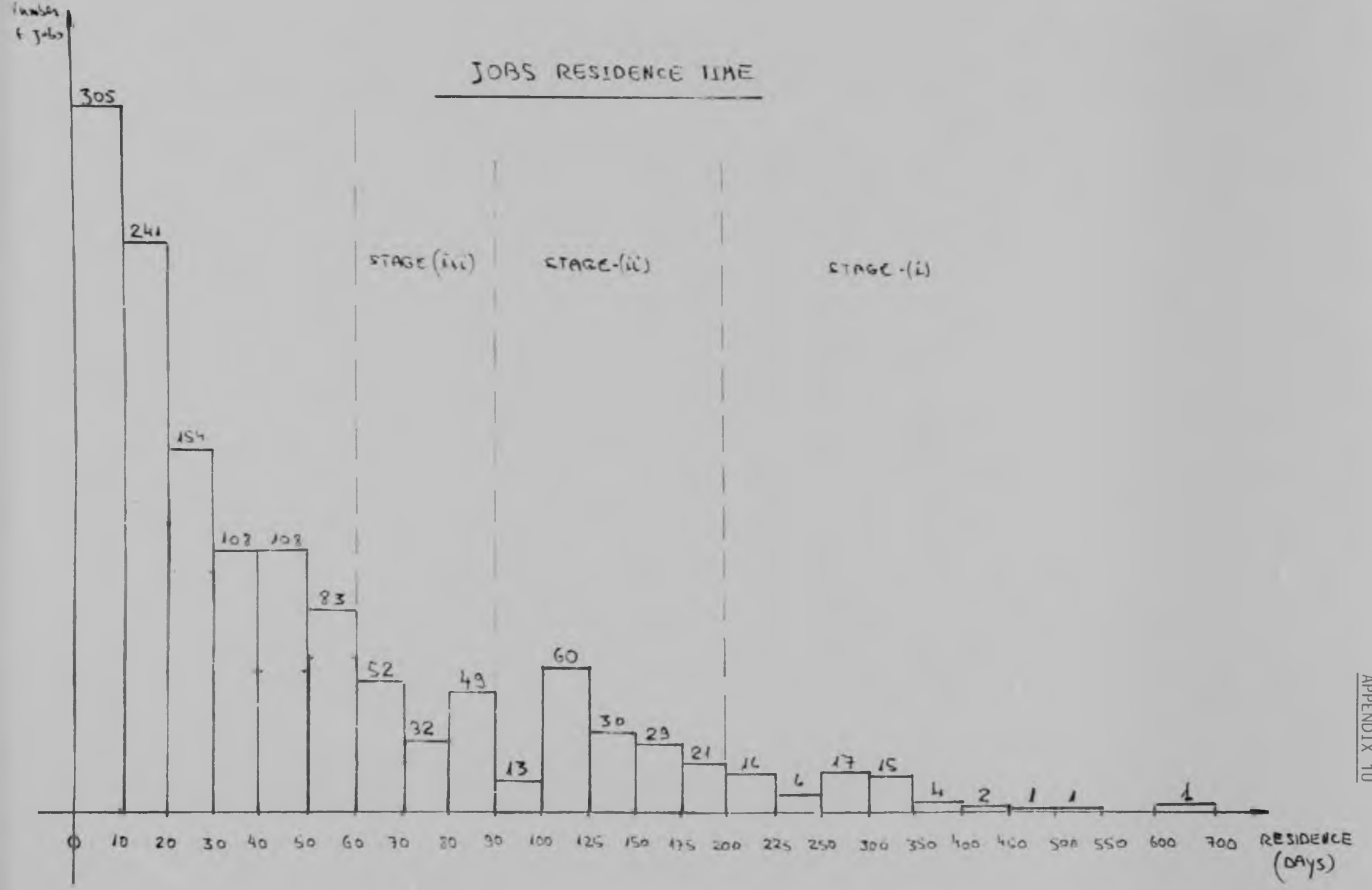
POSITION TITLE : EMERGENCY PROGRESSOR | GRADE: | DATE COMPILED:

KEY PERFORMANCE AREAS	MAIN ACTIVITIES	PERFORMANCE STANDARDS	WAYS TO MEASURE PERFORMANCE	ACTIONS	INFORM
1. Emergency jobs	1.1. Make decisions whether emergency job or ordinary job.	1.1. Only "real" emergencies are being accepted as emergency jobs.	95% of emergency jobs are being delivered within 24 hours.		
	1.2. Apply emergency procedure. Ensure availability of materials, tools and capacity.	1.2. Jobs are being progressed immediately when machines or tooling are available.	3% of emergency jobs are being delivered within 2 days.		
	1.3. Prepare proper registration and controlling procedure and paperwork for emergency job.	1.3. Jobs are being controlled. Adequate information regarding jobs in the various work centres is maintained.	2% of emergency jobs are being delivered within 4 days. Will be controlled by Progress Supervisor.		
	1.4. Control the job in process.	1.4. Jobs are progressed according to layout and properly.			
	1.5. Control completed emergency job in quality control bay.	1.5. Jobs are not being delayed on quality control bay.			
	1.6. Liaise with customer and ensure timeous delivery.	1.6. Jobs are being delivered within 24 hours . Acceptance of job is being ensured by the Emergency Progressor.			
2. Shut-downs.	2. Get shut-down jobs. -Ensure availability of materials, tools & capacity. -Ensure completion on day of receipt. -Liaise with customer. -Ensure delivery.	2. As above.			

JOBS RESIDENCE TIME



JOBS RESIDENCE TIME



APPROVED LIST OF SUPPLIERS AND MANUFACTURING DELIVERY TIME

APPENDIX 'B'

Approved list of Supplier and Manufacturing delivery times for the purpose of Workshop Planning, estimating and advising customer plants of likely delivery periods for component manufacture.

Date of Approval/Agreement of the List D.T.T.

Date of next update of List 01.10.6.

Estimated Delivery Times

SUPPLIER	MATERIAL TYPE	DELIVERY IN WEEKS
THOMAS & PILLINER	STEEL & MEEHANITE CASTINGS	16-20
DURBAN ALLOYS	STAINLESS CASTINGS	16-20
BRONZE CASTINGS	CAST BRONZE	6-8
ALROCAST	ALUMINIUM CASTINGS	2-3
SWEIGERS & SMITH	RAW STEELS	1-2
JACKSON	RAW STEEL	1-2
N.T.C.	RAW STEEL	1-3
ROBOR	RAW STEELS	1-2
KENNETH RAY	KEY STEELS	1-2
METALLURGICAL PROCESSES	S/STEEL HOLLOW BAR	6-8
PROCESS PIPE	PIPES & FLANGES	4-6
TANK END	DISHED ENDS	4-6
HEAT EXCHANGERS	BOILER PLATE	2-4
TESCO	FORGING MATERIAL	4-8
BROWN BAILEY	RAW STEEL	2-3
PRIMAFORCE PIPE	PIPING	1-2
MAKSAL TUBES	ALUMBRO TUBES	12-16
CAMEC SPECIAL	TOOL STEELS	1-3
MARATHON STEEL	TOOL STEELS	1-3
BOHLER STEEL	TOOL STEELS	1-3
SANDERSON NEWBOLDT	TOOL STEELS	1-3
STARCO SPRINGS	SPRING WIRE	2-3
CLYDE TRADING	TOOL STEELS	1-3
SANDVIK	[illegible] STEEL PLATE (SPECIALS)	10-12
CAMDER (FRANCE)	TUNGSTEN	20-30
HERMAN SCREENS	WIRE MESH	4-6
ANDREW MENTIS	PLATES [illegible]	1-2
TUFNOL PTY	TUFNOL [illegible]	6-8
LAND SEA & AIR	[illegible]	1-4
MARC EITER	[illegible]	4-6
GAP ENG.	[illegible].M.C.	3-4
PROLOCK	NEOPRENE CHEPT	5-6
CHICK HENDERSON	NEOPRENE TUBES	3-4
WEVELL BROS.	RUBBER BEARING	3-4
ALLANSON/WARMAN	RUBBER COVERING	6-8
GACO PRODUCTS	OIL SEALS	3-4
FIBRE GLASS SERVICES	INSULATION	4-5
COMPAIR	VALVES	10-12
E. LOWE	VALVES	10-12
FESTO	VALVE FITTINGS	2-3

3/...

Estimated Delivery Times

SUPPLIER	MATERIAL TYPE	DELIVERY IN WEEKS
LONGDALE ENG.	NON RETURN VALVES	2-3
PARKER HANNIFIN	CONNECTIONS	1-2
B.S. & W. WHITLEY	RED FIBRE - CELERON	4-6
BEARINGS & BELTING SUPPLY	BEARINGS AND PLUMMER-BLOCKS	1-2
ATLAS BEARINGS	BEARINGS & STEEL BALLS	2-3
S.K.F.	BEARINGS	2-3
REUNERT & LEINZ	FENNER PULLEYS & STAIR TREADS	2-3
RENOLD CROFT	PINIONS	3-5
METER SYSTEMS	COUPLINGS & PLUGS	4-5
GLACIER	BUSHES	3-4
DRITE BOLT	RIVETS & BOLTS	1-2
H. W. GOODWIN	PISTON RINGS	8-10
TRANSVAAL MOTORS	MOTORS (ELECTRIC)	6-8
INDUSTRIAL GALVANISERS	GALVANISING	4-5
MOSER H/CHROME	HARD CHROMING	8-12
R.A.R.E. EDENVALE	STEEL & CERAMIC COATING	4-6
MARATHON H/TREATMENT	HEAT TREATMENT	2-3
DYNAMIC BALANCING	FAN BALANCING	1-1½
CERITE ENG.	GRINDING	3-4
R. B. FASTENERS	FASTENING DEVICES	2-4
FALK ENG. SUPPLIES	MISCELLANEOUS	1-14
VENTERRY	MISCELLANEOUS	1-14
PATTERN MAKING	PATTERNS	4-6
OVERSEAS	MISCELLANEOUS RAW MATERIALS	25-30
OVERSEAS CLEARING	MISCELLANEOUS RAW MATERIALS	4-6

AECI REPORT NO. A6 — STORES SYSTEM - NCODERFONTEIN — RUN DATE 6/04/81

PROGRAM NO. CS5527 — ON DEMAND LISTING OF OUTSTANDING ORDERS — PAGE NO. 69

SEQUENCE - BUYER/SUPPLIER/ORDER

BUYER CODE	SUPPLIER CODE	COMMODITY CODE	DESCRIPTION	ORDER NUMBER	ORDER QTY	ORDER DATE	DUE DATE		CURRENT RATE	ORDER VALUE
14	0001	72463374	IMPELLER PART 23.0 GA0207M	14C0691 001	1	040380	040680	**	970.620	970.62
14	0001	72463375	IMPELLER PART 23.01 GA0207M	14C0880 001	1	040380	040680	**	907.120	907.12
14	0001	72463551	SHAFT CU LIQ BOOST PUMP 11	14C2516 001	3	200781	200581		50.000	150.00
14	0001	72463571	GLAND CU LIQ BOOST 3-12665 11	14C2384 001	2	290181	290481		10.000	20.00
14	0001	72463574	RING OIL CU LIQ BOOST PUMP 11	14C2385 001	2	290181	290481		5.530	11.06
14	0001	72474307	GEAR IDL STCHK RTSN80 TARPU 05	14C0785 001	2	150280	150580	**	68.650	137.30
14	0001	72474307	GEAR IDL STCHK RTSN80 TARPU 05	14C2327 001	4	150181	150481		68.650	274.60
14	0001	72474314	COVER BRG STCHK TAR PUMP 05	14C0196 001	2	141179	140180	**	39.650	79.30
14	0001	72474584	VIKING GEAR PUMP IDLER GEAR	14C1218 001	2	290380	290880	**	73.120	146.24
14	0001	72509638	SLIPPER 27 GA1006M	14C1243 002	1	030680	270780	**	75.213	75.21
14	0001	72521452	BUSH-1-12160 COPP-LIQ-INJECTII	14C1982 001	3	161080	160481		107.590	322.77
14	0001	73424622	OUTSIDE LINK CCKE 3 250/1 05	14C2441 001	360	180281	180581		2.500	900.00
14	0001	73424623	INSIDE LINK CCKE 3 250/2 05	14C2442 001	360	180281	180581		2.500	900.00
14	0001	73424625	ROLLER CCKE CCNN 3 250/4 05	14C2405 001	400	110281	110581		5.000	2000.00
14	0001	73424633	WASHER CCKE CCNVEYOR3 250/1705	14C2711 001	500	080481	081081		.500	250.00
14	0001	73482036	SLAT WCN 100x75x20	14C2066 001	150	121180	120281	**	.170	25.50
14	0001	73471311	BUSH-BUCK-SHAFT 1-37539ELEVA05	14C2719 001	400	080481	081081		5.110	2044.00
14	0001	73471338	LINK-INNER 1-37541 BUCK-ELEV05	14C2697 001	150	020481	020781		2.692	403.80
14	0001	73471341	SPACER 1-37537 BUCKET-ELEVAT05	14C2718 001	400	080481	081081		.884	353.60
14	0001	73471371	LOCK-PL 1-37539 BUCK-ELEVAT005	14C1709 001	100	210880	210281	**	1.690	169.00
14	0001	73471371	LOCK-PL 1-37538 BUCK-ELEVAT005	14C2701 001	100	020481	020781		1.890	189.00
14	0001	73512411	REV SCRW RAM ELN CAR PULL	14C2958 001	2	100381	100681		136.547	273.09
14	0001	74131331	UPPER BWG SLEEV RKA501M	14C2263 001	10	191280	190381	**	64.682	646.82
14	0001	74131332	UPPER BEARING RKA 0*M	14C2262 001	10	191280	190381	**	43.021	430.21
14	0001	74131333	LOWER BEARING RKA501M	14C2261 001	10	191280	190381	**	79.500	795.00

APPENDIX 12

QUALITY CONTROL ENGINEERING
MODDERFONTEIN

QUALITY ASSURANCE PROCEDURE STANDARD

REFERENCE	TITLE	STD NO.
	COMPONENT INSPECTION CONTROL CENTRAL WORKSHOPS	QA/ADMIN/001

AECI/ENG/A/03-8103 R
REV 'E'
REV 'D'
REV
REV 'B'
REV 'A'
ORIG ISSUE DATE
JUNE 1981
ORIGINATED BY:
E. MILLAR

PROCEDURE INDEX

Contents	Page No.
1. INTRODUCTION.	2.
2. SCOPE.	2.
3. RESPONSIBILITY.	2
3,1 Quality Control Engineering.	2.
3,2 Central Workshops.	2.
4. INSPECTION CONTROL - REQUIREMENTS AND SYSTEMS.	3.
4,1 General.	3.
4,2 Definitions.	3.
4,3 Inspection Procedures.	4.
4,3,1 Batch Quantities.	4.
i) First off Inspection.	4.
ii) Patrol Inspection.	5.
iii) Final Inspection.	5.
4,3,2 Non-Batch Quantities.	4.
i) First off Inspection.	5.
ii) Patrol Inspection.	6.
iii) Final Inspection.	6.
4,3,3 Final Inspection of component.	7.
5. REJECT CONTROL - REQUIREMENTS AND SYSTEMS.	8.
5,1 General.	8.
5,2 Component Rejection.	8.
5,3 Rework During Manufacturing Operation Period.	8.
5,4 Rework After Manufacturing Operation Period.	9.
5,5 Scrap.	9.
5,6 Deviation from Specification.	10.
5,6,1 Factory Made Spares (FMS).	10.
5,6,2 Maintenance Work.	11.
5,6,3 Emergency Work.	12.
6. EQUIPMENT CALIBRATION.	12

AECI/M/ENG/L93-8103 R

REV 'E' | REV 'D' | REV | REV 'B' | REV 'A' | ORIG ISSUE DATE JUNE 1981 | ORIGINATED BY: P. MILLAR

QUALITY CONTROL ENGINEERING
MODDERFONTEIN

QUALITY ASSURANCE PROCEDURE STANDARD

REFERENCE	TITLE	STD NO
	COMPONENT INSPECTION CONTROL CENTRAL WORKSHOPS	QA/ADMIN/C01

1. INTRODUCTION

This procedure standard identifies the inspection methods and systems that shall be operated by Quality Control Engineering in respect of components manufactured by the Central Workshops units of machine shop, fitting shop and fabrication shops so as to ensure that adequate levels of quality, reliability and performance are maintained for all components manufactured by these units.

2. SCOPE

The scope of this procedure details the specific methods of inspection that shall be applied during all phases of a components' manufacture, the systems for dealing with rejected work, and the responsibility and administration for the recovery of such defects through feedback and corrective action.

3. RESPONSIBILITY

3,1 QUALITY CONTROL ENGINEERING

It is the Quality Control Engineering Departments' responsibility in terms of the Factory Engineering Quality Policy to assure that all components manufactured fulfil their intended purpose with regards to safety, reliability and performance as well as such other quality aspects that may apply in specific cases by:-

3,1,1 Providing an effective and economic means of controlling quality by recognised and approved inspection methods and systems.

3,1,2 Acceptance or rejection of a component based on the requirements of the relevant drawing or specification.

3,1,3 Customer liaison in determining recovery of rejected components through acceptance or corrective action.

3,1,4 Assuring that defective or incorrect drawings and specifications are rectified.

3,2 CENTRAL WORKSHOPS

It is the manufacturing units of Central Workshops responsibility in terms of the Factory Engineering Quality Policy to manufacture quality components by:-

3,2,1 Ensuring accuracy of manufacture in producing components to the requirements of the drawing or specification supplied.

3,2,2 Bringing to the attention of Quality Control Engineering defective or incorrect drawings or specifications.

3,2,3 Bringing to the attention of Planning and Estimating departments defective or incorrect work routings for corrective action.

4. INSPECTION CONTROL - REQUIREMENTS AND SYSTEMS

4,1 GENERAL

All components manufactured shall be subject to quality control monitoring and inspection throughout every manufacturing operation of the component to completion and final acceptance.

Components shall be inspected to ensure compliance of the component to the relevant drawing, specification or quality standard and shall be accepted or rejected on their requirements.

Inspections shall be carried out under a system of three phase inspections as follows:-

4,1,1 First-off Inspection.
4,1,2 Patrol Inspection.
4,1,3 Final Inspection.

All inspections shall be undertaken by quality control inspectors who shall be responsible for nominated manufacturing work areas. The inspectors shall be accountable to the relevant Senior Inspector for all inspection work undertaken by them. The Senior Inspectors are accountable to the Quality Control Engineer for all inspection work undertaken by the Department.

4,2 DEFINITIONS

The definition of the expressions used in this standard shall be as follows:-

4,2,1 "FIRST OFF" INSPECTION: The method of inspection of the first made component of a manufacturing run which will ensure that the following are being achieved.

1. Any deviation of the component from the drawing or specification will be detected and rectified immediately.

2. Manufacturing instructions, drawings and specifications are correct and understandable.

3. Correct material has been issued.

4. Manufacturing equipment has been 'set up' and functioning correctly.

QUALITY ASSURANCE PROCEDURE STANDARD

REFERENCE	TITLE	STD NO.
	COMPONENT INSPECTION CONTROL CENTRAL WORKSHOPS	QA/ADMIN/001

AECI/MENG/L95-8103 R
REV 'E'
REV 'D'
REV
REV 'B'
REV 'A'
ORIG. ISSUE DATE
JUNE 1981
ORIGINATED:
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4,2,2 PATROL INSPECTION:- The method of inspection which provides for periodic sampling of a manufactured batch conducted during the progressing of the batch through manufacture to completion.

4,2,3 FINAL INSPECTION:- The method of inspection that will be undertaken prior to final acceptance of a component batch.

4,2,4 BATCH QUANTITY:- For the purpose of this standard a batch quantity will mean a manufacturing order in excess of three components.

4,2,5 NON BATCH QUANTITY:- For the purpose of this standard a non batch quantity will mean a manufacturing order of upto a maximum of three components.

4,3 INSPECTION PROCEDURES

It is a requirement of this procedure standard that all components manufactured shall be subject to the methods of inspection as follows and such inspection shall be carried out in respect of any and every operation during the manufacture of the component.

4,3,1 BATCH QUANTITIES

i) First off Inspection

a. The 'first off' shall be submitted to the area inspector by the operator for a full visual and dimensional inspection before continuing wit ne batch.

b. The inspector will en re that the inspection is carried out accurately and efficiently ensuring minimum delay to production.

c. On acceptance of the component as complying to drawing or specification the inspector shall immediately inform the operator to continue production and shall stamp, (using personal stamp) or mark (using green marking ink) the component to indicate acceptance.

d. The inspector shall then initiate an Inspection Record Card with the Job details taken from the job route card and shall complete the "first off" portion and sign the card indicating acceptance. The card will then be placed within the work pack.

ii) PATROL INSPECTION

a. On acceptance of a component on 'first off' inspection, the inspector will initiate a series of patrol inspections carried out at random on the component throughout the manufacture run.

b. The inspector shall carry out both visual and dimensional inspection and shall inform the operator and Leading Hand of any deviation from specification for necessary action.

c. The inspector shall update the inspection record card indicating his finding of the inspection, recording the time of inspection and signing the card for every inspection carried out.

iii) FINAL INSPECTION

a. Final inspection shall be carried out within the inspection areas after the components, drawings, route card etc. have been submitted by the operator.

b. Such inspections will be based on the information detailed on the inspection record card and should comprise:-

a. A cursory visual inspection to ensure no damage has occurred during transporting to inspection area.

b. A random dimensional check to satisfy the inspector of possible doubtful dimensions.

c. On completion and acceptance the inspector shall complete the inspection record card indicating quantity accepted, quantity rejected (if applicable) against original order quantity and shall sign and date the card.

d. The Job route card shall be completed to show quantity accepted, signed and dated by the inspector.

4,3,2 NON-BATCH QUANTITIES

i) First-off Inspection

a. The operator shall call the area inspector to carry out visual and dimensional inspection of the component at the area of manufacture when it is not possible to convey the component to the inspector.

AECI/M/ENG/L95-8103 R
REV 'E'
REV 'D'
REV 'C'
REV 'B'
REV 'A'
ORIG. ISSUE DATE JUNE 1981
ORIGINATED BY: F. MILLAR

AECI/M/ENG/L95-8103 R
REV 'E'
REV 'D'
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REV 'B'
REV 'A'
ORIG. ISSUE DATE JUNE 1981
ORIGINATED BY: F. MILLAR

b. The inspector will ensure that the inspection is carried out accurately and efficiently, ensuring minimum delay to production.

c. On acceptance of the component as complying to drawing or specification the inspector shall immediately inform the operator to continue production and shall stamp, (using personal stamp) or mark (using green marking ink) the component to indicate acceptance.

d. The inspector shall then initiate an Inspection Record Card with the Job details taken from the job route card and shall complete the "first off" portion and sign the card indicating acceptance. The card will then be placed within the work pack.

ii) PATROL INSPECTION

a. On acceptance of a component on "first off" inspection, the inspector will initiate a series of patrol inspections carried out at random on the component throughout the manufacture run.

b. The inspector shall carry out both visual and dimensional inspection and shall inform the operator and Leading Hand of any deviation from specification for necessary action.

c. The inspector shall update the inspection record card indicating his finding of the inspection, recording the time of inspection and signing the card for every inspection carried out.

iii) FINAL INSPECTION OF OPERATION

a. Final inspection shall be carried out within the inspection areas after the components, drawings, route card etc. have been submitted by the operator.

b. Such inspections will be based on the information detailed on the inspection record card and should comprise:

a. A cursory visual inspection to ensure no damage has occurred during transporting to isnpection area.;

b. A random dimensional check to satisfy the inspector of possible doubtful dimensions.

QUALITY ASSURANCE PROCEDURE STANDARD

REFERENCE	TITLE	STD NO.
	COMPONENT INSPECTION CONTROL CENTRAL WORKSHOPS	QA/ADMIN/001

4,3,3 FINAL INSPECTION OF COMPONENT

On completion of all operations and inspections the following shall be carried out:-

The inspection record card, route card, drawing and specification as applicable shall be passed to Quality Control Inspection Administration for preparing of Delivery Notes, (when applicable) forwarding of route cards to planning for the closing of CAPOSS and arranging delivery to customer. FMS components being sent for protection coating and packing before delivery to stores.

AECI/M/ENG/L95-8103 R

REV 'E'	REV 'D'	REV 'C'	REV 'B'	REV 'A'	ORIG. ISSUE DATE JUNE 1981	ORIGINATED BY: F. MILLAR

QUALITY ASSURANCE PROCEDURE STANDARD

REFERENCE	TITLE	STD NO.
	COMPONENT INSPECTION CONTROL CENTRAL WORKSHOPS	QA/ADMIN/001

AECI/M/ENG/L-95-8103 R
REV 'E'
REV 'D'
REV 'C'
REV 'B'
REV 'A'
ORIG ISSUE DATE JUNE 1981
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5. REJECT CONTROL - REQUIREMENTS & SYSTEMS

5,1 GENERAL

All components which do not conform to specification or drawing requirement shall be rejected by the inspector pending further investigation, plant feedback and/or corrective action decision.

Rejection of a component shall be made regardless of the extent of the deviation from the specification or drawing.

The procedure to be adapted for rejects shall vary according to the circumstances of requirements as detailed under. The skilful application of rework and corrective action methods will effectively reduce rejection costs.

"Not all rejected components are necessarily scrapped"

5,2 COMPONENT REJECTION

1. On rejection of a component at the 'first off' patrol or final inspection stage the inspector shall immediately inform the respective operator and the Leading Hand of the discrepancy and shall discuss and advise possible rectification and rework action.

2. The rework action permissible will vary according to whether the component is a:

   i) Factory Made Spare (F.M.S.)
   ii) Maintenance Component.
   iii) Emergency work component.

3. The responsibility for deciding whether rework and the method of rework is acceptable or whether the component must be scrapped rests with Quality Control Engineering who will consult with plant and workshop personnel before decision.

4. When possible, rework decisions will be taken quickly to enable rework to be carried out on the same manufacturing set up.

5,3 REWORK DURING MANUFACTURING OPERATION PERIOD

1. The components shall be reworked by the approved and agreed method and it shall be submitted by the operator for inspection as laid down in section 4,3 of this procedure.

2. A Quality Control Rejection Note shall not be issued for rejections that are reworked during the manufacturing operation period.

3. If a suitable rework method cannot be agreed the reject shall be dealt with as specified in section 5,4. The job route card shall be adjusted to reflect quantity accepted.

4. Inspection record card shall reflect the quantity accepted and a detailed description of the rework method entered.

5,4 REWORK AFTER MANUFACTURING OPERATION PERIOD

1. A reject that cannot be effectively rectified during the manufacturing operation period shall, at the request of the inspector, be removed from the batch pending a decision on the rework method from a higher authority.

2. The Leading Hand shall be notified of the rejection and the batch quantity on the job route card adjusted.

3. The inspector shall complete a Quality Control Rejection Note detailing the extent of deviation to specification. The Inspection record card shall reflect quantity accepted and quantity rejected detailing briefly cause for rejection.

4. The inspector shall pass information of reject to the Senior Inspector who shall deal with the reject and initiate possible rework and corrective action after discussion with plant personnel, and considering the requirement of section 5,6.

5. On a decision to rework the Senior Inspector shall liaise with workshop and planning personnel as to rework method and requirements. The details of the rework method shall be fully detailed on the reverse side of the Rejection Note. Copy of the note being submitted to Planning Department for action.

6. When a rework method or corrective action cannot be determined and/or agreed the Senior Inspector shall refer the matter to the Quality Control Engineer for a decision on the course of action after consultation with plant and workshop engineers.

5,5 SCRAP

1. Rejects which cannot be rectified to ensure compliance with specification, or which would be uneconomic to rectify shall be scrapped and the Rejection Note and Inspection record card updated to reflect the decision.

QUALITY ASSURANCE PROCEDURE STANDARD

REFERENCE	TITLE	STD NO.
	COMPONENT INSPECTION CONTROL CENTRAL WORKSHOPS	QA/ADMIN/001

2. Components scrapped shall be marked with red marking by Inspection and shall be removed from the workshops.

3. On a decision to scrap a component the Senior Inspector shall advise Planning Department of the action. Planning shall if the order quantity is critical initiate a sub-order for re-manufacture of the quantity scrapped.

5,6 DEVIATION FROM SPECIFICATION

The acceptability of a deviation from specification shall vary according to the status of a component as to whether it is a:-

i) Factory Made Spare(F.M.S.) produced on a stores work order for stores stock.

ii) Maintenance work produced on an engineering work order for use on the plant.

iii) Emergency work produced on a stores work order or engineering work order.

The requirements of feedback information and corrective action methods shall be carried out as under.

5,6,1 FACTORY MADE SPARES (F.M.S.)

"ALL COMPONENTS MANUFACTURED AS FMS STORES STOCK MUST CONFORM TO DRAWING SPECIFICATION. ON NO ACCOUNT WILL NON-CONFORMING FMS COMPONENTS BE HELD IN STORES."

a. Deviation from specification, which may be either functional or non-functional shall be brought to the attention of the relevant plant personnel by the Senior Inspector for clarification and possible acceptance.

b. Acceptance and agreement by the plant personnel of the deviation as not affecting the components function and reliability will require that the drawing specification is altered to accommodate the deviation. Such alterations will ensure acceptability of the component.

c. Dimensional deviations that are accepted by the plant personnel but agreement on drawing alteration is not given will render the component unacceptable. Such components will be rejected.

d. The Senior Inspector shall on agreement of acceptance complete an Accetance/Clearance Note detailing fully the deviation, have the drawing "marked up" and both signed by the accepting engineer and signing himself. Copy 2 of the Acceptance/Clearance Note shall be attached to and filed with the relevant inspection record card. The Quality Control Rejection Note shall be signed by the accepting engineer and filed with the inspection record card.

NB. Alterations affecting component tolerances shall have such tolerances enlarged to the maximum acceptable.

e. The senior inspector shall prepare a Modification Proposal slip, detailing the alterations and ensuring company standards requirements, submitting the proposal with "marked up" drawing and Acceptance/Clearance Note attached to the Quality Control Engineer and relevant plant Section Engineer for signature.

f. The approved and signed proposal with attachments shall then be submitted for corrective action as detailed in Quality Assurance Procedure Standard QA/ADMIN/005 - Engineering Drawing Control.

5,6,2 MAINTENANCE WORK

a. Components produced for maintenance work and not conforming to drawing specification may, on discussion between Quality Control Engineering and the relevant plant personnel, be accepted without alteration to drawing specification.

b. The senior inspector shall discuss deviations to drawing specification with the plant and shall request that on acceptance of deviation the relevant drawing specification be altered. In this situation, the methods as detailed in 5,6,1 shall be followed.

c. Components that are accepted but where the plant consider that no alteration need be effected in respect of the drawing the senior inspector shall complete the Acceptance/Clearance Note fully detailing the deviations and shall have this and the relevant Quality Control Rejection Note signed by the accepting engineer. The Acceptance/Clearance and Rejection Notes shall be attached to, and filed with the inspection record card.

AECI/M/ENG/-95-8103 R
REV 'E'
REV 'D'
REV 'C'
REV 'B'
REV 'A'
ORIG. ISSUE DATE JUNE 1981
ORIGINATED BY F. MILLAR

5,6,3 EMERGENCY WORK

a. Components that are being produced on an emergency basis and are rejected as not conforming to drawing specification shall be dealt with immediately by the Senior Inspector on the rejection being determined.

b. The method of feedback and corrective action shall be as detailed in sections 5,6,1 and 5,6,2 depending on the type of emergency work being undertaken.

c. Discretion shall be exercised related to the degree of the emergency and the circumstances.

6. EQUIPMENT CALIBRATION

All measuring equipment used within the machine shops and inspection areas will be subject to official calibration of the equipment carried out on a set calibration programme system. Details of the system are contained in Quality Assurance Procedure Standard QA/ADMIN/006 Equipment Calibration Control.

PROCEDURE APPROVED BY:

SIGNED: .....
QUALITY CONTROL ENGINEER
DATED: 81 6 22

PROCEDURE AGREED BY:

SIGNED: .....
ON BEHALF OF CENTRAL WORKSHOP
DATED: 16/7/81

AECI/M/ENG/L95-8103 R
ORIGINATED BY: F. MILLAR
ORIG. ISSUE DATE JUNE 1981
REV 'A'
REV 'B'
REV
REV 'D'
REV 'E'

SPOILED WORK

INTRODUCTION

This paper presents the procedures which have to be taken in a case of spoiled work. Actually, this is a completion to the Quality Control Reject Centre Procedure (See Appendix Q.C. Procedure Standards - Chapter 5) from the side of Planning and Control.

There are three possible situations:-

a) scrapped after intermediate operation
b) Scrapped after final inspection
c) partial batch being rejected

1. Scrapped after intermediate operation:

1.1 Example you have a route card with the following operations.

O.P. No.	W.C. No.	G.P. C.D.	BIN No.	DESCRIPTION	SPEC. BY D.K. DATE	QTY.	STD. TIME	Insp.	P.L.Man	Air. W/C	Asst.	Delay Before Op.	ESTIMATE NUMBER	INSP. INT.
0020	RCS	CUT 10 MM M/S PLATE × 1111 × 1111 MM				1	45						K DOTS	
0130	M16	CUT PLATES TO TEMPLATE ON DO-ALL				21	35						733	
0140	M11	MILL PLATES TO DRG. ALLOW 2MM ON THICKNESS FOR FINAL MACHINING				21	73						1811/1	
0350	F13	STRESS RELIEVE PLATES.				21	108						TD14	
	F13	STRAIGHTEN PLATES IF REQUIRED				21	21						U.C.W.	
0360	M11	MILL PLATES TO DRG. ALLOW .25 ASIDE ON THICKNESS FOR SURFACE GRINDING				21	53						1811/1	
0370	K11	SURFACE GRIND PLATES TO DRG.				21	174						13072	
0400	S04	DRILL PLATES ON N/C MACHINE				21	105						MOSEY	
1777	F99	FINAL INSPECTION				21	1							
8888	P98	PLANT ACCEPT JOB STORES				21	1							
9999	P99	PLANNING CLOSE JOB				21	1							

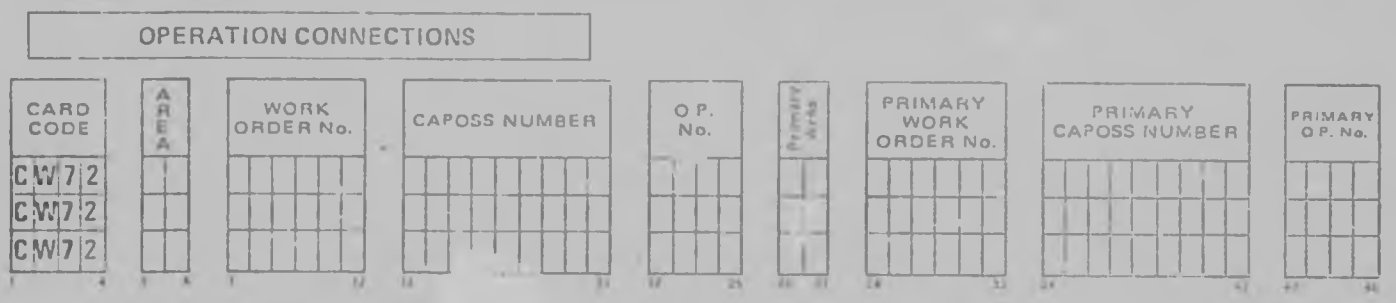
Assume that on operation 0040 the job has been scrapped by Quality Control. A Quality Control Rejection Note shall be received in Planning (PIMS Co-ordinator), before taking action.

2/.....

1.2 Procedures to be applied:`

a) produce a scrapped job card and give it priority 6.Scrapped Job Card; A copy of the original card with operations from 0020 (the first) to 0040 (inclusive), without all the other operations (0050-9999).

b) Connect operation 0040 to 0050 on the back side of the Scrapped Job Card.



Now there are 2 Route Cards for the job in the system: The card with operations from 0020 to 0040 on priority 6. The other card with operations from 0050 to 9999 on priority 5 and the two of them are connected, i.e., the other card will not appear on the Work Lists until the operations on the first card are completed.

c) Costing - use scrapped cost centre (817061) for the scrapped part of this job and the rework on it (i.e. charged to workshop). The Work Centre concerned will be charged by this cost. The original Cost Number (F xxxxY) will continue containing the regular costs.

2. Jobs scrapped after final inspection

When a completed job is rejected on final inspection (operation 7777), the same procedure as in 1 will be applied: on the planning side scrapped job card will be prepared from operation 010 to 7777 with connection to operation 8888 in the Original Card. Costing will apply the same procedure as in 1.2 (c).

3. Partial batch being rejected.

In a case of part of items on a batch job being rejected, the job will continue in the normal way. Rework and extra work will be considered as an emergency. Costing will apply the same procedure as 1,2 (c).

4. GENERAL

It is recommended that in case of any rejected work the Foreman concerned will inform the Planning Officer.

AF/jag
18/8/81

Number of days job on first day's Work List without being done.

ILLUSTRATION – TIMES SCHEDULE

Number of days job on first day's Work List without being done.

APPENDIX 16a

ENGINEERING WORK ORDER

PI51

ENGINEERING WORK ORDER

Forward this copy to the Data Co ordinator immediately

MODDERFONTEIN - WORKSHOPS

DEPT.

Area: 10 | Work Order No: H 1557 | ← Foreman Code | Plant Item Code

Sched. Maint. No. | Commodity or Drawing No.

Job Title

Originator's Initials

Originator		Phone
Plant Section		Date Orig nated
Early Begin Date	Date required	Clearance required?

Work Requested

PRIORITY *(Tick one box)*

Production loss	☐	Red safety hazard	☐
Imminent red safety	☐	Planned shut down	☐
Small job	☐	Imminent production loss	☐
		Planned	☐

Reason for priority

Priority Authorisation

PI52

1 4

5 22 as above

JOBCAT 1 (circle *one* only)

TYPE OF COST

Normal	N S	E P /Project Number
Capital	C	

23 24 27

JOBCAT 2 (circle *one* only)

RESPONSIBILITY

Mechanical	M
Electrical	E
Instruments	I
Civil	C

28

JOBCAT 3 (circle *one* only)

TYPE OF WORK

Scheduled	S
Break down	B
Other	Z

29

Standard Hours	Critical Duration	Estimated Labour in Rands	Est. Material in Rands
41 44	45 48	47 51	52 55

AECI/M/ENG/L28(A) 7810

MODDERFONTEIN
ENGINEERING WORK ORDER
CHECK LIST

1. Check whether item is held in stores.
2. On E.W.O.: (a) Print name of originator.
   (b) Insert phone number.
   (c) Insert plant section.
   (d) Insert date originated.
   (e) Insert date required: Must be reasonable, in accordance with the amount of work involved in job.
   (f) Sign E.W.O.: (a) EMERGENCY to be signed by Section Engineer.
   (b) ORDINARY planned jobs to be signed by Plant Engineer.
   (g) Give clear written description of requirements including number of items required.
3. Attach to E.W.O.: Approved drawing, or signed sketch (By Section Engineer).
4. Plant sketch to include the following:
   (a) Type of material to be used.
   (b) Special dimensions or finishes required.
   (c) Tolerances.
   (d) Welding Specification.
   (e) Item and Part numbers clearly specified.
   (f) Special instructions.
5. Before submitting E.W.O.:
   (a) Confirm material availability.
   (b) Check whether drawings are:
      (i) Not under or over specified.
      (ii) Legible.
      (iii) Latest issue, preferably metricated.
   (c) Check whether job can be done by plant shop rather than Central Workshops.
6. If insufficient space on E.W.O.: Use "E.W.O. Continuation Sheet".

NOTE!: NO SAMPLES WILL BE ACCEPTED

AECI

E.W.O. - CONTINUATION SHEET

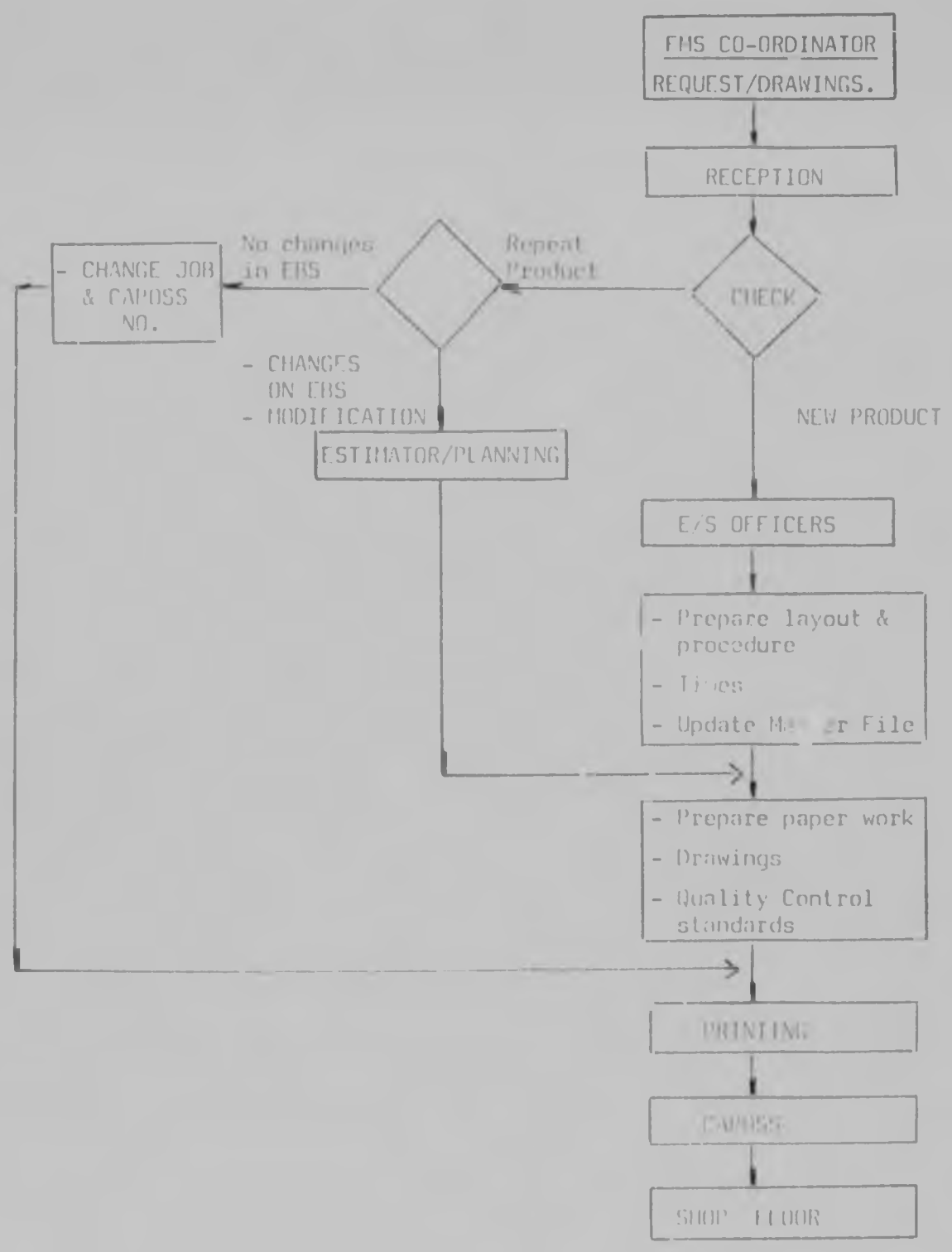
NO.	DRAWING NO.	JOB DESCRIPTION/MAT. SPEC./ADD. WORK	SKETCH

DATE:		PLANT:
DRAWN BY:		TITLE:
APPROVED BY:		

APPENDIX 16c

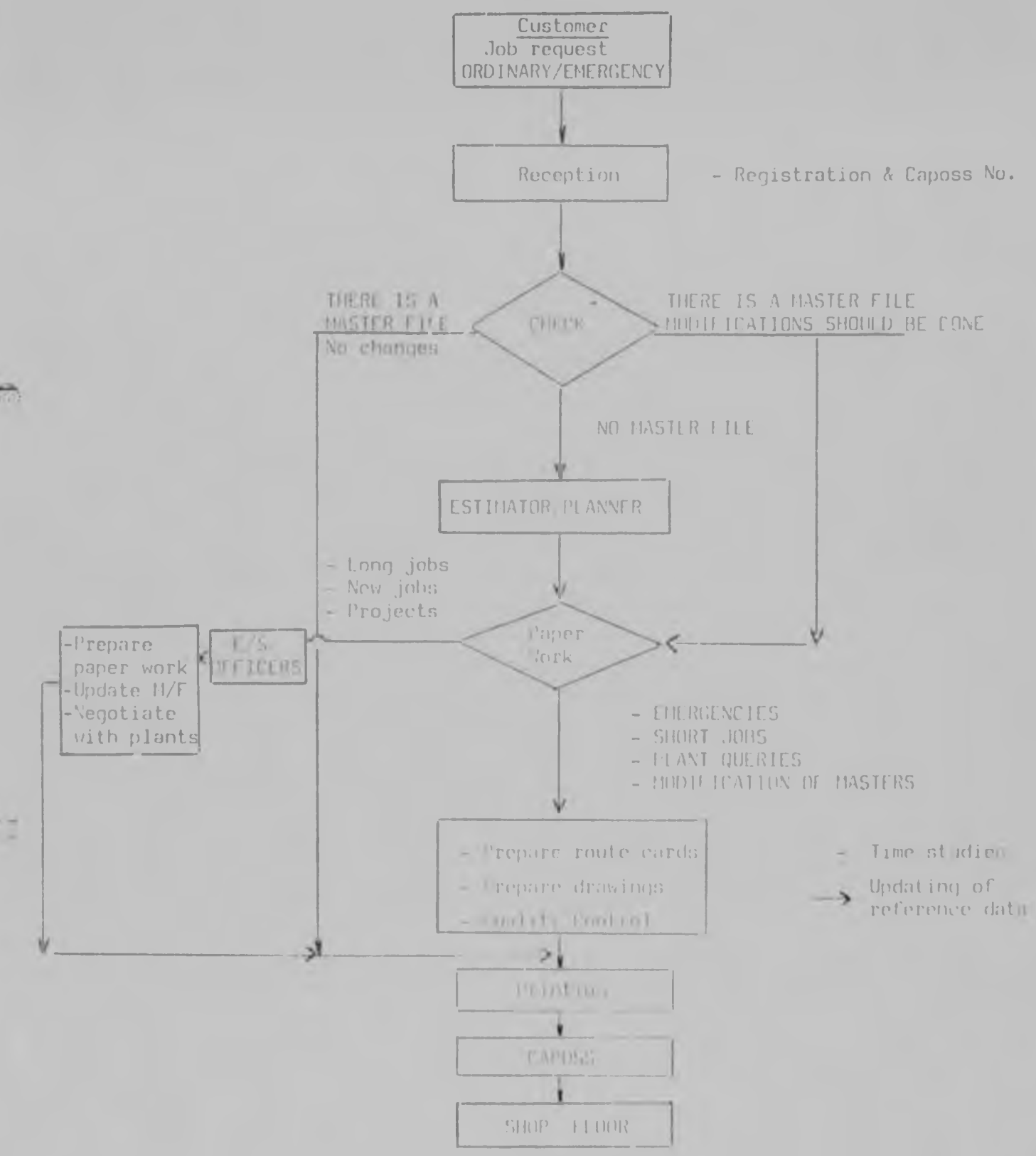
APPENDIX 17a

FMS JOB REQUEST PROCEDURE



APPENDIX 17b

PLANT JOB REQUEST PROCEDURE





2365 A. N. OTHER
58

01 230

52

1 2 2 1 φ 1 3 6 R
2 2 2 1 2 9 5 G
φ 2 2 N 2 6 3 1 R
1 6 3 5 2 2 2 9 2 1 3 6 5 2 2

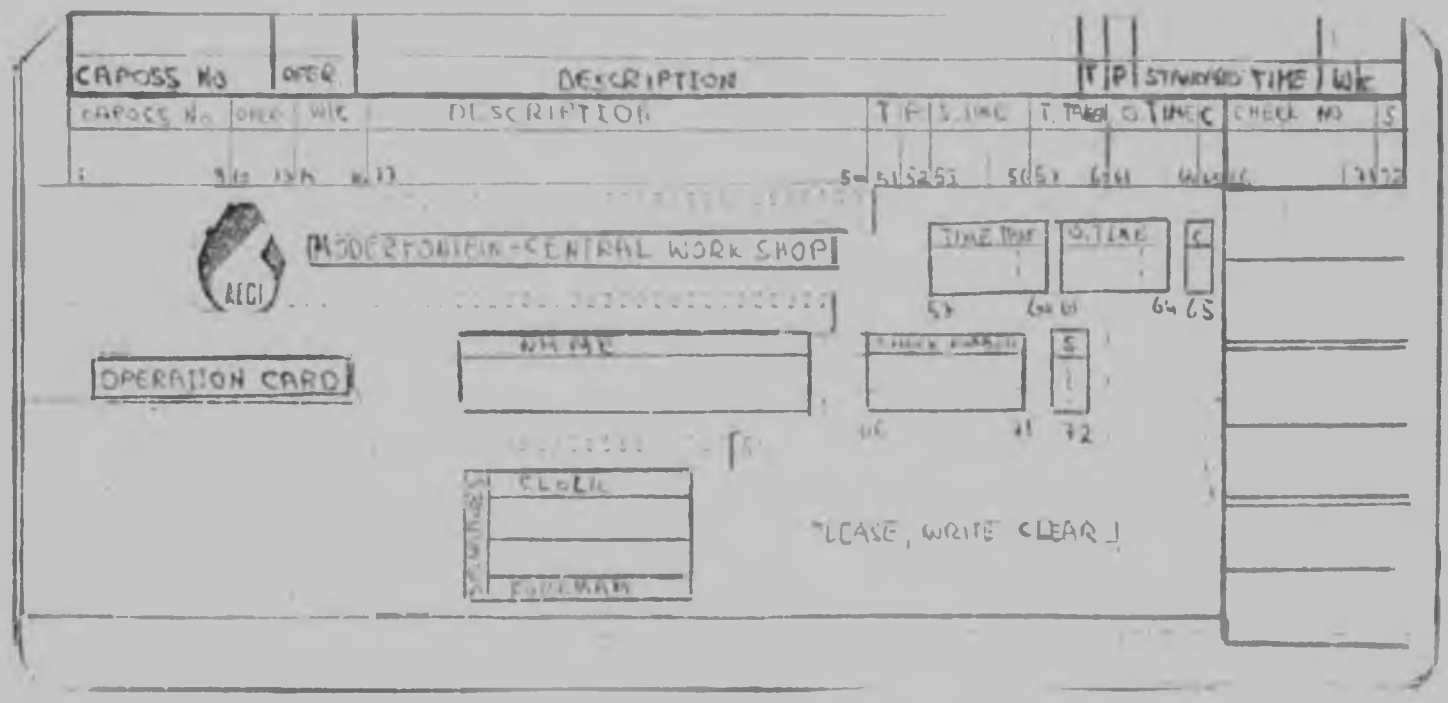
STATUS CODES
1 JOURNEYMAN
2 APPOINTED LEADING HAND
3 ACTING FOREMAN
4 OPERATOR
5 APPRENTICE
6 WORKING LEADING HAND
7 HANDYMAN ON BONUS
8 MOP
9 JOURNEYMAN ON UNCONTROLLED WORK FULL TIME
A ACTING LEADING HAND
T ADULT TRADES TRAINEE

ALLOC. COST CENTRE/ITEM
THESE ARE ENTERED FOR NON-ENGINEERING ONLY. CONSULT YOUR SUPERVISOR BEFORE USING THESE CODING

MACHINE CODE
ENTER THE RELEVANT MACHINE CODE FOR EACH JOB DONE

APPENDIX 18

BONUS SCHEME - RECOMMENDED OPERATION CARD



JOB SHOP PRODUCTION PLANNING & CONTROL - CASE STUDY

(AECI Modderfontein - Central Workshops)

Part D

Final Report - Results of the Project

Part D

CONTENTS

		Page
INTRODUCTION		1
1.	PROJECT SUMMARY AND CONCLUSIONS	2
2.	ORDINARY JOBS	
	2.1. Turnaround Time	4
	2.1.1. Analysis	4
	2.2. Delivery Dates	4
	2.2 1. General	4
	2.2.2. Adjustment of Due Dates	5
	2.2.2.1. Introduction	5
	2.2.2.2. Distribution Function	6
7	2.2.2.3. Analysis	7
	2.3. Conclusion	8
	2.4. Additional note from the Author	8
3.	CAPOSS - TURNAROUND TIME ANALYSIS (MONTHLY REPORT)	9
	3.1. Results based on DUE DATES	9
	2. Results based on FCFD	10
4.	EMERGENCY JOBS - TURNAROUND TIME	
	4.1. September-October Results	12
	4.2. Comparison between final results and previous months' results	12
	4.3. Discussion	13
5.	LONG TERM JOBS	
	5.1. Results	15
	5.2. Summary	15
6.	OUTSIDE ORDERS	16
7.	QUANTITY OF SERVICE	
	7.1. Results	17
	7.2. Analysis	17
8.	OPERATING RESULTS (COSTS)	19

2/...

		Page
9.	INDUSTRIAL ENGINEERING	
	9.1. Estimating	20
	9.2. Incentive Scheme Revision	20
	9.3. Computer System Support	20
10.	MANPOWER & TRAINING	
	10.1. Recruitment and Contract Labour	21
	10.2. Training	21
11.	ITEMS OUTSTANDING	23
	11.1. Carpenters Shop	23
	11.2. Other tasks	23
12.	MINUTES FROM DISCUSSION OF THE FINAL REPORT WITHIN THE COMPANY	24

APPENDICES

1	- Central Workshop	:	Deviation from jobs required delivery date
2	- Exactum	:	Deviation from jobs required delivery date
3	- Outside Orders	:	Deviation from jobs required delivery date
4		:	Changes of CFDs due to the new perception
5	- Central Workshop	:	Residence time of jobs in the System
6a	- Central Workshop	:	Number of jobs per input, output and order file January - September 1981
6b	- Central Workshop	:	Number of hours per input, output and order file January - September 1981

INTRODUCTION

This report is the final report following a series of four reports issued since December 1981 on my project for an MSc degree - "Job Shop Production Planning & Control - Case Study" (AECI Modderfontein - Central Workshops).

The report outlines the results achieved during the period March - October 1981 in improving the service provided by Central Workshops at AECI Modderfontein.

As a final report, it gives data on Planning & Scheduling, Production, and other matters concerning Central Workshops, and recommendations for maintaining and improving the quality and quantity of service given by Central Workshops to the various plants in the Factory.

1. PROJECT SUMMARY AND CONCLUSIONS

1.1. As a result of a survey of Central Workshops, carried out in October 1980, a programme to implement the recommendations was commenced in mid-March 1981.

A Production Engineer and a Planning & Control Engineer were appointed to augment the existing management structure and provide the main thrust for implementing the recommendations.

1.2. The main results are:

- The delivery of jobs on the due date has increased from 20 jobs per month (5%) to 391 jobs per month (56%).

- The average turnaround time of jobs (i.e. the period from receipt to delivery) has improved as follows:

  Ordinary jobs (Priority 5) - was 50 days, now 37 days
  Shutdown jobs (Priority 7) - was 56 days, now 4 days
  Emergency jobs(Priority 9) - was 63 days, now 6 days

  Approximately 75% of priority 9 (emergency) jobs have a turnaround time of 2 days.

- The volume of work completed by the Workshops has increased from:

  6818 hours per month to 10075 hours (+ 48%)

- The volume of work received has increased from:

  6198 hours per week to 9847 hours (+ 59%)

- The backlog of work has decreased from:

  14850 hours to 9499 hours (- 36%)

- Product quality has improved.

1.3. Factors contributing to these results are:

- Implementation of new approach to scheduling:

  Real queue for ordinary jobs, manual system for emergencies.

- Better operation of the planning system.

- Improved shop floor discipline; working to daily work list plan.

- Better progressing of jobs.

- More use of contract labour.

- Improvement in artisan performance.

- Better estimating service.

- Improved quality control procedures

3/...

- Improved supplies service

- Improved management control

1.4. Significant improvements have been achieved. Areas now receiving attention are:

- Job costing, accounting (including labour and overhead rates) and related management information system.

- Revised incentive schemes.

- Carpenters shop capacity.

- Recruitment of artisans.

Progressively improving results are anticipated over the next few months.

2. ORDINARY JOBS

An ordinary job, by definition, is a regular job which can be scheduled, in relation to the available capacity of the work centre concerned and with a delivery date within a maximum of 5 weeks.

2.1. Turnaround Time

Employing the accepted method for determining delivery dates and job scheduling, a comparison between customers required delivery date and actual delivery date has been made over the last 8 weeks. (15 August - 13 October 1981)

			Average deviation
i)	Central Workshops	:	1.002 days late
ii)	EXACTUM	:	35.68 days late
iii)	Jobs concerned with outside orders (both shops)	:	43.43 days late

For details, see Appendices 1, 2 and 3

2.1.1. Analysis

The above results can be attributed, to a large extent, to the REAL-QUEUE approach which has been implemented for ordinary jobs in Central Workshops. This insists on maintaining rigid queue and a strict policy of completing all the operations on the daily work list. Otherwise, work is deferred again and again, giving a "false" indication that there is enough capacity. The reason why Exactum gives a longer turnaround time, is that Exactum's management adopted another concept (REGISTRATION DATE + 60 DAYS = DUE DATE), which is contrary to the new approach.

2.2. Delivery Dates

2.2.1. General

The main problem which affected the quality of service given by the Workshops was recurring changes to current calculated delivery dates, due to the priorities approach built into CAPOSS. We aimed at modifying the system in such a way that our production programmes would adhere to the FIRST CALCULATED DELIVERY DATES, allowing for minor deviations only. This was done by having only one priority, as well as a manually manipulated registration of DUE DATES, given as input to CAPOSS. This part of the planning process became the most important part of control over inputs and hence the delivery service given to the client.

5/...

Previously, promised delivery dates were changing every run over an extended period. The new approach eliminates this phenomenon and changes, if any, are over a smaller period of time.

Using the priority approach, every new job coming into the system with an earlier due date and a higher priority rating than jobs already scheduled, resulted in a re-scheduling of all the jobs and old jobs were pushed back and replaced by new jobs. Under the new approach, this cannot happen. In cases where a job on the daily work list is not done on the first day, the job in that particular work centre is pushed back by 1 day. If it happens again, the job is pushed back by 2 days, and so on, until the job can be done.

In other words, before implementing this approach, the jobs were in a flexible queue which changed every day. Now the queue is rigid for as long as there is control over the running sequence of Due Dates and the Capacity of the various work centres.

A sample of the outcome of the approach is given in Appendix 4 (Changes in Calculated Finished Dates due to the new approach).

It should be noted from this Appendix the manner in which the Calculated Finished Date approaches the Adjusted Due Date.

2.2.2. Adjustment of Due Dates

2.2.2.1. Introduction

As previously stated, adherance to the new approach to scheduling requires manual modification of Due Dates. At first, this was established by discussing delivery dates with every customer. We soon learned that giving a high priority rating and an "early" delivery date, was done in order to ensure reasonable delivery regardless of the real importance of the job.

The importance of adhering to the first calculated delivery date, even if it was 2 months or more after the job had been initiated, was pointed out by the customers. After 3 months of implementation, it was no longer necessary to have negotiations with the customers, as the plant report indicated delivery dates; the actual delivery dates proved to the customers that the first calculated delivery dates were, more or less, being met.

/...

Thus, the situation eased and it is now only necessary to discuss Emergency jobs with the customers.

The following table shows the results, over the last 6 months, of this procedure:

TOTAL % OF JOBS	ACCEPTED: CAN MEET DEL. DATE	REQUESTED DEL. DATE WAS BEEN PUSHED BACK	CLASSIFICATION CHANGED TO EMERGENCY	SENT OUTSIDE
100%	3%	90.7%	5.5%	0.8%

The effect of the new approach is significant when comparing the percentage of accepted job Due Dates in March to the average presented above:

Whereas in March, 70% of job Due Dates were accepted by planning, as requested by the customers, in October, only 3% were accepted on the date requested originally by the customer.

This gives another indication of the inadequacy, for job shop production planning, of priorities built into CAPOSS.

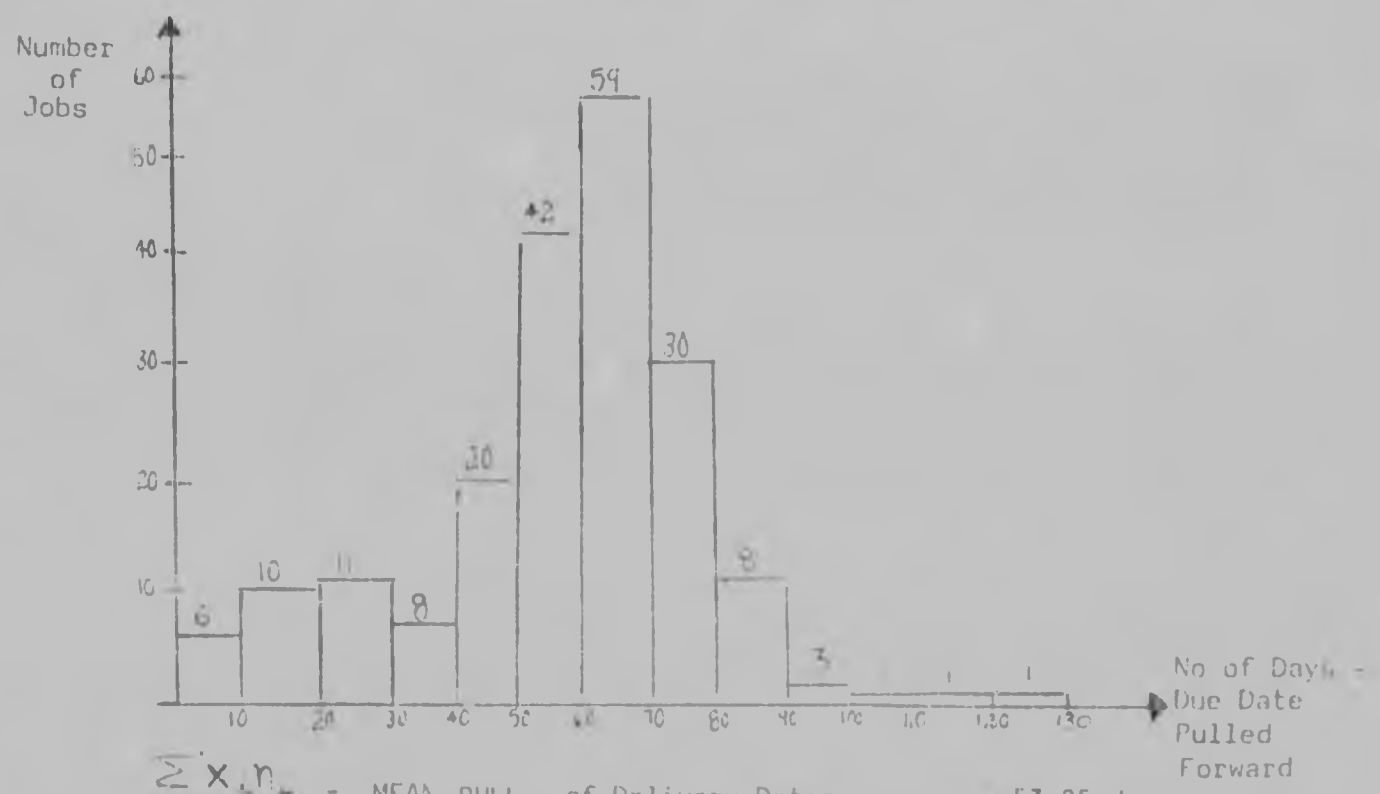
Theoretically, if every customer could identify the importance of his job in relation to all other jobs existing in the system, and if he knew the last date of the planned jobs in every work centre, then the system could perform properly. However, the original implementation of CAPOSS, using determined priorities and customer due dates, was not successful.

This brought us to the conclusion that customers can only give an indication of the job's classification, either ORDINARY or EMERGENCY, which can be controlled easily. Workshop plannning is the function which will give them the Due Date based on work in process, capacities and technical expertise availability. If is suits the customer, he will accept it. If not, the job will either be put under emergency classification, or it will be done in another way, i.e. by overtime work or by contracting it out.

2.2.2.2. Adjustment of Delivery Dates - Distribution Function

A finding which enforces our claim that "Requested Due Date" for a job by a customer is meaningless in our type of production is the adjustment of delivery dates which is given on the following page. A representative weighted average distribution curve for 200 jobs during the last 6 months gives the following results:

7 ...



$\frac{\sum x_i n_i}{\sum n_i}$ = MEAN PULL of Delivery Dates - 53,25 days

MODE INTERVAL (The interval with the majority of observations) - 60-70 days

$X_{\frac{n+1}{2}}$ = MEDIAN (The intermediate interval) - 60,51 days

2.2.2.3. Analysis

When analysing the above data, we find that the Average Push of Due Dates is approximately 53 days. As a result of this, it would appear that the Turnaround Time of jobs in the Workshop is at least 53 days.

The way in which we pushed a job backwards in the queue of existing jobs in the system originally was that

every new job was given Due Dates based on a running number of dates. In order to avoid one job overtaking a previous job, we allocated only one job, per day, per work centre, while the available capacity was sufficient for more than one job. This created float between jobs in the work centre's queue.

To close these gaps, the system was allowed to pull the jobs forward, thus achieving the best utilisation. Due to a systems constraint, jobs could not be pulled forward by more than 99 days, thus leaving several jobs "stacked beyond" 99 days.

B...

This brought us to the conclusion that we should allocate jobs to the various work centres as per capacity and as a result, the range of the pull became shorter. This yielded maximum capacity utilisation and an average deviation from requested delivery dates of 1.002 days.

2.3. Conclusion

The above findings have proved that the best way of scheduling ordinary jobs in job shop production, is the REAL QUEUE approach. As CAPOSS cannot be modified to do so on it's own, manual control over inputs is required in order to monitor Due Dates based on capacity per work centre. In other words, the GANTT approach to scheduling should be done outside of the system for every work centre.

However, monitoring of Due Dates cannot be done precisely by manual involvement, and, under the present circumstances, we can say that it is only 90% accurate, as there are aspects concerned with outside orders, quality control rejects and other problems that the manual control cannot manage.

Additional comparison between Residence Time requested by the customer to Residence Time after Due Date is adjusted by Planning is given in Appendix 5.

2.4. Additional note from the Author

Although, in principle, CAPOSS also uses the GANTT approach, the large number of priorities previously available, caused jobs to skip queues. By limiting the number of priorities, the system was forced to stick to a rigid queue, therefore not allowing jobs other than emergency work to pass existing jobs in a queue.

Emergency work is handled by reserving capacity in very much the same way as supermarkets reserve counter capacity at a "Quick Exit".

Some jobs, because of the need to be done very quickly, are allowed to go through the "service counter" (operations) quickly. However, the number is restricted and the majority follow the "rigid queue" approach.

3. CAPOSS MONTHLY TURNAROUND TIME ANALYSIS

For the first time since April 1981, the computerised report is "clean", i.e. data appears only for priorities 5,7 and 9.

This follows working on the basis of two types of jobs:

ORDINARY(5) or EMERGENCY(9). SHUTDOWN jobs are under priority (7) and are treated as emergencies.

This should be retained and it requires the maintenance of an accurate Masterfile ("Bible") and strict control over inputs.

Completed Jobs Turnaround [illegible] for various priorities resulted this week (13.10.81) as follows:

3.1. Results based on Due [illegible]tes

a) Central Workshop

PRIORITY	1	2	3	4	5	6	7	8	9	TOTAL
AVERAGE DEVIATION FROM REQUESTED DATE	0	0	0	0	63	0	5	0	7	40
AVERAGE TURNAROUND TIME	0	0	0	0	45	0	7	0	4	29
TOTAL JOBS WITH DUE DATE	0	0	0	0	309	0	33	0	173	515
TOTAL JOBS WITHOUT DUE DATE	0	0	0	0	0	0	0	0	0	0
TOTAL JOBS	0	0	0	0	309	0	33	0	173	515

b) Exactum

PRIORITY	1	2	3	4	5	6 *	7 *	8	9	TOTAL
AVERAGE DEVIATION FROM REQUESTED DATE	0	0	0	0	41 **	19	26	0	16	38
AVERAGE TURNAROUND TIME	0	0	0	0	69	19	57	0	4	65
TOTAL JOBS WITH DUE DATE	0	0	0	0	86	2	10	0	3	101
TOTAL JOBS WITHOUT DUE DATE	0	0	0	0	0	0	0	0	0	0
TOTAL JOBS	0	0	0	0	86	2	10	0	3	101

* Have not the same meaning as in Central Workshop - on account of Exactum's approach.

** Lower than Central Workshop because every FMS job is automatically being pushed backwards in the queue by 60 days.

10/...

3.2. Results based on the First Calculated Finish Date*

a) Central Workshop

PRIORITY	1	2	3	4	5	6	7	8	9**	TOTAL
AVERAGE DEVIATION FROM PLAN	0	0	0	0	30	24	2	0	0	10
AVERAGE TURNAROUND TIME	0	0	0	0	45	35	7	0	4	29
TOTAL JOBS WITH FCFD	0	0	0	0	280	1	5	0	173	290
TOTAL JOBS WITHOUT FCFD	0	0	0	0	29	0	28	0	0	223
TOTAL JOBS	0	0	0	0	309	1	33	0	173	516

* An outcome of the scheduling approach.

** Further details are given below:

PRIORITY : 9

EARLY JOBS - DAYS EARLY												LATE JOBS - DAYS OVERDUE											
>-50	-50	-40	-30	-25	-20	-15	-10	-8	-6	-4	-2	0	2	4	6	8	10	15	20	25	30	40	50	>50
***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
0	0	1	0	0	0	0	1	0	0	0	0	169	0	0	0	0	0	0	0	0	0	1	1	0

NO. OF JOBS EARLY = 2

NO. OF JOBS LATE = 2

AVERAGE DEVIATION FROM PLAN	=	0
AVERAGE TURNAROUND TIME	=	4
TOTAL JOBS WITH FCF DATE	=	4
TOTAL JOBS WITHOUT FCF DATE	=	169
TOTAL JOBS	=	173

11/...

2) Exactum

PRIORITY		2	3	4	5	6	7	8	9	TOTAL
AVERAGE DEVIATION FROM PLAN	0	0	0	0	20	7	48	0	0	33
AVERAGE TURNAROUND TIME	0	0	0	0	69	12	57	0	0	69
TOTAL JOBS WITH FEED	0	0	0	0	86	2	10	0	0	98
TOTAL JOBS WITHOUT FEED	0	0	0	0	0	0	0	0	3	3
TOTAL JOBS	0	0	0	0	86	2	10	0	3	101

"For further detailing and better understanding, see Planning - Turnaround Time File"

4. EMERGENCY JOBS TURNAROUND TIME

4.1. September - October Results

The following table presents the results of the past 6 weeks for emergency jobs:

NUMBER OF DAYS	0-2 DAYS	3 DAYS	4 DAYS	5-10 DAYS	10-20 DAYS	20-30 DAYS	<30* DAYS	TOTAL
Number of Jobs	214	27	19	20	31	6	32	349
%	61.4%	7.7%	5.4%	5.7%	8.9%	1.7%	9.2%	100%
Accumulated %	61.4%	69.1%	74.5%	80.2%	89.1%	90.8%	100%	100%

* Long-Term jobs and Carpentry work - classification changed to emergency.

4.2. Comparison Between Final Results To Previous Months Results

The objectives set by Central Workshop's management for Emergency Jobs Turnaround Time are as follows:

Group I : 95% of emergencies : 0-2 days

Group II : 3% of emergencies : 3 days

Group III : 2% of emergencies : 3-10 days

The above objectives have been determined arbitrarily as Central workshop's management had no accurate figures of the number of incoming emergency jobs and the capacity required for them, at the beginning of the implementation.

The following table presents the results for emergency jobs of group(I)since March 1981.
As previous months results have been presented in different ways, some of the results were adjusted to this way of representation : See following page.

13/...

MONTH	TOTAL NUMBER OF EMERGENCY JOBS COMPLETED	GROUP I 0-2 DAYS	AVERAGE TURNAROUND TIME (DAYS) FOR GROUP I
MARCH	123*	116 96%	1.53
APRIL	182	136 75%	2.00
MAY	200	132 66%	2.00
JUNE	201	139 69%	2.00
JULY	227	189 83%	2.00
AUGUST	260	136 52%	2.00
SEP-OCT(15)	349	253 73%	2.00

* only 15 days.

.3. Discussion

From the above table. we learn that there are high fluctuations in the number of emergency jobs and in the percentage of jobs being done by average of 2 days. To a large extent, it can be attributed to old jobs which have been pulled from the system, to the Ardeer Packer Jobs and to Carpentry Jobs, which have been a long time in the system. It should be emphasized that, during this period, the policy for accepting emergency jobs was strictly practised.

The average results from the above table are:

- 220 emergency jobs/month

- 83% of them have Average Turnaround Time of 2 days.

14/...

It is recommended that the objectives set for emergency jobs, be amended to the following:

Group I	:	75% of emergencies	:	0 - 2 days
Group II	:	7,5% "	:	3 days
Group III	:	7,5% "	:	4 days
Group IV	:	5% "	:	5 days
Group V	:	5% "	:	5 - 10 days

These objectives should be reviewed from time to time, to improve on previous best performance. This should be based on the number of jobs in the system and not an average turnaround time

5. LONG TERM JOBS (Jobs more than 200 days in the system)

5.1. Results

The following table presents the number of old jobs remaining in the system at various dates:

	CENTRAL WORKSHOP	EXACTUM
6.04.81	74	52
13.04.81	73	47
22.06.81	41	27
30.06.81	33	21
31.07.81	28	14
31.08.81	22	16
30.09.81	17	16
13.10.81	12	14

The reasons for jobs being delayed at present are as follows:

	CENTRAL WORKSHOP	EXACTUM
Carpentry Overload	6	-
Waiting for outside order	2	4
Quality Control	4	3
Problems	-	7
	12	14

5.2. Summary

In Central Workshop, there are no more jobs from 1979. Action was taken in October to complete the above list of remaining jobs in Central Workshop and, from November, long term job lists will consist of jobs being more than 150 days in the system.

The aim is to arrive at a situation where 90 days will be the upper limit for jobs being in the system. There are exceptions such as outside orders and rejection of jobs in interim operations,which will always happen, but this is negligible.

16/...

6. OUTSIDE ORDERS

There has been a significant improvement in services given by Supply Department, and as a result, long term outstanding orders have been eliminated.

Control over accepted delivery dates is fully implemented and it would appear that Turnaround Time of jobs concerned with outside orders has been reduced significantly. (See Appendix 3).

The one problem remaining is the placing of MC OUTSIDE FMS orders.

It is strongly recommended that, as soon as the report on "Recommended new procedures for placing O/S-FMS orders", is approved, it should be implemented. This will result in planning having full control over all outside orders, jobs being done outside will be progressed and inspected and, as a result, the quality of service given by Planning will be higher.

17/...

7. QUANTITY OF SERVICE

7.1. Results

The main results under this heading are:

a) The volume of work received has increased by 59% (hours).

b) The volume of output has increased by 48% (hours).

c) The order file (backlog) has decreased by 36% (hours).

7.2. Analysis

The volume of incoming work has increased substantially since January. Throughput has increased even more, resulting in a 30% reduction of backlog hours.

	INPUT		OUTPUT		ORDER FILE	
1981	JOBS	CAPOSS HOURS	JOBS	CAPOSS HOURS	JOBS	CAPOSS HOURS
JAN	458	6255	383	6378	955	15400
FEB	499	6142	499	7259	N/A	14300
MAR	518	10691	412	8029	N/A	17000
APR	410	9043	668	9098	943	16900
MAY	675	4582	772	7632	880	14500
JUNE	527	7400	761	7804	656	13000
JULY	589	8619	726	11128	513	10500
AUG	486	9333	699	9163	452	10156
SEP	564	10361	731	10988	383	8842

(For a graph on the above, see Appendix 6)

NOTE: The hours figures do not balance exactly, due to cancellations and the cleaning of redundant jobs from the system. May and June input and output hours are suspect because No. 4 Ammonia shutdown jobs were processed on an ad hoc basis.

Using an average of the first two months as 100% and an average of the last two months as the current situation gives the following figures:

	INPUT		OUTPUT		ORDER BOOK	
1981	JOBS	CAPOSS HOURS	JOBS	CAPOSS HOURS	JOBS	CAPOSS HOURS
JAN/FEB	478	6198	441	6818	955	14850
AUG/SEP	525	9847	715	10075	420	9499
CHANGE	+10%	+59%	+62%	+48%	-56%	-36%

18/...

At this stage, there is no information available as to the type and volume of work that is still being placed with outside firms by the plants. It is therefore impossible to state whether Central Workshops is fulfilling key objectives e(i) and c(ii) established in Part A item 2.1. of this project.

In March, there were 13 work centres in an overload condition, totalling 4080 hours overload. Currently only the carpenters shop is overloaded (3 work centres) and the total hours are 410. However, the lead time for carpentery work remains excessive at 5 months (100 days) due to a shortage of manpower. Of the 10156 hours in the order book, 4000 hours are carpentry work.

19/...

8. OPERATING RESULTS (COSTS)

It is not possible at this stage to quantify whether the workshop is cheaper, on average, than outside firms (one of the key objectives). This will require an organised sampling procedure. In addition, changes will be needed to the present basis upon which labour rates and overhead rates are calculated in order to maximise the competitive edge which the workhops possess.

Turnover to the end of July appears to be R3,8m (R6,5m annually), but it is known that all costs are not included in this figure.

Discussions are presently in progress with Accounts Department to revise the accounting procedures and he job costing system with a view to obtaining more accurate and comprehensive information and presenting it in a more logical form.

In the area of job costing, it will be necessary to have a much improved feedback of progressive costs on a daily basis, if the concept of charging on a quoted price is to be introduced. Also, the method of establishing the estimated price will need revision.

20/...

9. INDUSTRIAL ENGINEERING

9.1. Estimating

The estimating service is considerably improved. Further changes in the organisation and location of the estimators will result in further improvements to the service. The number of shop personnel receiving estimator training is being increased to provide more reliefs. Relationships between the Estimator and the shop floor have improved.

9.2. Incentive Scheme Revision

The preparation for changing to an individual incentive scheme will be completed within 2 months. The present group scheme has very little motivating effect, as the accuracy of collecting and calculating performance indices for the scheme is very poor.

9.3. Computer System Support

During the last 2 months, there has been a significant improvement in support by system and Head Office computer personnel.

However, due to a lack of knowledge in production systems by these personnel, and reluctance to hear other views on job shop production planning & control, there were no discussions or interchange of ideas which could contribute to the implementation of planning & control systems in other AECI factories.

An important factor concerning this issue, is the role of the Factory Systems Co-ordinator. His position is not clearly defined but it is considered that he should be involved in promoting the recommendations of the present report.

21/...

10. MANPOWER & TRAINING

10.1. Recruitment & Contract Labour

The recruitment and retention of artisans still causes concern. There has been no improvement following the increases which were granted recently to journeyman.

ARTISAN TURNOVER

	START	LEAVE
March	5	1
April	3	4
May	3	7
June	9	5
July	5	7
Aug	6	5

Source : FIRO

There are 46 vacancies (26%) for journeymen in Central Workshops.

Contract artisans have been used extensively during the last six months, to alleviate the situation.

CONTRACT ARTISAN HOURS AND COSTS

1981	Hours	Rands	R/hr	% AECI Wages
Jan	805	7300	9,06	8,2
Feb	1059	10419	9,83	4,5
Mar	1766	17628	9,98	10,0
Apr	2269	26629	11,73	15,8
May	4793	52016	10,85	27,1
June	5077	57197	11,26	28,7
July	4500	48070	10,68	23,2
Aug	4400	47608	10,82	23,0
Sept	3100	34162	11,02	19,0

10.2. Training

The workshops establishment is 114 artisans and 61 trainees (adult trade trainees and apprentices). Although, the apprentices are not all in the workhops simultaneously (tech; army etc), it was considered that the volume of trainees justified a full-time Workshops Training Supervisor in order to co-ordinate and programme the training.

A Training Supervisor has been recruited and is at present carrying out programmes for each trade and adapting the standard E.I.I.B. module system to our needs.

22/..

With this system, the training period is split up into periods of approximately 6 months. Each period is covered by:

a) A syllabus

b) A text book (manual) showing in detail the skills to be learned.

c) A log book, which is kept and maintained by the trainee, showing the work he has done.

d) A series of phase tests, usually at 3 or 4 weekly intervals, where the trainee does a test piece incorporating the skills recently learned. This is recorded in the log book and assessed and marked.

It is anticipated that the new system will be introduced into all departments by end-October.

23/...

11. ITEMS OUTSTANDING

The major tasks remaining to be completed are:

a) Carpenters shop

b) Accounts, job costing

c) Incentive schemes

d) Full achievement of 95% jobs delivered on time

11.1. Carpenters Shop

The present delivery period is around 6 months. This remains as the only problem shop in the workshops. The shop is under capacity, but efforts to recruit or hire artisans of the necessary calibre have been unsuccessful. Attempts to offload some of the work have met with only limited success and the cost has been high, sometimes 400% higher than workshops prices.

The wood machining section is the main bottleneck. The solution is believed to lie in the area of de-skilling the job to some extent by training specialists on single machines rather than trying to recruit artisans who are skilled on all machines. However, we have, so far, had no success in recruiting adult trainees for this work.

Until this problem can be solved, it is unlikely that the Carpenters Shops can be expanded to provide a service to the new explosives factories currently being planned.

11.2. Other Tasks

No further comments.

24/...

12. MINUTES FROM DISCUSSION OF THE FINAL REPORT WITHIN THE COMPANY

The author's final report on his 10 month Workshops project was discussed at a meeting attended by the Chief Engineer, Assistant Factory Manager, Industrial Engineering Manager, Workshops Manager and the author. Details of Final Recommendations and their outcome is given below.

SUMMARY OF RECOMMENDATIONS

It is strongly recommended:

		AGREED	ACTION BY
a)	That jobs continue to be strictly scheduled using the "REAL-QUEUE" approach, as has been the case during the last seven months. (April - October 1981)	Agreed	FWE
b)	That EXACTUM jobs be scheduled in the same manner as Central Workshop jobs.		
c)	That EMERGENCY & SHORT JOBS continue to be managed manually by continuous control of the capacity allocated to such jobs.	Agreed	FWE
d)	That present procedures continue to be followed for:		
	i) The placing of outside orders and the strict control of their delivery.	Not agreed Awaiting finalisation of report.	
	ii) The implementation of decisions made at Supply/Planning meetings.	Agreed	FWE
e)	That a suitably qualified and experienced Planning & Control Engineer be appointed as soon as possible.	Agreed Strong w/s background essential	MIE & FWE
f)	That the present Planning Officer be replaced by a suitable candidate.	Agreed	MIE & FWE
g)	That a Materials Co-ordinator be appointed as soon as possible.	Agreed	Done
h)	That estimating planning re-organisation be carried, out, using the programme devised by A. Franco. (Report issued 31.8.81)	Agreed	MIE
i)	That FWE and ACE(M) agree on definite key responsibility and decision areas for the Production Engineer and for the Planning & Control Engineer.	Agreed	FWE
j)	That there should be close co-operation by FWE with the Planning & Control Engineer, Production Engineer and Quality Control Engineer.	Agreed	FWE
k)	That Maintenance and Industrial Engineering - Pinelands be kept informed of the "REAL-QUEUE" concept of scheduling as implemented in Central Workshops.	Agreed	MIE

Maintenance & Industrial Engineering, Pinelands - Company's highest level of I.E.
FWE - Factory Workshops Manager
MIE - Factory Industrial Engineering Manager

APPENDICES

Appendix 1 - Central Workshop : Deviation from jobs required delivery date

Appendix 2 - Exactum : Deviation from jobs required delivery date

Appendix 3 - Outside Orders : Deviation from jobs required delivery date

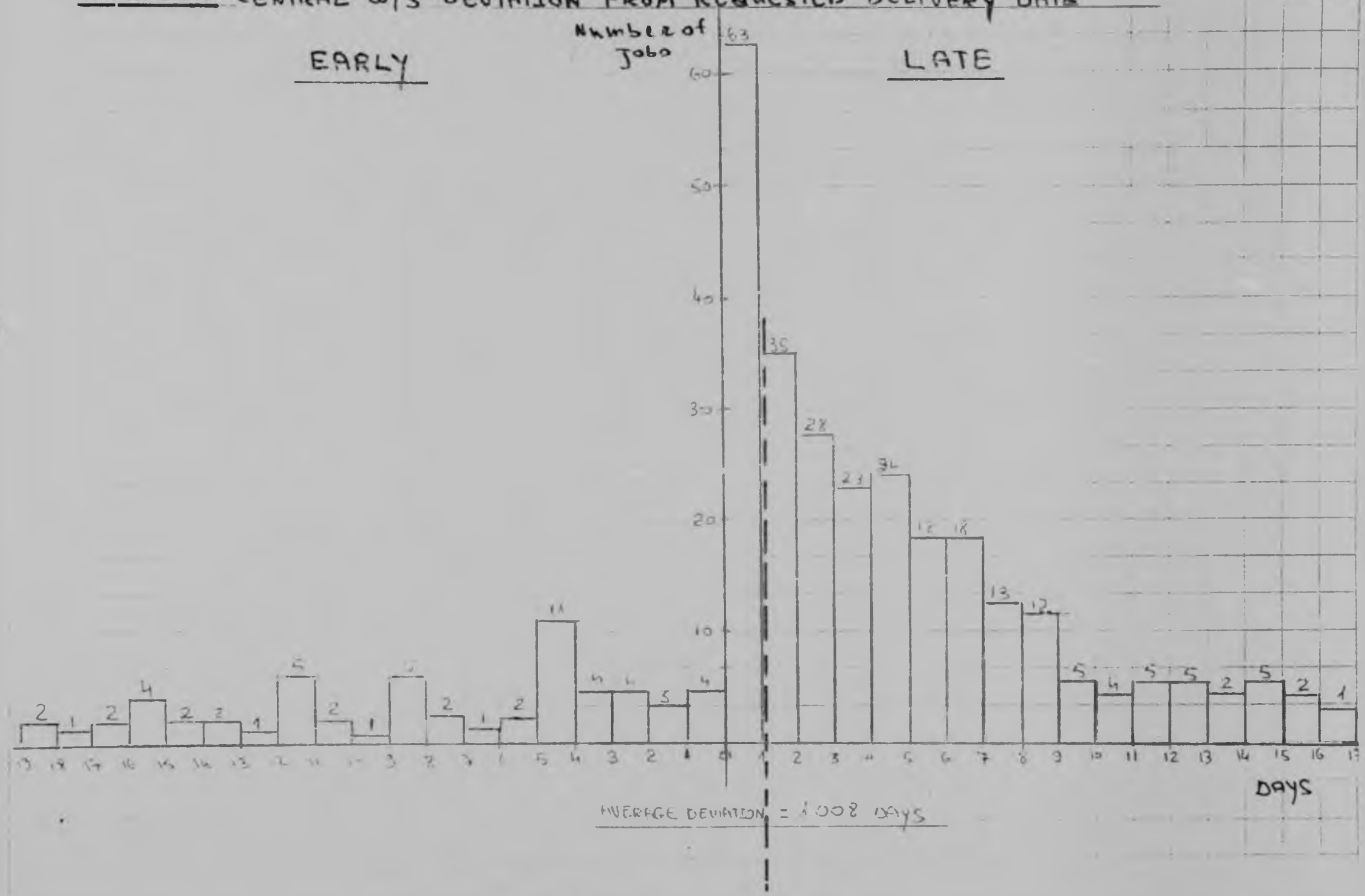
Appendix 4 : Changes of CFDs due to the new perception

Appendix 5 - Central Workshop : Residence Time of jobs in the system

Appendix 6a - Central Workshop : Number of jobs per input, output and order file January - September 1981

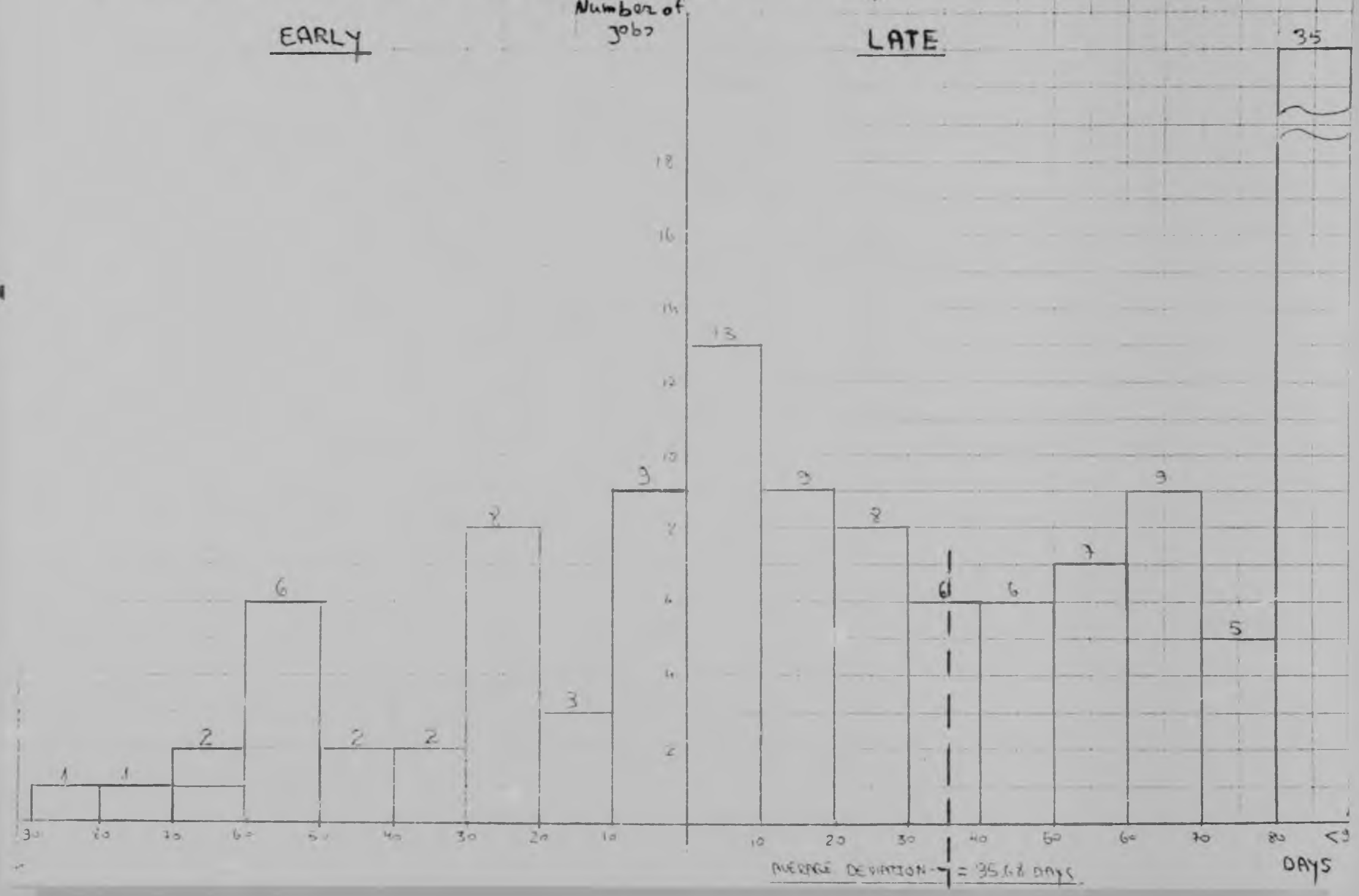
Appendix 6b - Central Workshop : Number of hours per input, output and order file January - September 1981

APPENDIX 1: CENTRAL W/S DEVIATION FROM REQUESTED DELIVERY DATE

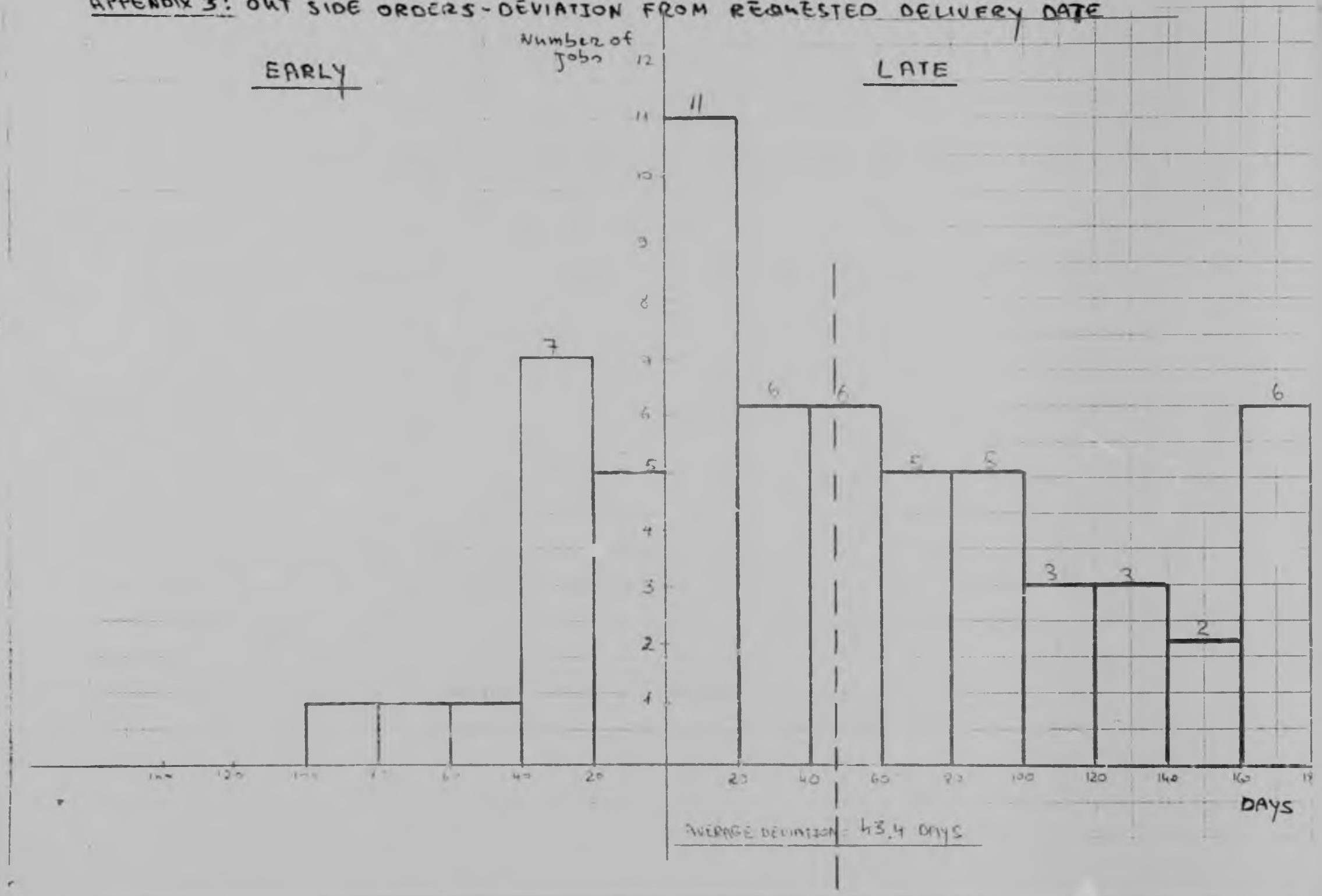


AVERAGE DEVIATION = 1.008 DAYS

APPENDIX 2: ISANDO - DEVIATION FROM REQUESTED DELIVERY DATE



APPENDIX 3: OUT SIDE ORDERS - DEVIATION FROM REQUESTED DELIVERY DATE

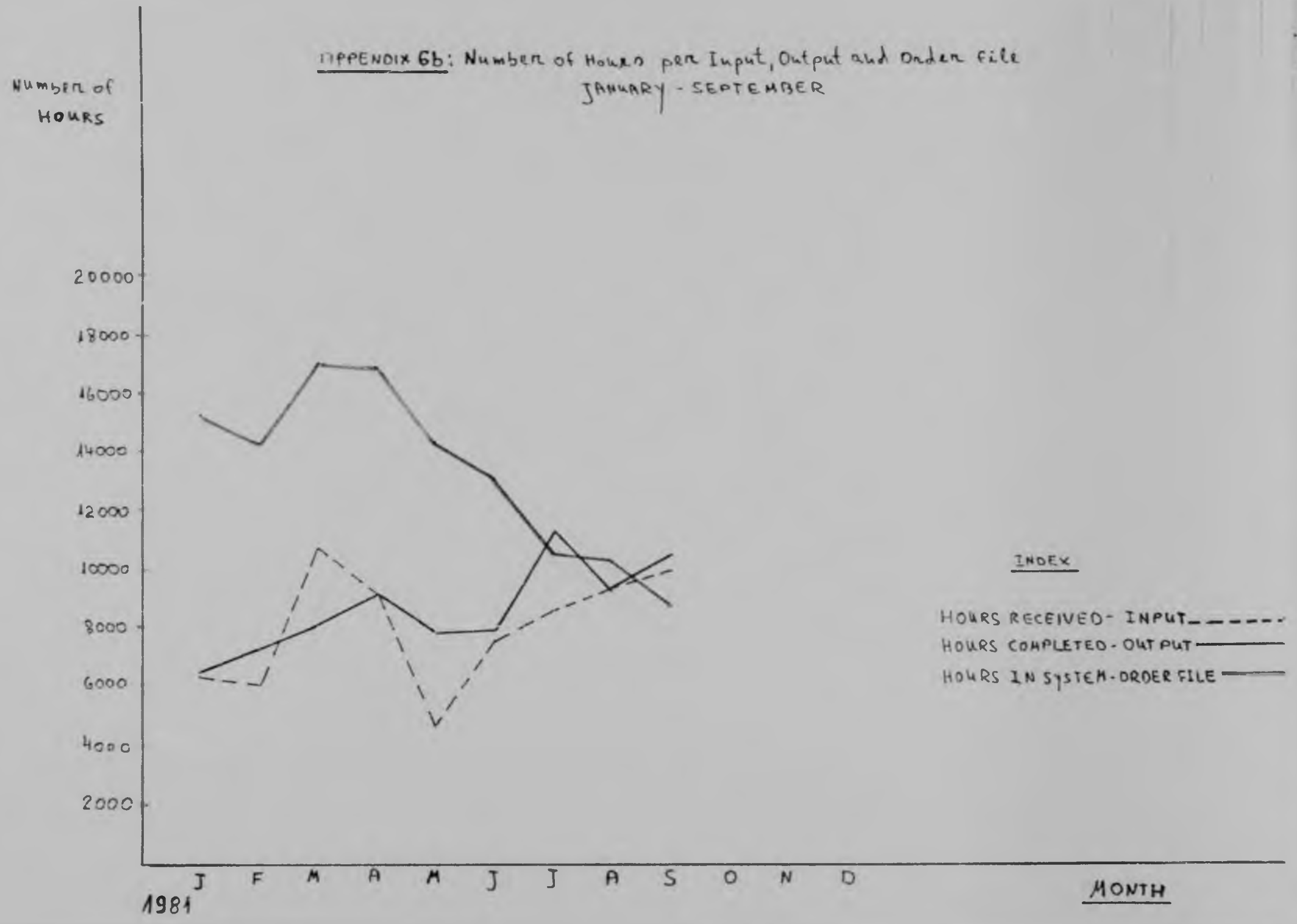


A P P E N D I X - 4

CHANGES OF CFD'S DUE TO THE NEW APPROACH

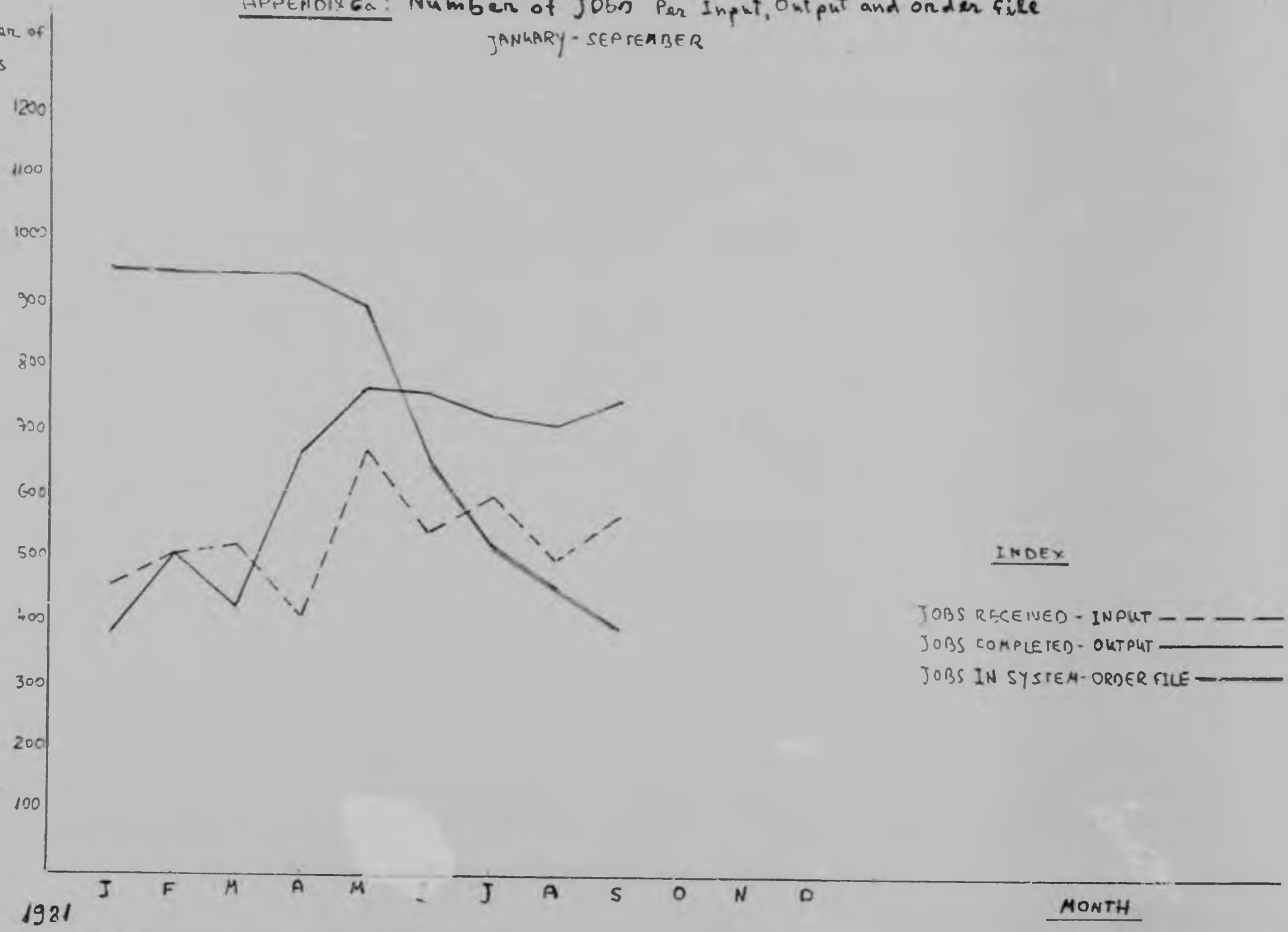
CAPOSS NO	REQUEST DEL DATE	ADJUST DUE DATE	FCFD	CFD1	CFD2	CFD3	CFD4	CFD5	CFD6
113825300	1146	2005	1213	1213	1208	1204	1208	1223	
113906100	1158	1175	1171	1171	1175	1181	1187	1191	
113912200	1140	1150	1154	1154	1159	1164	Comp	1158	
113915300	1162	2006	1203	1203	1211	1211	1202	1209	
114107300	1146	2007	1207	1207	1209	1209	1209	1209	
114115903	1145	1166	1162	1162	1166	1172	1165	Comp	
114117200	1157	1150	1150	1150	1151	1160	Comp	1156	
114205200	1150	1169	1166	1166	1151	1161	Comp	1154	
114303300	1162	2009	1206	1206	1206	1206	1206	1210	
114328200	1155	1190	1169	1169	1169	1169	1174	1179	
114406300	1155	2008	1209	1209	1209	1209	1205	Comp	
114425500	1165	1206	1165	1165		1160	Comp	1157	
114501900	1153	1182	1168	1168		1165	1168	1172	
114501901	1153	1181	1177	1177		1165	1169	1171	
114507300	1147	2008	1206	1206	1206	1206	1206	Comp	
114508900	1197	1208	1178			1178	1171	1174	
114508901		1205	1178			1178	1170	1174	
114518900	1163	2022	1234			1234	Comp	1155	Emergency
114608000	1161	1192	1187			1187	1173	1178	
114609900	1168	1183	1170			1170	1166	Comp	
114609902	1168	1184	1170			1170	1166	Comp	
114609903	1168	1185	1173			1173	1178	1172	
114616400	1161	1182	1157	1157		1162	1167	1190	
114618500	1168	1180	1156	1156		1160	1165	1170	
114702500	1169	1217	1173			1173	1168	1173	
114704700	1152	2022	1220			1220	1220	1220	
114705300	1148	2011	1211			1211	1211	1214	
114707900	1157	1176	1163			1163	Comp	1158	
114709300	1167	2021	1223			1223	1224	1224	
114710700	1158	1220	1177			1177	1178	1183	
114727000	ASAP	1191	1169	1169		1159	Comp	1157	
114803300	1167	2010	1213			1213	1210	Comp	Emergency

APPENDIX 6b: Number of Hours per Input, Output and Order File
JANUARY - SEPTEMBER



APPENDIX 6a: Number of Jobs Per Input, Output and order file

JANUARY - SEPTEMBER



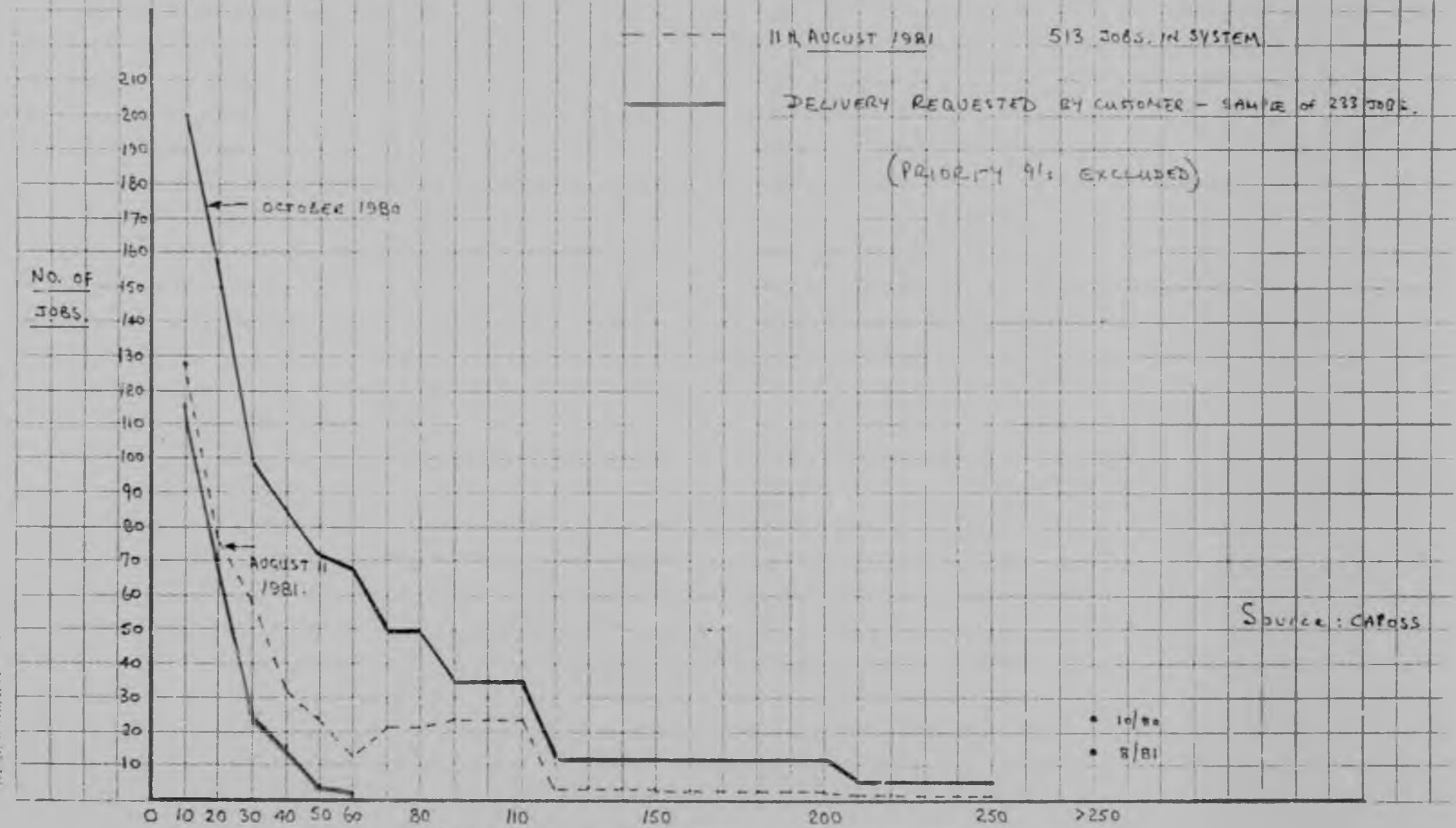
APPENDIX 5: RESIDENCE TIME OF JOBS IN SYSTEM - c. w/s

OCTOBER 1980 — 1053 JOBS IN SYSTEM.

11 AUGUST 1981 — - - - - 513 JOBS IN SYSTEM.

DELIVERY REQUESTED BY CUSTOMER — SAMPLE OF 233 JOBS.

(PRIORITY 9's EXCLUDED)



REG.MIMS/1.41-7111

JOB SHOP PRODUCTION PLANNING & CONTROL - CASE STUDY

(AECI Modderfontein - Central Workshops)

Part E

Production Planning and Control - Literature Survey

Part E

C O N T E N T S

		Page
	PREFACE	
1.	PRODUCTION PLANNING AND CONTROL - GENERAL INTRODUCTION	1
	1.1 Definitions 1.2 Tasks of Production Planning and Control	
2.	PRODUCTION PLANNING AND CONTROL DEPARTMENT FUNCTION AND POSITION WITHIN THE ORGANISATION	2
3.	INTERNAL DIVISION OF PRODUCTION PLANNING AND CONTROL FUNCTION	4
4.	CONTROL SYSTEM	6
5.	PRODUCTION PLANNING	8
	5.1 Long Term Planning 5.2 Short Term Planning	
6.	TECHNIQUES USED IN PRODUCTION PLANNING AND CONTROL	9
	6.1 GANTT Chart 6.2 Introduction to computer use	
7.	COMPUTER USES FOR PRODUCTION PLANNING AND CONTROL	11
	7.1 General 7.2 Basic techniques used in computers for Production Planning and Control	
8.	ADVANTAGES ON USING COMPUTER FOR PRODUCTION PLANNING AND CONTROL	13
9.	COMPUTER PROGRAMMES FOR PRODUCTION PLANNING AND CONTROL	14
10.	SYSTEMS VIEW FOR PLANNING AND CONTROL	17
	10.1 General 10.2 Planning 10.3 Control 10.4 Planning and control summary	
11.	MANAGEMENT INFORMATION SYSTEMS	20
	11.1 Systems view to M/S 11.2 Building a M/S	
12.	PRODUCTION PLANNING AND CON ROL INTEGRATED	25
	12.1 Toward better control 12.2 Need for flexibility 12.3 Long term capacity planning 12.4 Master scheduling 12.5 Short term scheduling 12.6 Control and Progress 12.7 Scheduling approaches 12.8 The Integrated System	
13.	OTHER VIEWS ON PRODUCTION PLANNING AND CONTROL	29
	13.1 General 13.2 Pre-production planning 13.3 Production control 13.4 Dispatching and follow up	
14.	QUEUES	36
	14.1 The investigation of queueing sy tems 14.2 The modification of queueing systems 14.3 Few notes on some simple queues	

PREFACE

This report is a final following a series of 5 reports to my project for the MSc degree in Engineering.

The report presents a literature survey on the various views and approaches to Production Planning and Control and other subjects concerned with my project such as Management Information Systems and the operational research - Queues theory.

As many books were written on the various aspects of Production Planning and Control the survey given is an overall summary of the important points about the subject envisaged on these books and others not appearing on the reference list as well.

The few notes on the Queues basic theory are given as the significant point of the overall project is "Real-Queue" approach to job shop production scheduling versus "Priorities" approach.

Another issue discussed in the survey is the Systems Engineering view to production planning and control as I found it one of the major factors contributing to the development and advancement of the planning and control systems since the last 15 to 20 years.

A. FRANCO

1. PRODUCTION PLANNING AND CONTROL - GENERAL INTRODUCTION

1.1 Definitions

Short and overall definition for Production Planning and Control based upon APICS is :-

"Co-ordination among all the production facilities in order to produce products as per schedule and optimum cost."

It means that the planning and control function must look after regulating of materials supply and all the production operations in the plant for producing products by means of methods and certain processes in order to meet the commercial department programmes and customer requirements.

The activities should be directed in such a way that the equipment, the machines, manpower and the capital available to the plant will be used and fully utilized.

1.2 Tasks of production planning and control

i) To ensure production of the right product.
ii) Meeting customer's requirements on determined delivery date.
iii) Producing the product in the most suitable work centre and the adequate equipment.
iv) Producing the required quantity.
v) Production with minimum scrap and rejects.
vi) Maximum utilization of machines and equipment production capacity.
vii) Maximum utilization of plant available resources.
viii) Co-ordination between contractors if required
ix) Achieving the above in such a way to enable minimum cost.

2. PRODUCTION PLANNING AND CONTROL DEPARTMENT FUNCTION AND POSITION WITHIN THE ORGANISATION

The position of the Production, Planning and Control department within the organisation structure of the plant of which it applies, is of utmost importance. Success in achieving most of the above tasks depends essentially on the authority and responsibility definition provided to the function by the firm.

Based on Production and Engineering Control to F.E. Bullet and on APICS there is no universal recipe which suits all the plants. The above give examples of the various possible ways of planning applicable in many organisations, depending on production type, size and organisational structure. A recommended 4 steps to treat this matter, when introducing the function, due to the above, is as follows :

a) To determine and match the Planning and Control function tasks to those of all the plant.
b) To determine the relative importance which the plant gives to every one of these tasks.
c) To determine the amount of knowledge, the information, the technical reliability and the personal character required from the function incumbents for achieving the tasks.
d) To determine the duties, the authorities and responsibilities of the function, and to appoint right people based upon their character to the above position.

Another article analyses the position of the function in the plant; and the possible organisational relations with other functions. Due to the article, Production Planning and Control is a function which correlates the sales, the purchasing and the production functions. The relations among these are strong or weak, upon the position of the Production Planning and Control Manager in the organisation structure.

The author gives examples for the position of the Planning and Control Manager in 6 different possible organisational structures.

i) Usual structure in industry where the responsible man on production planning and control has direct and immediate connection to the production manager, as shown in figure 1. This type of organisation structure has advantage when Long Term Planning is being determined by the high level management and the plant has flexible production capacity. Under this type of organisation there is not connection between the sales programme and the production programme.

   The conflict between the production departments to sales is sorted out in the high level of the plant management; which determines policies. The Production Planning and Control function has a duty of production progressing in this case.

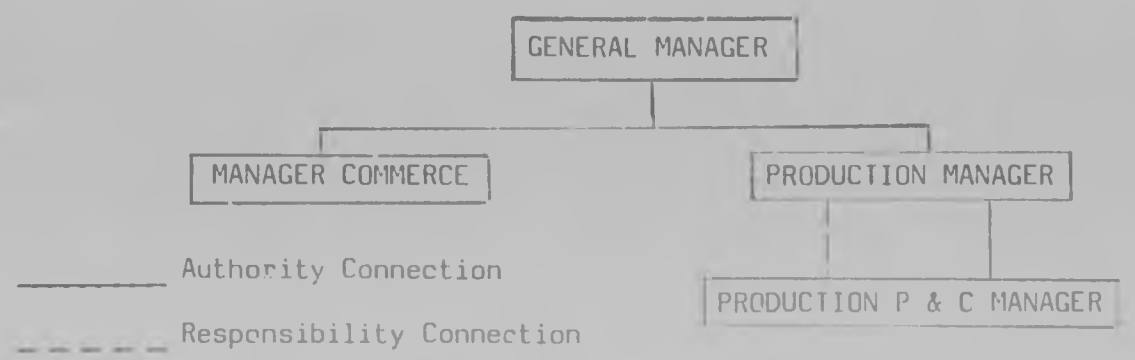


Figure 1. Usual position of P & C position in Industry

ii,iii,iv) There are various variations where the status of the men responsible for planning and control is independent on the production manager and on the commercial manager. The variations are shown in figure 2. This enables him to have influence on both of them and to balance between the contrary interests of the production and the sales.

The justification to such an organisation structure is where a balance between maximum fulfilling of customer requirements to most effecient production is required.

Everyone of the above three variations is applicable in a plant producing a wide range of products and having limited production capacity.

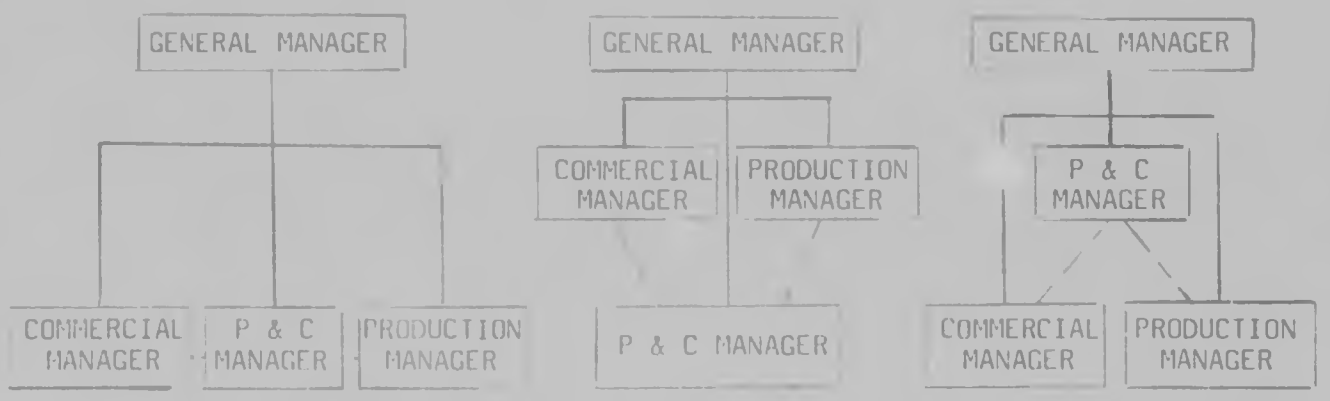


Figure 2. Various variations for Production Planning and Control Position

3. INTERNAL DIVISION OF THE PRODUCTION PLANNING AND CONTROL FUNCTION

Based upon the classical approach which can still be found in the literature, Production Planning and Control Function consists of the following four main activities :-

i) PLANNING - Production planning through machines. Load and manpower available.

ii) ROUTING - Determination of the place where job should be done. Where once this activity consisted of the preparing of drawings, detailing for production tools required and determining of the work centres, today it is condensed to the determination of machines and work centres required for a job.

iii) DISPATCHING - Issue of work orders due to schedule and issue of orders for materials and tools required.

iv) SCHEDULING - Determination of work programme in each one of the work centres.

v) EXPEDITING - Determination of work progress as per programme, when exercising deviations from it.

iv) CONTROLLING - Control of carrying out the work programme as per schedule.

Essentially, the relative importance of each one from the above activities depends on the way in which production is organised.

Production can be organised in one of the following four ways :-

a) Flow mass production.
b) Batch production.
c) Job production.
d) Group Technology production.

a) In flow mass production Routing and Timing problems do not exist. Single orders are not connected to the production programme. The customers should wait for meeting their requirements based upon the plant production programme. The main problems in such a plant are of dispatching and control. Planning and Control Function should ensure continuous flow of materials and items on the right rate to the production lines, and rational stock levels in stores and in process as well.

b) In the Batch production plant the production facilities are used for producing a wide range of products as per customer requirements, or to stock.

In this case all the activities of the Production Planning and Control Function are directed to ensure the best utilisation of these facilities and at the same time meeting the customer's required delivery dates.

c) In job production the same problems as in the case of b) exist. The Production Planning and Control Function has in addition to ensure completion of design and drawing before planning.

d) In group technology production the same problems exist as in the previous 3 production types. Production Planning and Control has in addition to co-ordinate and balance between the groups.

4. CONTROL SYSTEM

In Production Planning and Control to J.H. Green a more modern approach to the Internal structure of the Production Planning and Control Function is given :-

The author envisages this function as a control system. The type of system depends only on the sort of production technology being used. In other words the type of control system used indicates the production technology of the plant.

The author differentiates between 3 types of control systems :-

i) Order Control System - which is defined as control system for progressing every customer's order or stock order through all the activities in the production cycle.

ii) Flow Control System - which is defined as a system for control on production flow of production orders for groups or blocks of product which is processed through the same production processes, for instance : Clothing Factory.

* Comment : The above definitions are based upon APICS dictionary.

Every Control System immaterial of production technology type includes 3 stages :-

Planning
Action
Compliance

All the activities concerned with production in every plant are connected to these three stages.

When comparing these three stages with the four tasks which presented the classical division of the Production Planning and Control function we deduce that there is an analogy between them as shown in figure 3.

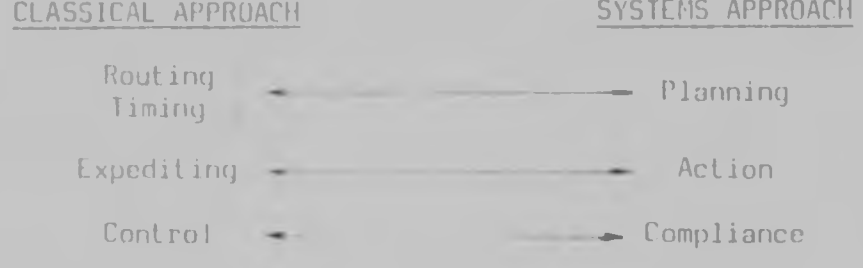


Figure 3 Comparison between the approaches

Today there is a tendency to limit the control activity which should build a bridge between the production and the planning up to replacing it by data captured and worked out in the EDP System.

Indeed, there is an analogy between the production control system to the Servo Control System based on the fact that production control has the duty of a production regulator as shown in figure 4.

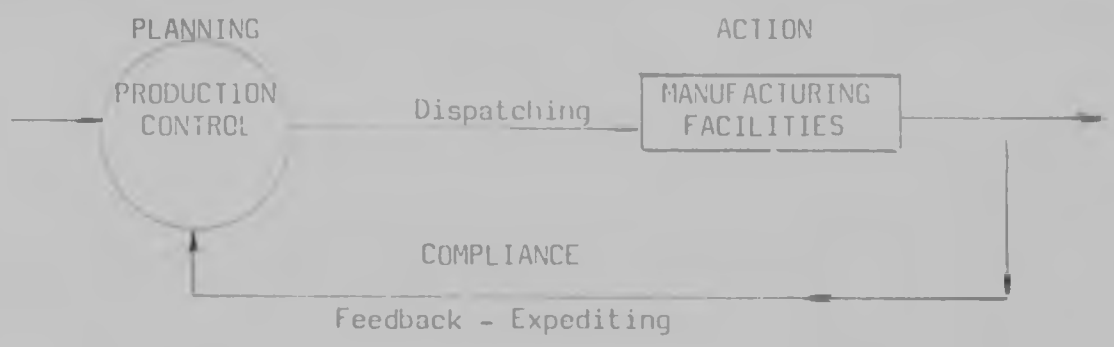


Figure 4 Control - Analogy to regulator

5. PRODUCTION PLANNING

When considering production planning, there is a distinction between two aspects of it :-

a) Short Term Planning
b) Long Term Planning

5.1 Long Term Planning

Under this concept of planning all the policy principles and key points are determined for optimisation.

Optimisation size : Stock level, minimum production cycles, etc, subject to demand forecast, market survey, machines and available resources.

Production programmes are being prepared based upon Long Term Planning as well as the capacity requirements.

However, if there is no possibility to extend capacity, the programmes and capacity requirements are revieved until optimum correlation is achieved.

5.2 Short Term Planning

Usually, the idea referred to procedures for conversion of production order into production programme. In every planning system immaterial of production process it is possible to determine six main activities :-

a) To determine what to produce - Targets.
b) To determine how to produce - Production processes.
c) To determine when to produce - Activities order and timing.
d) To determine where to produce - Routing and work centre.
e) To determine who will produce - Manpower.
f) To determine by what to produce- Production resources.

6. TECHNIQUES USED IN PRODUCTION PLANNING AND CONTROL

6.1 GANTT Chart

The traditional and mostly used tool during many years has been the GANTT Chart.

This is a very simple way to present, in a graphic way, the production stages and that is his most important contribution.

Advantages of this method which do not exist in the other methods are :-

- Forces preparing of production programme which is itself an important stage towards making activities efficient.
- Makes it easier to compare between scheduled work and actual work done. Eliminates the need to remember a great deal of information for comparison.
- The chart is of compact structure - one chart can replace a large cardex of information.
- Simple to introduce : Everyone, after short training, can build up such a chart.
- Dynamic in his feature.

Of course, at the present stage of technology, the GANTT Chart has more disadvantages than advantages.

The GANTT Charts are of two basic types :-

i) Forvard charts - on this chart work schedule is determined from the present date forvard and based on it the end date is determined.

ii) Backvard charts - when the end date is known it is desired to start from it backvard in order to determine the desired start date.

6.2 Introduction to computers use

As Production Planning and Control department has the duty to co-ordinate between Purchase department, Production, Stores and Sales, various reports about plant activities are required for it.

Based on these reports production planning should be carried out. Since the last two decades as the volume of required information is increasing and due to the quick development of the PERT technique, the use of computers in planning is being extended.

The contribution of the computer is significant when considering capture of large amounts of data, quick processing and the follow up after progressing production.

Today it is applicable to use a joint application of the GANTT Chart, PERT Chart and balance line.

This type of diagramme presents :-

a) General layout of project and his activities order.
b) Critical rout and sub-critical routs.
c) Work state before and now.
d) Resources requirements.

In addition, the following information is given :-

a) Execution times.
b) Start and finish of activities.
c) Cost control centres.
d) Completion percentage of every activity execution.

Two tables complete this diagramme :-

i) Cost Analysis · regarding Normal time and crashed time.
ii) Manpower Analysis : Supplies the same information but on budgeted work hours.

7. COMPUTER USE FOR PRODUCTION PLANNING AND CONTROL

7.1 General

As it was mentioned before the need to store large amounts of data and activities brings the Production Planning and Control to use the computer.

The computer assists a great deal in the use of many planning techniques, for instance CPM.

IBM was the pioneer in development of new techniques for network planning and for production planning and control (Kraus, Class, CAPOSS, etc).

Later on all the other companies such as CDC, HP, Borough and others dumped the market with many packages for production planning and control, integrated with other aspects of management in the firms such as Costing, Marketing, Inventories, etc.

7.2 Basic techniques used in computers for production planning and control

7.2.1 PCS 360

This technique provides the user with a technique called "precedence network" or another name "Precedence list".

The advantage of this method over the others CPM/PERT is in the way interactions between various activities are given.

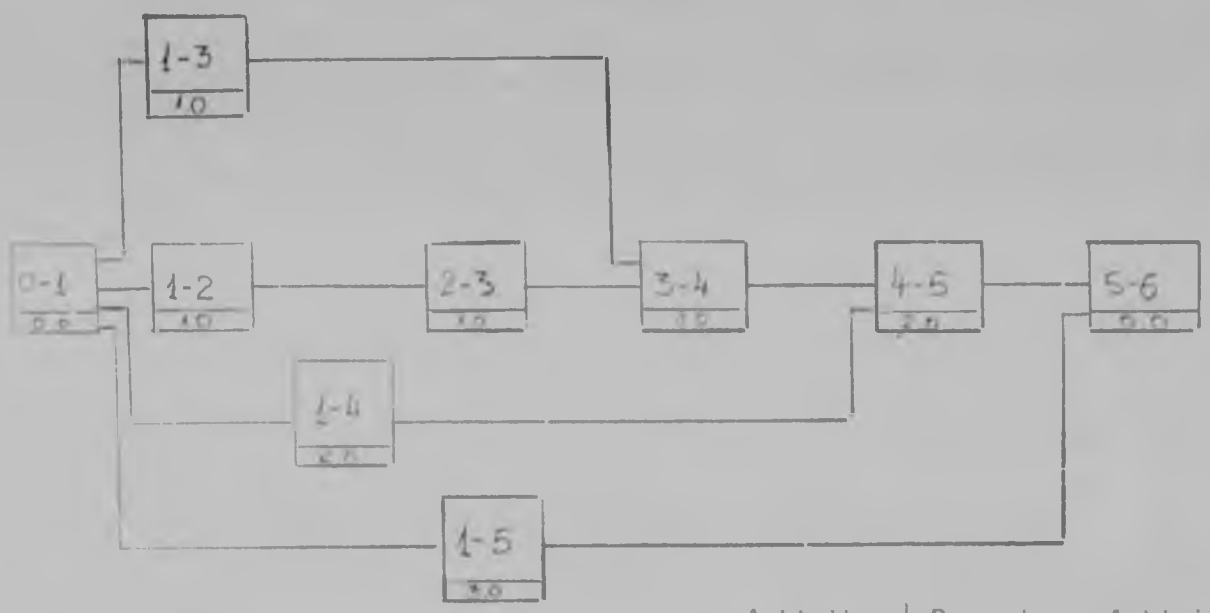
An example which illustrates the difference between CPM/PERT network to PCS network is given in figure 5.

CPM/PERT



Precedence Event	Follower Event
0	1
1	2
1	3
1	4
1	5
2	3
3	4
4	5
5	6

PCS 360



Activity	Precedence Activity
0 - 1	
1 - 2	0 - 1
1 - 3	0 - 1
2 - 3	1 - 2
1 - 4	0 - 1
3 - 4	1 - 3; 2 - 3
1 - 5	0 - 1
4 - 5	1 - 4; 3 - 4
5 - 6	1 - 5; 4 - 5

In this case all the relations are : start of every activity depends on finish of precedence activities.

Figure 5 The difference between CPM/PERT to PCS-360

The techniques presented above are available in PERT and are called A-O-A and A-O-N i.e. activity defined by Arrows and activities defined by Nodes.

Other network techniques available : PERT/COST, PERT/TIME, PERT/LOB.

8. ADVANTAGES ON USING COMPUTER FOR PRODUCTION PLANNING AND CONTROL

The larger the plant and the production scale the more the importance to have Electronic Data Processing (EDP) for success in achieving of the organisation goals.

Obviously, computerising only available reports in order to save manpower can result in disappointment and uneconomics.

It should be born in mind that not only saving in manpower is aimed at when introducing computer but his potential possibilities for improvement of present procedures or the introduction of new procedures which are responsible without using computer.

The criteria for efficient use of computer for Production Planning and Control are as follows :-

a) The system will be assigned to control with exceptions.
b) The system will not be assigned to eliminate manpower but to avoid clerical work done by technical workers (Technicians, Engineers, etc).
c) The system will be used for day to day decision making.
d) The required information for non-usual decision making will be assessed.
e) Minimum paper work.
f) Information processing will be of high level i.e. Inputs will have as such quality, layout and timing that no reprocessing for reports is required.
g) Information processing and reports will be timeous in order not to lose their utility.
h) The system will be flexible for extension and improvement without essential modification in the system or in the programmes contained.

9. COMPUTER PROGRAMMES FOR PRODUCTION PLANNING AND CONTROL

The first programme developed by IBM in order to enable use of computer in Production Planning and Control is the "KRAUS" programme. The programme can be used by every plant, small and large size.

The programme is built in such a way that her introduction does not require organisational changes in production plant and every plant can process the data based upon his particular organisation structure by means of a leading card and without modification of the programme itself.

The big disadvantage of this programme is not having an optimal cost element. Layout of a "KRAUS" programme is shown in figure 6.

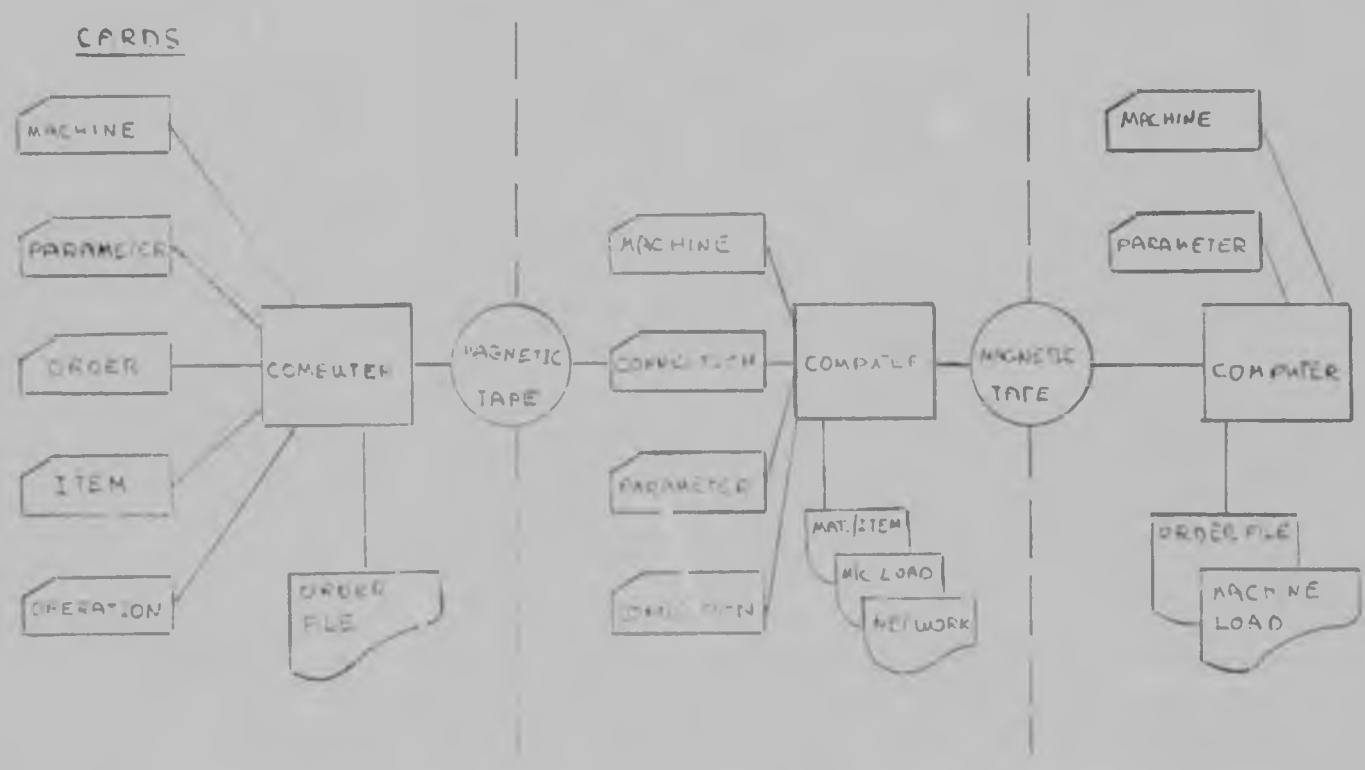


Figure 6 "KRAUS" layout

IBM planning and control programmes archive offers many other programmes for project planning and control. Few of them are :-

PCSI/1130 - The programme can process no more than 2 000 activities by IBM 1130 computer. Hence, there are certain limitations on the amount of data processing.

PMS/I8 - Used mainly for data processing. The system is flexible on input layout, on data included and on the significant way of getting reports.

The system consists of modular programmes in which each one of them does a significant job, either processing network or managerial data processing.

The programmes are joined into 4 sub-systems :-

i) Network processing system (Times analysis)
ii) Resources allocation system (Resources analysis)
iii) Costs analysis system (Cost analysis)
iv) Reports producing system (Output analysis)

JAS/3 - The system can process between 300 to 736 activities and up to 10 joint networks.

The programme contains most of the possibilities of the PCS and in addition enables printing of the network itself based either on arrows or on rectangles.

The system gives the following :-
- List of activities and progress data.
- List of activities and resources consumption.
- List of precedence operations.

APL-Mini Pert- A programme for quick reporting. Can be applied only through terminal No 2741 which is not available in every plant. The programme gives the designer all the possibilities for storing network, maintaining it and reporting on about 200 activities. After then it is possible to incorporate the network to other more complicated networks.

Class-25 - One of the most developed programmes for Production Planning and Control which is being used in many industrial organisations. The system can be anplied through an IBM/360 computer.

The system is based on CPM/PERT and mainly suits assembly plants and works due to the timing approach.

Advantages - Suitable for assembly plants.
- Forecasts future events.
- Besides production programmes and load programmes for the Production Planning and Control Department, it is used by the costing and accounting departments.
- A great number of activities can be processed through it.

Disadvantages- Complicated to be applied for plant other than assembly.
- Useful only for large plants as a result of high operation costs.
- The programme does not keep history.

CAPOSS - Version 1,2,3,4,5

- Programme to use whenever there is a problem of allocating a large number of activities to limited capacity resources based upon job priorities. It contains many features such as overlapping and splitting of operations, use of alternative resources, grouping of similar activities and resources for efficiency.

  The system generally is one of the most developed systems of IBM.

  Detailed description of the system is given in part B to this project.

Other programmes

- The other companies such as CDC, Borough and Hullet Packard also offer programmes which are sometimes more useful for small plants as the systems offered are of Integrated Management Information Systems approach.

GENERAL - After more than 20 years of experience in using computers for Production Planning and Control and the increasing number of plants using computers many plants and organisations find it feasible to build suitable self programmes as the big companies offer too general programmes to suit all which cannot be utilized properly by sophisticated users.

10. SYSTEMS VIEW OF PLANNING AND CONTROL

10.1 GENERAL

R.L. Ackoff in his book "A concept of Corporate Planning" sees Planning and Control as clearly related activities.

The main tasks of Planning and Control are as follows :-

Planning : To co-ordinate various parts of an organisation and to allocate resources according to its objectives and the forecast state of the environment.

Control : To ensure that plans are implemented so that the desired co-ordination is achieved and the organisation develops in the desired direction.

In terms of a "gap" planning and control can be illustrated as shown in figure 6.

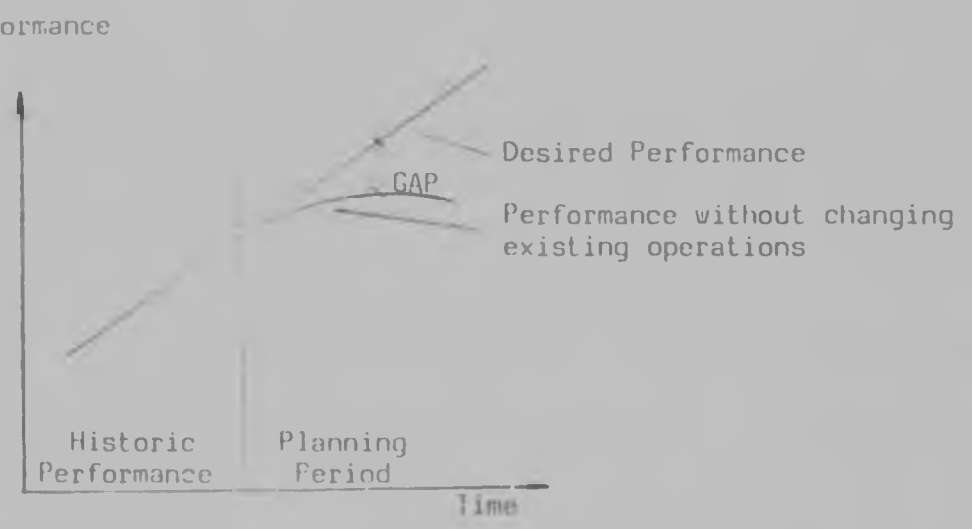


Figure 6 'GAP' term to planning and control

Planning is therefore concerned with identifying where the organisation is going through exploration and evaluation of alternatives and deciding where the organisation should go.

Control is concerned with bringing about the gap closure by maintaining and adjusting the chosen alternative by planning.

10.2 Planning

In any organisation three types of planning should exist in order to ensure continuity : Strategic, Project and Operational. Together they form a hierarchy of the Planning System.

Another way to illustrate the regulator role of Planning and Control given in item 4 can be shown in figure 7.



Figure 7. Systems view to planning and control

As all planning systems require a measure of performance feedback is necessary.

Every planning system has to co-ordinate between the various parts within the system and as this is the case systems approach insists on having considered all the properties of the relevant systems such as : objectives, wider system, boundaries, resources, connectivity, decision takers etc.

10.3 Control

Control is a mechanism to ensure bringing about of programmes as per planning programmes.

The results are measured through outputs. It is preferred to have them as quantitative as possible.

In human activity it is difficult to measure outputs quantitatively, thus, in many cases, it is done qualitively.

When considering a Production Planning and Control System a control consists of meeting daily production programmes, meeting operation estimated time and ensuring feedback which are a few of the interrelated variables composing higher target as x% products deliveredon time. This implies they are connected and should be known and clear enough to the system users or incumbents.

Having known all the variables of the system, adjustment of them is required. This is the task of control and it should be done through monitoring inputs, outputs and related variables which affect the systems performance.

A practical example for control in this particular project is the control over the computerised planning and control system in central workshops.

The basic model used is in figure 8 taken from readings on Systems Engineering by J. BICHENO (Wits University).

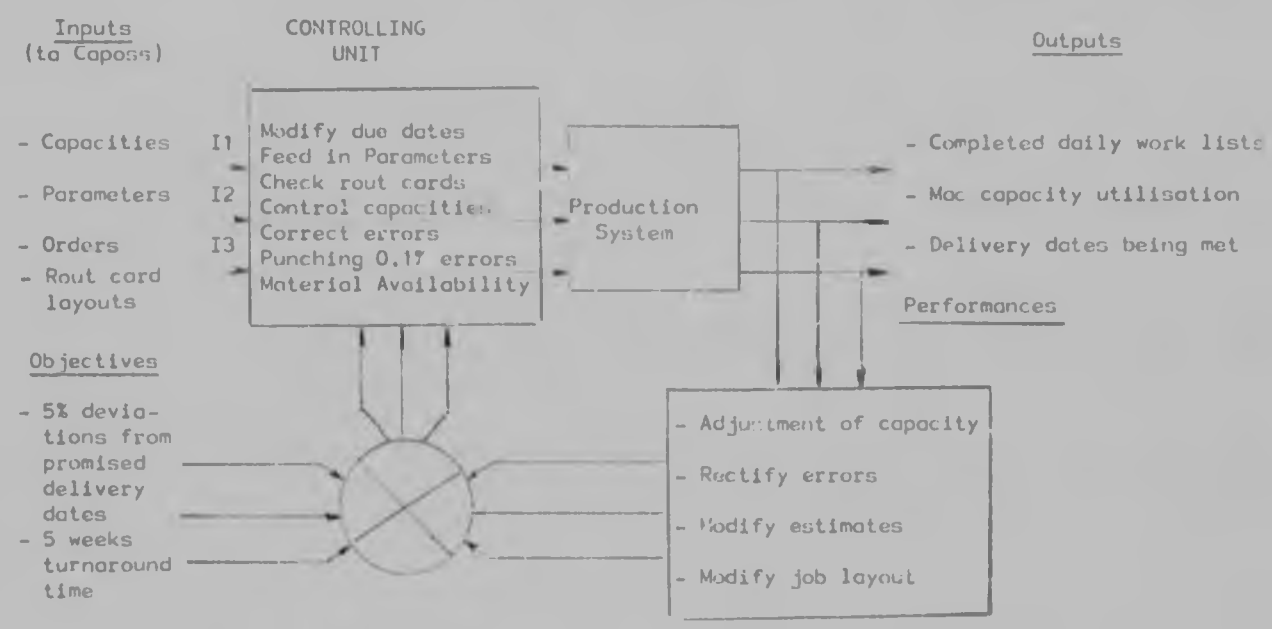


Figure 8. Control Model

10.4 Planning and Control summary

The essential difference between planning and control can be thought of as a difference in system boundaries. Nevertheless there is a large overlap between them, thus it is useful if not essential to consider planning and control as integrated activities. In actual fact that is the case in most of the Industrial Planning and Control units.

11. MANAGEMENT INFORMATION SYSTEMS

11.1 Systems view to MIS

Many books and notes have been written about management information systems. This chapter will present selected topics in view of the above subjects. The basic rule for information is "Information has no value unless it causes us to change our course of action".

Change in course of action implies from a stand point of Information : Relevance and interpretation.

Computer output data does not imply an information system but mean oriented.

Since every system does not consist only of operations but is also concerned with planning, control and with bringing about change, these variables are interrelated and require information to allow its system-continuity.

The information required for each part can be unique or common to few parts. As these parts overlap to a greater or lesser extent. Schematically it can be looked as in figure 9.

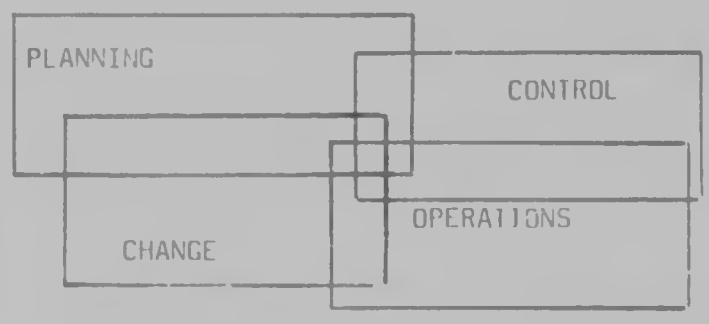


Figure 9 Planning, control, operation and change overlapped

Good information system considers the above overlap, tailored to different people in different levels within the organisation and is being used by them for decision making procedures, on a continuous basis.

11.2 Building a MIS

11.2.1 Introduction

For several years, qualified systems and data processing personnel in a great number of companies have been devoting a substantial amount of effort to the design and installation of so-called "management" information systems of "total" information systems. Raymond J. EPICH draws the following conclusions about these efforts :-

- The systems being designed do not deal with actual "management" information.
- The systems are not "total" in any sense of the word.
- Most frequently, the cost of systems design and computer programming is several times greater than is should be.
- Companies that have automated too much, too soon at too great a cost, may be at greater disadvantage in the long run than those that have automated relatively little thus far.

11.2.2 Management information

"Management" information can be defined as the information needed to manage. Management itself is the allocation of company resources to the accomplishment of predetermined objectives, a process requiring strategic and tactical planning, factoring of these plans to smaller scale objectives, assignment of these objectives to subordinates and control of subsequent progress. Using this definition, management is distinguished from the actual accomplishment of the smaller scale objectives which will be referred to as operations.

Discussing management information requires sorting executives into two groups : management and personnel, which as a practical matter is extremely difficult.

Sorting activities is equally difficult, since few, if any, are readily distinguishable by the planning, factoring, assignment and control features of the definition.

If we take planning for example : Is an executive "planning" when he reacts to stiff competition by cutting his price? In some respects he may be. The price cut may be the initial action to a whole series of factored smaller scale objectives, responsibility assignments, control processes and follow-up activities. The decision to make the cut may require access to more data, require more penetrating analysis and entail greater computational activity than a formal plan to build a new factory or market a new product.

Having arrayed management activities as carried out by management personnel further question have emerged : Do we know how these are carried ut? Do we know what management information is required to carry out a particular activity?

Actually, we know relatively little about management decision making. Herbert A. Simon in his book "The new Science of Management Decision" focused attention on the actual process itself rather than to specific examples of management decisions. The conclusion from it is that information system should deal with the overseeing of operations and not with management itself.

Thus, the fundamental stage is to make management a programmable activity before management information can be much more than a loosely used term, not at all descriptive of the information truly needed to manage resources.

11.2.3 "Total" information

Whoever coined the term "total" information systems certainly gave it little thought. Those who use it are guilty of gross overstatements. So-called "total" systems, as presently conceived do not convey 0,00001% of the information needed to manage a company, and probably 0,001% of the information needed to operate one.

Use of the word "total" for information may prove embarrasing to systems personnel for two reasons :-

i) Your management may actually expect a total system and you may be hard pressed to explain why the system as designed falls short of work.

(ii) Your management may accept your system as "total" looking at it for the totality of management and speaking information.

Indeed, the use of this term has greatly diminished and it may soon leave the vocabulary altogether.

11.2.4 Costly design and programming

During his work on design and installation of computers, the author found that design and programming are being carried out in a manner that is astonishingly inefficient.

i) At the outset, while systems are being conceived, too little attention is paid to sub-system integration. Often systems are heedlessly proliferated when a more thorough examination of the objectives would have eliminated them entirely.

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i) At the outset, while systems are being conceived, too little attention is paid to sub-system integration. Often systems are heedlessly proliferated when a more thorough examination of the objectives would have eliminated them entirely.

ii) At the next level of effort, run flow design (the specification of run to run computer processing flow), has observed the greatest waste.

It is not unusual for several computer runs to be eliminated entirely when run flow concepts are examined by experienced and imaginative people. Failure to perform such a review could represent a needless great deal of increase in total installation cost.

iii) At the detailed systems design and programming level it is likely that much of the work proceeds in an undisciplined manner. Accuracy is left to stochastic processes, which can increase costs by an additional hundred of percents.

The reasons for such a phenomenon are as follows :-

i) The personnel assigned the responsibility for systems design fail to make full use of the experience of operating management.

ii) Personnel having responsibility for systems design do not have the necessary intelligence or creative imagination to conceive of suitable systems.

iii) Operating management has not actively participated in the installation of the systems.

iv) Basic scheduling and control devices are not used to monitor progress.

v) Surveillance is inadequate on both the quantity and the quality of the output because much routine work is erroneously classed as highly creative labour not susceptible to measurement.

11:2.5 Safeguard against costly failure

At the end of the article, the author gives a list of recommendation for improvement which might be usefully adopted by companies building large scale information systems.

While these seven recommendations may not become as noteworthy as Mr Fisck's Seven Deadly Dangers in EDP (Harvard Business Review : May-June 1902 p88) they are offered nevertheless :-

i) Place the information system design project under the direction of an executive whose ability is commensurate with the scope of the project, measured in terms of either payout or cost.

ii) Take a good look at all of the systems and data processing personnel participating in the project. Use whatever criteria you wish but weed out sub-standard personnel before the project is too far along.

iii) Take full advantage of the experience of operating management by assigning several as principal members of the installation team.

iv) Look at the opportunities for computerised operating systems more completely before approaching Management System.

v) If you really know how management decisions and procedures are made and what the information requirements will be - try an improved manual management information system first.

vi) Formulate an overall concept but do not try to install it all at once. Factor the project into several integrated sub-systems and rank these in priority sequence. Tackle each sub-system separately, in series or in parallel, yet provide for overall integration.

vii) Do not hesitate to defer the design and installation of true management systems for a few years until we all understand it a little better; it is quite possible that this may put you ahead of your competition.

12. PRODUCTION PLANNING AND CONTROL INTEGRATED

Introduction

In his article Production Planning and Control Integrated William K. Holstein discussed the identifying and tying together of the various parts of Production Planning and Control System in order to achieve the above goal.

12.1 Toward better control

The author gives in detail the 2 major ranges of planning and aims required of them. Long term planning which commits the company to adopt the right strategy on manpower, skills, plant, production approach, machinery and equipment.

These require information to be analysed and within the guidelines formed by long term plans, tactical control must be exercised over the uncontrollable variation in product mix and productivity in the short term.

Control in the short term involves : Meeting daily production programmes, meeting standards times, allocating resources, controlling stock levels and meeting required delivery dates.

The performances required can be measured through the key result areas of the above targets.

12.2 Need for Flexibility

A task of utmost importance in designing a Production Planning and Control System is the flexibility. The boundaries and guidelines drawn up by the long term planning should be followed by the short term planning operators.

This can be achieved through the right information system and feedback from the bottom to the top to update programmes and give indications on deviations and modification required. An example to this procedure can be a standard time for the production of a certain product; long term programmes about quantities is based upon this standard time. If the standard time is wrong the programme cannot be met. Having flexible MIS that give a feedback on meeting of standard time will bring about either change on the long term programme or investigation why the time cannot be met.

Action will be taken in due course given by high level management.

12.3 Long term capacity planning

Since production programme in the short term cannot be carried out with short notice of high level management long term planning programme must be prepared in the right timing and is the starting point for production planning and control.

12.3.1 Forecast of future demand

Demands can be forecasted through analysis of available data for trends, market survey and competition.

This will lead to knowing the capacity, machinery, technology required, etc for drawing up long term planning.

In make to order shops future demands are being analysed through available data, the state of economy and its impact on the company's future business.

An example of this type of forecasting is this project case : Central workshop job shop production.

We used to collect data as per units within the various plants Ammonia, Explosives, etc. We learn the trends in the maintenance state through the data and based upon know where to increase capacity or in the case of new plants or machinery through maintainability studies to a certain extent.

12.3.2 Continual adjustment

Capacity requirement planning is not a one-shot operation after getting the forecasts.

This should be updated in predetermined frequencies and established procedures. Adjustment consists of building new plants, purchase of new machinery, acquisition of knowledge and technology, recruitment of skills, engineers etc. Again, this can be achieved through elaborated management. Information System Computer can provide data but cannot do it by itself. This should be done by the users.

12.4 Master scheduling

Master scheduling includes the production programme for the next several months ahead. When establishing the schedule, consideration is given to the plant load, leveling of load where required, manpower, machines, stock level, etc.

The master scheduling establish deadlines for orders considering customer requests and internal factors as stated above.

12.4.1 Estimating shop loads

Accurate estimating of shop loads is the key area for accurate master files. This can be done through having accurate estimates of job duration, analysis of past data available and other methods.

Today as the computer can store large volumes of data it is being used for measuring loads as per department, work centre, or even machine load.

12.4.2. Inventory Control

Inventory control is not a separate entity, but rather it is a pervasive factor which runs throughout any Production & Control System.

A lot has been written about inventory control systems and all that they entail; re-order level, lead times, economic order quantity etc. Briefly, as stated above, inventory control is a part of Planning & Control and, as such, it should be used for master scheduling and capacity requirements.

12.5. Short-term Scheduling

As mentioned before, this is derived from the Master schedule. It can be a one week or even a one day programme. This includes; capacity loading per work centre, area or machine, based on the schedule period or on infinite capacity (i.e. queue of jobs based on priority type job or ordinary job).

The basic idea under this category, is that short-term production programme should be met in order to fulfil the Master schedule programme.

12.6. Control & Progress

The author gives other important factors for meeting the short-term programme, such as, despatching, progress, and control over the shops which have been discussed already in previous items.

12.7. Scheduling Approaches

The author gives a few possible approaches to scheduling:

- Real queue
- Priorities; Pre-emptive, ordinary
- Profitable payoffs

As this issue is discussed in detail in parts B, C and D of this project, it will not be discussed here.

Something new, is the use of Hot/Cold terminology for job priorities. However, this is another literal version of the pre-emptive priority approach.

The profitable payoffs approach is a scientific one and I do not think that this can work properly, as sometimes, an expensive project which pushes back small jobs can be of a one-off customer type, while the small jobs are incoming on a continuous basis and from constant customers.

However, every case should be considered separately, but, generally, every priority scheduling system is too scientific for practical application and does not fulfil what is required of it.

12.8. The Integrated System

The various parts of a Production Planning & Control System as described in previous items, should be tied together, in order to achieve an integrated system. An integrated system is necessary to achieve better management, making decisions and continuity, in the long run.

The information flow and the feedback are the most significant factors in tying these parts together.

Long Range Forecasts are transformed into capacity plans to guide Master scheduling. Master scheduling supplies a load programme. From this Master scheduling, we derive scheduling, despatching, capacity adjustment and inventory control. It can be seen as a closed system in which all parts are interrelated.

At present, progress towards this approach is being made to a large extent, as computers are becoming more and more an integral part of many organizations.

13. ANOTHER VIEW ON PRODUCTION PLANNING & CONTROL

13.1. General

Another approach to Production Planning & Control, is the early Fifties Approach, which involves having 3 major functions:

i) Pre-production Planning & Control - equivalent to Long Range planning.

ii) Production Control - equivalent to Middle Range p' n. ing.

iii) Despatching and follow-up - equivalent to Short Range planning.

This approach emerged from experience gained in small and middle size companies, before the computer revolution. Nevertheless, today many industrial plants, including large ones, although using computers and sophisticated management information systems, are following exactly this approach, thus I found it useful to give readings on this approach, based on old literature on the subject. Moreover, it appears that, in many large companies, including the multinationals, subsidiaries and companies within the large ones, are working as per this approach. One could say that the large companies should have the sophisticated system in order to survive in the long term, which is more difficult for the middle size and small companies, which is correct, but obviously, the present approach for an integrated Planning & Control System emerged from it.

13.2. Pre-production Planning

This consists of taking a new (or changed) material, part, product or line of products and organizes, in advance, the men, materials, machinery and money required for a pre-determined output in a given period of time

While the responsibility for pre-production planning is one of sufficient importance to reside directly with top Management, nevertheless, the actual steps are performed by a variety of key personnel in the organizations, co-ordinated, almost invariably, by a committee. Since the activities are so broad and transcend divisional lines, the committee approach seems to be the most successful way to good planning, so thing like co-operate Management.

In the usual sequence of steps, the production control specialists and the plant and industrial engineers "explode" or breakdown the product or part into it's components and materials. These groups, togeth with the purchasing buyers, determine next what is to be made and what is to be purchased. If not already in existance, the physical facilities must be acquired and organized by the plant and industrial engineers, for the level of production desired.

These same people also develop and detail the operations and their sequence, prepare time standards or estimat , determine process quality standards and plan the tools, jigs and fixtures as to both type and number necessary for the anticipated production quantity.

Pre-production planning then proceeds to a consideration of the manpower needs by the personnel division. The required skills and number of people are determined from the sales forecast plus the operation and time data mentioned previously. The procurement planning of materials and supplies from external sources, including the setting of time schedules, is performed by the inventory control and purchasing functions. Yet another section, that of cost accounting, estimates the cost of making the product in the forecast quantity.

In summation, it can be said that pre-production planning is a series of related and co-ordinated activities performed by a number of different departmental groups, each activity being designed, in advance, to systemize the manufacturing effort in it's area.

Organization of the physical facilities is, of course, one of the principal activities of pre-production planning and it's starting point, in the case of new facilities, is selection of the plant location, designing of plant buildings, layout, machinery, equipment etc.

13.3. Production Control

13.3.1. Function & Duties

After pre-production programmes and activities are completed, someone should carry out the production programmes. This is the duty of the production control unit, which is also called Production Planning & Control in many plants. Small plants do not need the elaborate and detailed production control systems which may be required by their larger counterparts. However, the same control principles apply for all plants, large or small. Plants with 50 or more employees, for example, may have a one-man production/control system operating under the wing of the factory superintendent. During the course of his work, this man is engaged in all the production/control activities - but in a more simplified manner - which are performed by a battery of specialists and clerks in large plants. Briefly, the activities of the production manager and his specialists embrace the development and operation of the production/control techniques, procedures and paperwork used in manufacturing the products of the enterprise.

They co-ordinate the various production/planning activities of the manufacturing divisions and the other staff functions.

Since product designs, production methods, manufacturing requirements and work priority are continually subject to revision, the production control routine is seldom stabilized for long. Thus, the work of the production manager and his specialists is, at times, as hectic as it is varied.

13.3.2. Routing

Fundamentally, routing determines what work will be done on a product or part, as well as where and how it will be done.

It establishes the operations, their path and sequence and the proper class of machines and personnel required for these operations.

While routing is a major responsibility of the production/function, it is also connected with the field of product development in beginning a product which can be readily manufactured. Likewise, it is closely allied with plant and industrial engineering, in setting up the most efficient operating methods and establishing a materials flow through the plant for a minimum of handling and backtracking. Thus, at one time or another, each of these departments may have a hand in product routing.

Routing Procedures

i) An analysis of the product to determine what to make and what to purchase: A decision is made; what to produce and which parts to purchase outside. This is based upon technology, machinery, skills and capacity availability of a particular plant.

ii) An analysis of the product to determine what materials are needed: Drawings, specifications, standards of quality and identification symbols are usually condensed by the routing section, into a parts list. This is used for preparing a "Bill of Materials" which indicates: part name, identification number, quantity required and application of the product.

iii) Determining the manufacturing operations and their sequence. The engineering standards office or Industrial Engineering uses data on files, to establish the operations necessary to manufacture the product and lists them in proper sequence on a route card/sheet. This card will be used in production, when transferring the product from one work centre to another. The route card/sheet includes standard times for operations as well as which are used for bonus schemes, costing and scheduling.

iv) Determining Lot Sizes: The number of units to be manufactured in any one lot or order as established by routing, depends primarily on the type of manufacture involved. If it is a product to be manufactured strictly to a sold order, the quantity to be made will usually equal that required by the customer plus a certain average or allowance for rejections.

Where manufacture is to stock, the lot size is usually based on the economic lot quantities.

v) An analysis of the cost of the article: Based on established time to produce, direct materials cost and specific and general indirect expenses.

vi) The organization of Production Control Forms: The type of manufacture exercises considerable influence on the forms required by the plant departments. In production line manufacture, work is organized around a form known as a schedule. For job order manufacture, a manufacturing order, sometimes called a work order, is required.

13.3.3. Scheduling

Scheduling is that phase of production control which rates the work in order of priority and then provided for it's release to the plant at the proper time and in the correct sequence.

The function of scheduling closely resembles that branch of railroading which schedules the use of railroad/track facilities. The aim in railroad scheduling is to run as much traffic over the same tracks as safely as possible without interference or collisions. Similarly, the aim in industrial scheduling within the limits of the customer orders available, is to schedule as great a volume of work as the plant equipment can conveniently handle, without similar interference or "collisions" resulting in material stoppages along the route.

Scheduling establishes the begin and finish dates of a job, machines and labour required for doing the job.

Sequence of Scheduling Procedure

Scheduling usually starts with the Master schedule. This schedule is simply a weekly or monthly breakdown of the production requirements for each product for a definite period of time (such as, per quarter, 6 months or per year). As new orders or requirements are received, they are scheduled on the Master schedule, with due regard to the available plant capacity. If no capacity is available, (in that particular week, month or year), it is obvious that the new requirements must be carried over to a subsequent period or the present schedule for the capacity period must be re-arranged to accommodate the additional orders.

Scheduling of serialized manufacture is primarily a matter of translating the sales or programme requirements into a schedule of the amount of material which can be manufactured on the production line in any given period. The length of time required for the production cycle of a serialized production line is usually established when the line is set up and material entering that line usually finishes the cycle without a change of sequence.

Semi-serialized manufacture on the other hand, usually does permit some storage and re-shuffling of the orders along the production lines, particularly if a range of products or parts, with varying process times, are fabricated on a single production line.

When dealing with scheduling of job order manufacture, particularly where a range of parts is required for one assembly project, it becomes infinitely more difficult, for the fabrication of each part and the assembly of each group of parts must be scheduled with due regard to the availability of equipment, personnel and materials.

In the scheduling of several component parts of a job order as[illegible], each with a different process time, theoreti[illegible], each part is scheduled so that it will be completed [illegible]ately prior to it's being required for assembly.

An important factor to remember in scheduling is that it is being made in order to be revised. After all, a schedule is based on the priority or relative urgency of the work involved and as conditions and customer requirements change, so also does the relative urgency change. In summary, a schedule must be flexible to meet changing conditions.

13.3.4. Control Charts

Charts are widely used in industry for control purposes. Particularly in the field of production, scheduling charts often constitute the foundation on which all scheduling activities are based.

Control charts offer a quick, compact and visual means of recording information. Charts are useful in establishing control by exception. The exception is the area of poor accomplishment compared with the original plan readily stands at when charted and thereby points out the need for investigation and possible correction. Control charts are usually dynamic. That is to say, as conditions change, the charts are successively revised so as to furnish a moving force for current as well as for future action.

Control charts used as a tool of production control include:

i) The project layout chart (the curve chart): This schedules, in advance, the work ahead of either men or equipment, or both, and determines the relative importance of the work and hence the sequence in which it should be performed. Figure 10 would be representative of such a chart.

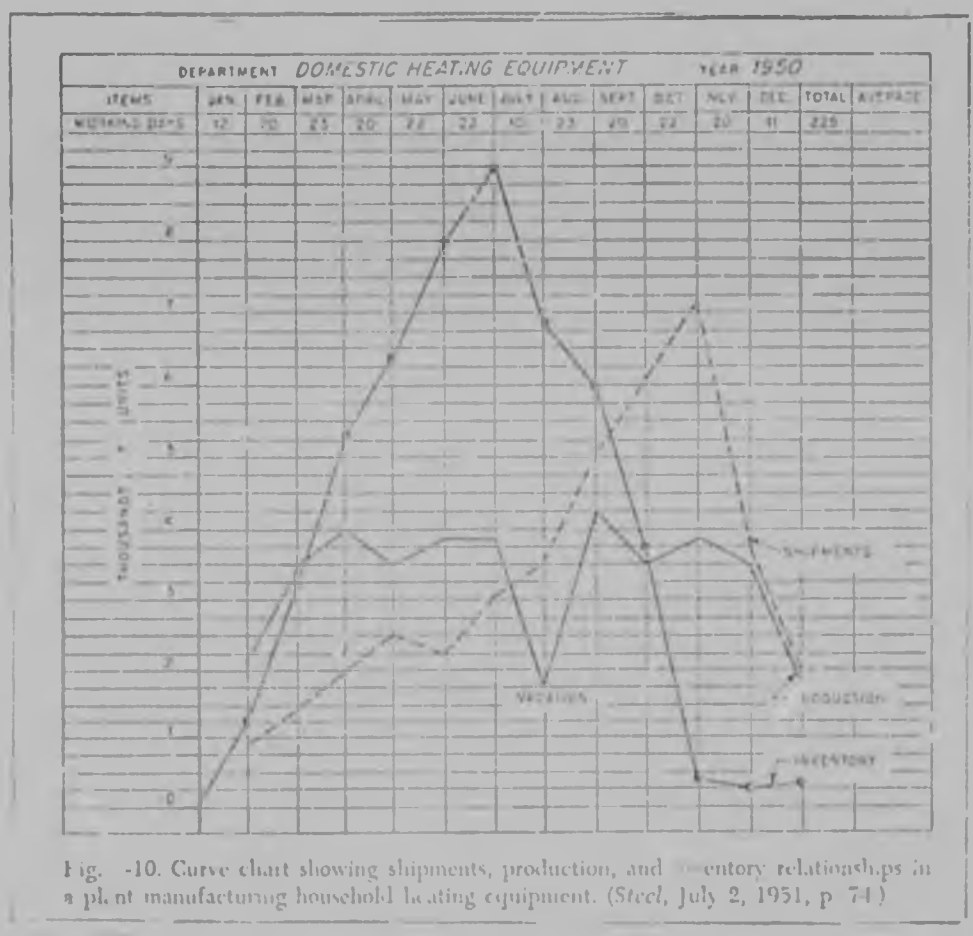


Fig. -10. Curve chart showing shipments, production, and inventory relationships in a plant manufacturing household heating equipment. (*Steel*, July 2, 1951, p 74)

ii) The load chart (the BAR chart): This indicates by number of hours, days or job, the work load ahead of a particular machine, battery of machines, department or plant, as shown in figure 11.



Fig. -11. Bar chart showing the load in terms of number of days of work ahead of machines in a machine shop.

iii) The progress chart (The GANTT chart): This compares the progress or accomplishment made against a prescribed plan. It directs attention to failure, thus making possible the appropriate investigation and action, as shown in figure 12.

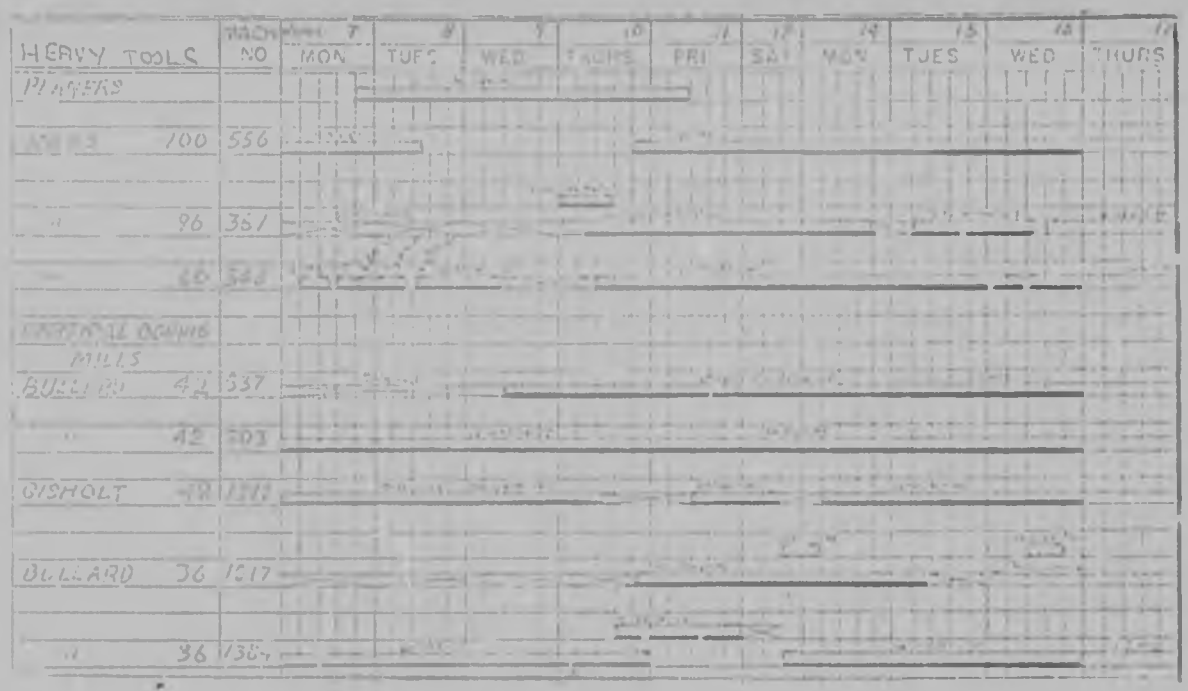


Figure 12 - GANTT Chart

iv) Mechanical charts: These are charts which include visible index files, various wall charts and scheduling boards which are available from manufacturers of production control equipment. These charts are enlarged adaptations of one of the foregoing three chart forms, with the addition of mechanical clips, pegs, strings and other signalling devices.

Dispatching and Follow-up

Dispatching is the initial action element of production control, consisting of the issuing of orders in terms of their priority as determined by scheduling. It includes the assignment of work to the operators at their machines or work places. Thus, despatching in effect, determines by whom work shall be done.

Follow-up or expediting is that branch of production control procedure which regulates the progress of materials and parts through the production process. Although it is the agency charged with the responsibility for production orders after they are despatched, it is, nevertheless, closely interrelated with despatching.

The various types of follow-up are:

- Materials
- Work in process
- Assembly and erection

14. QUEUES

Since the core of my project is the Real Queue approach in job shop production versus the Priorities approach, a few selected readings on Queues Theory will be given.

The notes are based mainly on the books of D.R. Cox and Walter L. Smith and the book by Philip Morse.

14.1. The investigation of queueing systems

Generally, mathematical solutions for queueing systems can be implemented for relatively simple situations.

If numerical results are needed for a complex system, these have to be obtained by sampling experiments, which nowadays can be aided by computers and other high speed computing facilities.

The practical approach for investigating a queueing problem as recommended by Cox, is as follows:

i) A preliminary survey consists of the following steps:

a) In a complex system, the construction of a flow diagram for customers and a listing of the points at which there is a restriction on service.

b) The approximate measurements of arrival rates, service times and queuing times at the main points of congestion. This will give a general idea of the main points at which excessive congestion occurs, or at which there are service facilities which are idle for a high proportion of the time.

ii) Rough assessment of possible modifications

At this stage, we determined the possible changes that are reasonably likely to lead to an increase in efficiency or quality of service.

iii) More detailed data

In this stage, the statistical properties of the input and service time are estimated in sufficient detail to help in selecting an appropriate model and enables the giving of numerical values to the parameters in the model.

In a simple single-server queue, in which arrivals are thought to be random, it might be enough to obtain data to estimate the arrival rate, to provide a rough check on the randomness of arrivals and to estimate the frequency distribution of service time. In a complicated system where the priority approach is applied, it is necessary to make a detailed record of the behaviour of the system.

iv) The effects of modifications

At this stage, we carry out an experiment to test the effects of different types of modification. This can be done by factorial design or simulation. Few of the parameters will be assumed as remaining unchanged after modification. Parameters can be arrival dates and service time.

v) Formulation of practical recommendation

At this stage, the best solution will be chosen, based on predetermined criteria. A criterion can be a customers's waiting time exceeding say, ω_0 is not to exceed say, $\leq_0$ or service time M equal or less μ_0.

vi) Small-scale trial

Having decided in v) on a selected solution, a small-scale trial is required. This will be done in order to find those snags that could not be identified in the theoretical model. This study should be detailed as much as possible, as it will be the foundation for a final decision on modification.

vii) Full-scale practical action

The final step is the full-scale introduction of the new system. Observation of the modified system from time to time may well be advisable.

14.2. The modification of queueing systems

In bringing about a change, we aim at having gained a clear and practical advantage. In a complex system in which each individual phase passes, in turn, through several queueing points, it may be possible to re-organize the flow pattern.

Simple modifications are as follows:

i) Modification to arrivals

We may

a) Modify the total mean arrival rate by, for example, excluding some customers from service.

b) Control the arrival times of individual customers by an appointment system designed, usually, to produce regular arrivals.

c) Even-out systematic variations in arrival rate by considering more uniform flow of groups than of individual customers.

d) Arrange that customers are encouraged to join or discouraged from joining the queue, depending on the number of customers currently in the queue.

ii) Modification to service mechanism

a) Decrease the mean service time.

b) Reduce the coefficient of variation of service time.

c) Arrange for the service times to be reduced during periods of more than average congestion.

d) Increase capacity of servers.

e) Increase server availability, either on the average or by arranging that service is more likely to be available when customers are present.

iii) Modification of queue discipline

We may

a) Give priority, pre-emptive or non-pre-emptive, to "important" customers, i.e. to one for whom the cost per unit waiting time is high.

b) Give priority to customers whose service times are expected to be short.

c) Introduce into a system in which the queue discipline is not "first come, first served", a device to ensure that the probability of very long queueing times is reduced.

d) In a multi-server queue, modify the arrangement by which customers are allocated to a particular server.

NOTE FROM A. FRANCO

Giving priority to customers whose cost per unit waiting time is high, seems to be a total failure in practical application, as it leads to a situation where the majority of customers are of high priority, a situation which hurts them in the end. However, priority to customers whose service times are expected to be short, can work properly, provided that having control over the time service is given. This is implemented at present in Supermarkets ("quick counters"), Production Control and Government Offices giving a service to the people.

14.3. Notes on some sample queues

14.3.1. Basic Queues

i) Queueing System: A system where customers arriving for service remain some time in the system.

1 - server, 1 - customer - M/M/1 system



A - time between arrivals

S - service time in which every customer is served

Assuming that arrival rate is of a Poisson Distribution, with mean time between arrivals λ and service time is of exponential distribution with expected mean $1/\mu$.

The probability of completing service in time interval Δ is the probability that service time will be shorter than Δ .

$$P(s \le s) = 1 - e^{-\mu s} = 1 - \left(1 - \mu\Delta + \frac{(\mu\Delta)^2}{2!} - \frac{(\mu\Delta)^3}{3!} + \dots\right) =$$

$$\mu\Delta + O(\Delta)$$

Our population is the number of customers into the system. The rate of arrival is not the important factor, but the service level. When there are 0 customer $\mu_0 = 0$.

When $x > 0$, $\mu_x = \mu$

The theorem identifies the number of customers into the system only when there is statistical equilibrium.

$\alpha_0 = 1$

$$\alpha_x = \frac{\prod_{i=0}^{x-1} \lambda_i}{\prod_{i=1}^{x} \mu_i} = \frac{\lambda^x}{\mu^x} = \left(\frac{\lambda}{\mu}\right)^x$$

Criteria for statistical equilibrium:

$$\sum_{x=0}^{\infty} \frac{1}{\lambda_x \alpha_x} = \infty$$

$$\sum_{x=0}^{\infty} \frac{1}{\lambda\left(\frac{\lambda}{\mu}\right)^x} = \infty = \frac{1}{\lambda} \sum_{x=0}^{\infty} \left(\frac{\mu}{\lambda}\right)^x$$

This expression is so only when $\frac{\mu}{\lambda} > 1$ or $\frac{\lambda}{\mu} < 1$

which means: the average time between arrivals $E(A) = \frac{1}{\lambda}$

the average service time for customer $E(S) = \frac{1}{\mu}$

Thus, the required service time from the system:

$$\frac{\lambda t(E(s))}{t} \le 1 \longrightarrow \lambda E(s) \le 1$$

$E(S) = \frac{1}{\mu}$ thus $\frac{\lambda}{\mu} \; 1$

When $\frac{\lambda}{\mu} = 1$ the queue will increase to ∞.

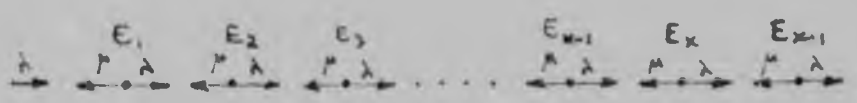
$\lambda E(S) = \rho$ = The server's busy period

$P_0 = 1-\rho$: stationary probability of having unemployed server

$$P_n = \frac{\alpha^n}{\sum_{n=0} \alpha_n} = \frac{\rho^n}{\frac{1}{1-\rho}} = (1-\rho)\rho^n$$

$$E(n) = \sum_{n=0}^{\infty} n(1-\rho)\rho^n = \frac{\rho}{1-\rho} = \underbrace{\rho}_{\text{Average number in service}} + \underbrace{\rho^2/1-\rho}_{\text{Average number in the queue}}$$

Stationary equilibrium can be illustrated as follows:



Ex-X customers in the system

Average queueing time = Average number of customers into the system X Mean time between arrivals

ii) Arrival rates and service times dependent on queue size

We shall assume for the present discussion, the following:

-($P_A(t)$ = the probability that at time $t+\delta t$ the system is in state A

-Transitions $A_n \rightarrow A_{n+1}$ are associated with a probability differential $\alpha_n \delta t$ and that transitions $A_n \rightarrow A_{n-1}$ (for $n>0$) are associated with a probability differential $\beta_n \delta t$.

-The probabilities referring to transitions in $(t, t+\delta t)$ do not depend on what happens before t.

From the equilibrium equations giving the stationary distribution of queue size we get

$$P_1 = \frac{\alpha_0}{\beta_1} P_0 \qquad P_2 = \frac{\alpha_0 \alpha_1}{\beta_1 \beta_2} P_0 \;,$$

and in general $P_n = \frac{\alpha_0 \alpha_1 \cdots \alpha_{n-1}}{\beta_1 \beta_2 \beta_3 \cdots \beta_n} P_0$,

We must choose P_0 so that $\{P_n\}$ adds correctly to unity. This will only be possible if the series

$$S = 1 + \frac{\alpha_0}{\beta_1} + \frac{\alpha_0 \alpha_1}{\beta_2} + \frac{\alpha_0 \alpha_1 \alpha_2 \cdots \alpha_{n-1}}{\beta_1 \beta_2 \beta_3 \cdots \beta_n}$$

converges to a finite value

If $S = \infty$ the customers, on average, are arriving quicker than the server can deal with them and arbitrarily large queue result.

If $S < \infty$ the stationary probability distribution of queue size is then given as:

$$P_n = S^{-1}\frac{\alpha_0\alpha_1\cdots\alpha_{n-1}}{\beta_1\beta_2\cdots\beta_n} \qquad (n=1,2\ldots),\ P_0 = S^{-1}$$

iii) Queue with m servers

n - The number of customers

m - The number of servers

if $n \geq m$; $\alpha_n = \alpha$ for all n $\quad \beta_1=\beta,\ \beta_2=2\beta$ $\beta_{m-1}=(m-1)\beta,\ \beta_n=m\beta$

if $\alpha < m\beta$

$$S = 1+\frac{\alpha}{\beta}+\frac{\alpha^2}{2!\beta^2}+\frac{\alpha^3}{3!\beta^3}+\cdots+\frac{\alpha^{m-1}}{(m-1)!\beta^{m-1}}+\frac{m^{m-1}}{(m-1)!}\sum_{n=m}^{\infty}\left(\frac{\alpha}{m\beta}\right)^n$$

if $a = \alpha(m\beta)^{-1} \Longrightarrow$

$$S = 1+(ma)+\frac{(ma)^2}{2!}+\cdots+\frac{(ma)^{m-1}}{(m-1)!}+\frac{(ma)^m}{m!(1-a)}$$

$$P_n = S^{-1}\frac{(ma)^m}{m!} \qquad (n<m)$$

$$P_n = S^{-1}\frac{m^m}{m!}a^n \qquad (n \geq m)$$

iv) Queue with limited waiting room

Suppose we have single-server, random arrivals and exponential service time, but there is no room for more than R customers to queue (including the one being served)

$$\alpha_n = \alpha \qquad (n<R)$$
$$= 0 \qquad (n \geq R)$$
$$\beta_n = \beta \qquad (n = 1,2,\ldots)$$

Customers who arrive and find no waiting room leave without service and do not return later. The S is a finite sum

$$S = 1+\frac{\alpha}{\beta}+\left(\frac{\alpha}{\beta}\right)^2+\cdots+\left(\frac{\alpha}{\beta}\right)^R$$

for

$$P_n = \frac{\left(\frac{\alpha}{\beta}\right)^n\left\{1-\frac{\alpha}{\beta}\right\}}{\left\{1-\left(\frac{\alpha}{\beta}\right)^{R+1}\right\}}$$

There are four other implications of the basic queues, but for our discussion, we will refer directly to the queues concerned with the project subject.

14.3.2. Queues with priorities

Sometimes, the queue discipline may be such that some types of customers receive priority because of high cost per unit time of waiting, loss of production in industrial cases, or because of profit consideration. We will discuss here mainly two types of priorities without complications.

i) Non-pre-emptive priority

- Each customer has priority class 1, 2 .....k
  When k priority > k-1, > k-2,.....,> 1
- A customer of class j = a j-customer with priority over j + 1...k
- Customers of different classes arrive independently at random, at rates $\alpha 1 \ldots\ldots \alpha k$ subject to:

  $$\alpha_1 + \alpha_2 + \cdots + \alpha_k = 1$$

  Then: αj = P(Particular arrival is a j-customer)
- Service time of different customers is independent and distributed B(X).
- A single-server system.

'overall' service time distribution is

$$B(x) = \sum_{j=1}^{k} \alpha_j B_j(x)$$

When b_i, α_i ... are first ... moments of $B_j(X)$ for instance, $C_j = \int_0^\infty x^2 \, d B_j(x)$

Since $\Sigma \alpha_j = 1$, the traffic intensity ρ is equal to b when $b = \Sigma \alpha_j b_j$

Now if $j = n$ customer with the same priority, the expected number of n customers in the queue as service was completed and they are going to start being served is

$$1 + \frac{\frac{1}{2}\alpha_j c}{\rho\left(1 - \sum_{i=1}^{n-1} \alpha_i b_i\right)\left(1 - \sum_{i=1}^{n} \alpha_i b_i\right)}$$

ii) First come, first served approach

If the approach is "first come, first served", then the mean queueing time Q_0;

$$Q_0 = \frac{\varepsilon \rho}{2(1-\rho)b}$$

The strategy based on service times is optimum when the service time of each customer can be predicted accurately on arrival and when it is known that future customers arrival rate $\lambda = 1$ and the distribution function of service time.

iii) Simple priority system based on service time $b_x = 2\lambda^{-2x}$

Suppose $\rho = 2^{-1}$ and that:

a) All customers whose service time $\leq \Phi\rho = 1$

b) All other customers $= 2$

Then the queueing time $Q = \frac{\varepsilon(1-\rho+\rho e^{-\rho\Phi})}{2(1-\rho)(1-\rho+\rho e^{-\Phi}+\rho\Phi e^{-\Phi})}$

If the cost per unit queueing time is equal for all customers, Φ should be chosen so that it minimizes Q.

By calculation. it can be found that the optimum Φ satisfies the equation:

$$\frac{1}{\rho} = 1 + \frac{e^{-\Phi}}{\Phi - 1}$$

Figure 13 shows the relation between and for optimum division into two priority classes

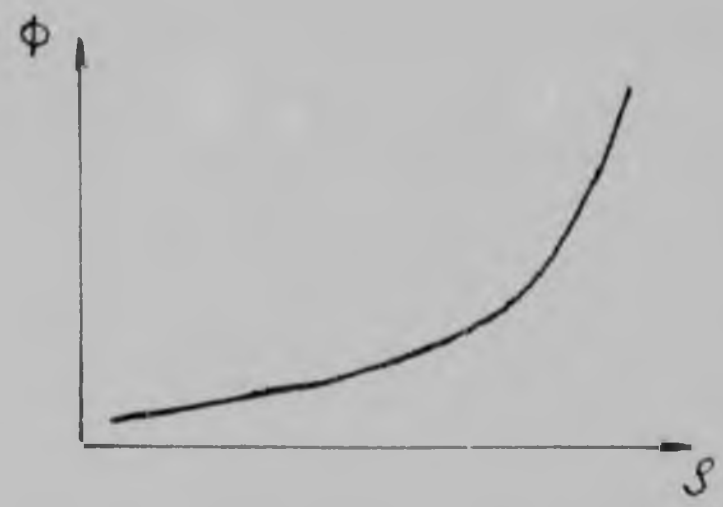


Figure 13: Relation between traffic intensity ρ and Φ (parameter determining the optimum division into two priority classes)

vi) Other implications

Other implications of the priorities approach are:

a) Pre-emptive priority: When a customer of low priority is served and one with higher priority arrives and receives the service instead of him.

b) Server availability: For a certain period the server should rest, or do other duties.

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