A METHOD FOR DEVELOPING PRODUCTION STANDARDS FOR A FOURDRINIER PAPER MACHINE PRODUCING SPECIALTY PAPER GRADES

by

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I. INTRODUCTION

The purpose of this investigation is to explore a method for developing production standards for a low-production fourdrinier paper machine (a machine for making papers in an endless sheet) producing a wide range of specialty paper products over a wide range of basis weights. Such a method could be applied for both specialty and high-production machines. Uses would include estimating production run times for production scheduling, obtaining product costs and evaluation of machine and crew performances. Many authors (2, 5, 6, 9, 10, 12, 13) have considered the problem of making these estimates using formulas describing pounds of paper produced for a given paper basis weight, ream weight, machine speed, and trim width; but the deviations of actual performances from these theoretical formulas and nomographs (5, 12, 13) have not been properly considered for a variety of reasons. This investigation is a continuation of work (1) which was started when these deviations were noticed in actual production runs. A general model, programmed in FORTRAN IV, which includes the basic variables of ream size, basis weight, actual trim width, net production in pounds, and machine speed as they interact in both theoretical and actual situations, was developed to indicate the deviations from theoretical by basis weights and by paper types. These deviations based on historical data become standards, which are comparison for daily production runs. Daily runs will then become part of the historical data on subsequent runs. Actual production data from the Hollywood Paper Machine of the Richmond Division of the Albemarle Paper Company was used with the permission of the company in this study. This machine produces a very wide range of specialty papers on a relatively low production basis; and it was hoped that general concepts could be developed which could apply to similar machines as well as those producing relatively few paper types in high production.

Theoretical production of a fourdrinier paper machine may be described by:

$$P = \frac{720\ D\ S\ W}{r\ d\ L} \qquad (10)$$

where:
- D = width of the sheet (actual trim) in inches
- S = machine speed in feet per minute
- W = weight of one ream of paper in pounds
- r = ream count in sheets of paper per ream
- d = width of a ream sheet in inches
- L = length of a ream·sheet in inches
- P = production in pounds per hour
- 720 = conversion factor for feet per minute to pounds per hour.

In order to agree with the practice at the Hollywood Mill the standard ream sheet size will be taken to be 24 inches wide by 36 inches long and a standard ream will consist of 500 sheets of paper.

Where the company practice differed from this standard, primarily on blotting grades where a 19 x 24, 500 count, ream was used, the appropriate conversions were made to a 24 x 36, 500 count, ream. Therefore, the general formula may be reduced to:

$$P = \frac{720\ D\ S\ W}{(500)(24)(36)} = \frac{D\ S\ W}{600}\ .$$

Since the production is desired in pounds per inch per hour, the formula becomes:

$$P' = \frac{S\ W}{600}\ .$$

where: P' = production in pounds/inch/hour.

If all the appropriate variables could be instantaneously measured as the paper is produced, this formula would give results which would exactly compare with actual production. However, this is not possible with present instrumentation. Measuring procedures will vary from company to company and from production run to production run within companies depending on many factors such as TAPPI requirements, customer specifications, paper types, testing costs and so forth. Therefore, the data to be used in the formula is subject to error and its use will indicate production that differs from the actual production as some function of these errors. Various papers have their own particular operating problems as well, which are difficult to quantify and which will affect the net production.

By separating papers into groups of similiar running characteristics for simplicity, the deviations of actual production of net pounds of paper from the amount predicted by the formula for each basis weight in each group may be determined.

This investigation, of course, applies only to one particular machine but the methodology developed could, with minor modifications, be adapted to production of paper on any fourdrinier machine. As paper runs and types become highly consistent, deviations from theoretical should lessen.

II. REVIEW OF LITERATURE

A review of the literature reveals that some work has been done in the area of the theoretical formula describing the production of a fourdrinier paper machine (2, 5, 6, 9, 10, 12, 13). Various formulas, all based on the one general formula, have been developed as needed in particular situations. Davis (5) has developed a nomograph based on the formula for the rate of production for kraft papers for ream data of 24 x 36 inches, 500 count, and a general one for a wide variety of ream definitions. His general nomograph has been reproduced (13) for pulp and paper manufacturers. The Technical Association of the Pulp and Paper Industry (TAPPI) has also issued a series of nomographs for determining production involving various ream sizes and basis weights as expressed in both English and metric units (12).

However, no information could be located describing deviations from the theoretical in actual running situations. Doane (6) has expressed one approach to figuring paper machine efficiency, which ties in to this approach. He states that "the instant a machine commences an order to the time another order is started, the theoretical production is calculated using the total time at the basis weight, speed, and deckle run. This, divided into the actual tonnage times 100 is the per cent efficiency." (6). Other work in this area may have been done by various paper companies; but such work is normally restricted to the companies concerned and no other material could be found in the published literature.

An unpublished report (1) prepared for and owned by the Albemarle Paper Company of Richmond, Virginia dealt with the problem to a limited extent and led to further investigation as reported here.

III. A BRIEF DESCRIPTION OF A FOURDRINIER PAPER MACHINE

Paper produced on a fourdrinier paper machine is a homogenous formation of primarily cellulose fibers which are formed in water suspension on the machine wire and bound together by weaving of the fibers and bonding agents. The paper is produced in a continuous sheet. There are a wide variety of fourdrinier paper machines from relatively slow and narrow machines, which are generally used in the manufacture of high-quality papers (the Hollywood machine falls into this general classification), to those high-production machines used in the manufacture of kraft papers, tissues, or newsprint. They roughly range in size from 30 to 320 inches as expressed as the width of the wire and in speeds from below 100 f.p.m. to over 2,500 f.p.m. (10). As the size and speeds increase, the machines tend to become more simple and are generally used to make only a narrow range of products.

A glossary of some paper mill terms is given in Appendix J; and a rough schematic of a fourdrinier paper machine is given in Appendix K.

At the "wet end" of the machine is the headbox (or in some older machines, a flow box or a breast box), which has the purpose of distributing the "stuff" (wood pulp, chemicals, water, and other ingredients of the paper) in a uniform sheet on a moving wire. The wire is one of the most delicate and expensive parts of the machine equipment and is composed of a sheet of fine wire gauze joined by a seam to form a continuous band. The wire type and construction varies from application to application. It moves in the machine direction as the "stuff" is deposited upon it allowing the water to pass through it. This causes the various solids in the "stuff" to settle on the wire in a mat. Shaking the wire in a cross-machine direction, suction, and other mechanical processes aid the paper-maker in establishing the manner in which the paper is formed on the wire, which is a very crucial stage in the process and in the quality of the final product. In effect, the wire is simply a filter for removing the water and receiving the fiber deposit upon its surface. The wire is supported by a series of large rolls. The breast roll is located at the headbox and the couch roll (usually with suction capabilities to draw off excess water) is located at the end of the wire and is the driver to power the wire. Wire speed must be carefully coordinated with the rest of the machine operations and speeds which vary along the length of the machine. In addition, a series of other rolls guide the wire as well as keep it taut and smooth. Table rolls, for example, aid in supporting the wire from the breast roll to the suction boxes located under the wire.

They also aid in the removal of water by their mechanical actions on the wire. After passing the couch roll, the continuous sheet is for the first time in a condition to support itself for short spans. Then the paper is usually passed through a series of press rolls and felts or suction press rolls to squeeze more water from the sheet before entering the drier sections of the machine. The term fourdrinier originally dealt with the "wet end" of the machine, which comprised the headbox, wire, and press sections; but its usage today implies the entire machine to include drying and calendering sections and the final take-up reel on which the continuous paper sheet is wound. (9).

Having pressed as much water out of the sheet as possible, there still remains approximately 64 to 72 per cent of water to remove from the paper in order to obtain the desired final product. This is accomplished by running the paper over steam-heated cylinders. The Hollywood machine in addition has a special oven attachment above the dryer sections through which certain grades may be run for more rapid or special drying. The drying cylinders normally vary in size from three feet to six feet in diameter, and steam temperatures and pressures also vary somewhat. The paper is guided through this section and pressed to the dryers by dryer felts, which are continuous felt webs of cotton, wool, or some other fiber. Of course, the felts pick up a considerable amount of moisture in this process and they must be kept evenly and properly dried to keep the paper from having moisture streaks. The dryer rolls and felts must also be kept clean since they could imprint impurities on the paper passing over them.

Calender rolls impart the final finish on the paper as well as determining the final thickness of the paper (caliper) to a certain extent. These rolls may not be used on all papers, of course. After leaving these rolls, which resemble a stack of wringers on an old washing machine, the paper is wound on a reel and then re-wound to a uniform tension. In the re-winding process the paper is cut to various size rolls in both diameter and width as required. This becomes the net production from the machine.

The qualities as well as the production rate of the final paper are determined by many factors, machine conditions, and external conditions such as atmospheric heat and humidity. Unfortunately, too little is known in the present state of the paper-making art about many variables affecting the process much less how they interact. Those under the control of the paper-maker are carefully regulated in order to obtain the desired final product, which is then tested to ascertain how closely the desired specifications were met.

With the speed of the wire being held constant the thickness of the sheet and its weight may be increased by increasing the flow of the "stuff" from the headbox on the wire. Similiarly, by holding the flow from the headbox constant, a decrease in the speed of the wire will result in a larger buildup of "stuff" on the wire and a correspondingly thicker sheet. Hundreds of adjustments must be made on these huge machines to obtain a particular desired product.

In the past and even today papermaking has tended to be an art with much reliance on the machine tender's abilities to adjust the machine according to his experience, feelings, and so forth. There is an increasing trend towards making quantitative rather than qualitative decisions concerning the process and machine settings. However, for many reasons paper making is still highly qualitative in nature, making some studies of the machine and the process somewhat difficult if not impossible today. As required instrumentation is improved or developed, the trend away from the papermaking art to the papermaking science will continue.

IV. DIFFICULTIES IN COLLECTING DATA AND ERROR SOURCES IN THE DATA

Much of the desired data for this study was not available when it was first initiated in the spring of 1967 and initial work had to be based largely on inferences from various charts describing the actions of the Hollywood machine (1). For example, run times on various grades were either missing or highly suspect; however, automatically recorded charts were available which gave the times the machine was running and approximated the times the machine was producing a certain grade. Data gathered in this manner over one year of production was used in the initial study as better data recording procedures were established. Based on the initial study and the experience of those in charge of the machine and its operations, almost 200 different grades of papers were reduced to six major groups with similar operating characteristics. These six major groupings are in present use in the Albemarle Paper Company (Appendix I) and will therefore be used in this study. Only four months of data is considered here due to restrictions placed by the Company.

Despite new recording procedures and stress to workmen by supervisors on the necessity of accuracy, some of the data in this study, if not all, is suspect and must be considered in that light.

The primary information bits required in this study were:

The grade name,

The grade code (APPENDIX I),

The basis weight (laboratory determined on a 24 x 36 inches, 500 count, basis),

The final trim width in inches,

The machine speed in feet per minute (speed of the wire),

The actual run time (disregarding set-up times, and time spent producing bad paper),

The pounds of net production.

However, the basis weights were not always tested for each paper, since some customers did not specify basis weight tolerances. Therefore, in those cases the nominal (aimed for) basis weight was recorded and not the result of a test. In addition, the laboratory procedure varied from paper to paper depending on TAPPI, customer, and plant requirements; but in no case was it on a continuous basis. At best, it was a test per reel of paper. Even those measurements carried out in accordance with TAPPI Standards produced results that were subject to error. TAPPI Standard, T 410 os-61 (11) states that not less than ten sheets representative of the shipment, each of at least 500 square centemeters (80 square inches) in area, and for paperboard, not less than five representative sheets each at least one square foot in area were to be used in the testing for basis weight. Each sheet is to be weighed under standard TAPPI conditions and the average weight is then calculated. The basis weight, which is a measure of the weight of 500 sheets measuring 24 x 36 inches in this case was obtained by multiplying the average sheet weight by 500. Of course, there is an obvious source of error in this testing procedure since only a few sheets are weighed and any error in the measurement will be compounded by the multiplying factor used to find the basis weight (2).

The trim width of the final roll is subject to little error and may be regarded as accurate.

The speed of the wire in feet per minute was recorded hourly (or by product if the run was less than an hour) by the machine tender from an instrument resembling a speedometer on an automobile. This could give only instantaneous readings, of course, and left no permanent record that could be checked. In addition, the speeds for a given production run, if that run was greater than one hour, were averaged based on the reported hourly readings. The machine tender, however, kept a careful watch on the instrument and made adjustments on the machine as required so that the speed of the machine as recorded may be assumed to be relatively accurate.

The net production was used in this study since, due to the pecularities of the particular machine, the rewinding operation could not be separated from the first winding operation with a scale between them to record the gross production. This could mean that paper may have been produced and thought to be good by the machine tender and the run time recorded accordingly; but a section could be found to be bad upon rewinding and therefore cut out of the reel thereby reducing the final weight. The net production then recorded would be based on the actual paper that was available to be sold while in that case the run time would be based on the production in total including that which was discarded. Attempts to prevent this from happening were made but it is possible that such a situation may have occurred and there is no means of accurately checking for it now.

In addition, the workmen recording some of the information tended to be men accustomed to the art rather than the science of papermaking. They could not see the importance of recording the information as long as they were making salable paper.

All of these errors, if they exist in a given run, tend to confound the results, although some of them might tend to cancel each other out. Since the calculations of theoretical production from the formulas depend on the recorded data, they are subject to error as are the calculations of the actual net production in pounds per inch per hour. The formula was, as stated before, based upon the assumption that the basis weight and other variables are exactly correct and remain constant. "Up to the present time this has been found to be impossible, due to the many variables in the papermaking process that have not been brought under control". (10).

In the study of the data those with obvious errors such as incomplete recordings, actual production greater than theoretically possible, and so on were discarded. In addition, a fraction defective control chart was applied to the remainder (Chapter VI) in order to further eliminate questionable data. Of course, some bad data may remain but this could not be identified. This is no fault of this study, only of the manner in which data was recorded by the production personnel in the plant. Better instrumentation and recording accuracy would aid in future studies as well as in the papermaking process itself.

V. BRIEF HISTORY OF THE HOLLYWOOD MACHINE AND MILL (9)

The Hollywood Mill and 80 inch fourdrinier paper machine were built in 1888 to serve as a blotting mill to provide the paper which was in great demand at that time. Due to a number of reasons the market for blotting grades of papers dropped off in the 1930's and the mill started to manufacture various kraft grades to take up the slack. However, due to the introduction into the South of many large, high-production kraft machines in the 1940's, the low-production Hollywood mill and machine were at a considerable competitive disadvantage, and the income from the blotting grades was not enough to offset the rising losses on kraft. In early 1950 due to these losses, a lack of capital, and several other reasons, the mill was put on the market. However, top management, upon reviewing the potential of the mill in the specialty paper field, withdrew the offer and added high grade specialty papers to the line of products produced on the machine and processed in the mill.

As profits from the operations increased, management felt justified in making large capital expenditures to update and improve the machine and supporting equipment. These capital additions were to a large extent aimed at improving not only the general running capabilities of the machine but also making it possible to run effectively a very wide range of specialty paper grades. These improvements have continued to the present making the Hollywood machine unique in the paper industry in both appearance and capabilities.

As new demands for various specialty papers such as those used in filters appear, the machine is used in experimental work to determine how to make the new paper and what, if any, machine modifications may be necessary. As a result, today the Hollywood machine is producing the widest range of paper products in the world according to the mill manager. A very rough breakdown of the present product mix is

Blotting	- 25%
Kraft	- 25%
Specialties	- 50%
	100% .

The actual breakdown is very difficult to determine since some of the orders are experimental, some are one-time only orders, and some occur on a very infrequent and irregular basis. In general a rough estimate of the different grades produced at present would be approximately 200.

Operating over such a wide spectrum causes fluctuations in the machine output, costs, and profits. For example, the mill normally operates on a seven-day week, twenty-four hours per day, and is capable of producing from approximately 20,000 to 75,000 pounds of salable paper per day depending upon the grades and product mix.

With such a wide range of products and product mix to say nothing of the various sizes of orders the costs associated with producing a particular grade on a particular production run are very difficult to determine at the present time. In addition the furnish (ingredients of the paper) costs per ton vary widely from one grade to another. In general the mill personnel do not know, nor does management, what a particular paper costs to make and what loss or profit may be associated with it. Therefore, the development of production standards as part of a standard cost accounting procedure becomes desirable.

Such standards, once tested and verified, are invaluable to the accounting function, are an aid in the scheduling of the machine, aid in evaluation of improvements on the machine, and help in evaluations of machine and crew performances.

With a wide product range and mix the Hollywood machine is ideal for a study from one viewpoint, since it is operating over a wide spectrum while most paper machines operate on a very few grades. This would make it more difficult to draw general conclusions from a study of them.

However, dealing with such a wide product range has many drawbacks. The needed data in some areas is very limited since only one or two runs of a particular paper may be made per year or even less frequently and some grades are made in very small quantities on short production runs. These can tend to confound and cloud the actual characteristics and make a study most difficult.

After preliminary studies for the development of standards for production were made in the spring of 1967, they were put into use on a temporary test basis and proved to be relatively accurate in predicting and evaluating machine capabilities. Based on this initial success, further investigation and work in the area was desired. In addition, a computer adapted procedure was desirable from management's viewpoint. Therefore, this study was initiated and should provide many answers and ideas for future work.

VI. INVESTIGATION

The period for this study was from August 1, 1967, to December 1, 1967, which was selected and limited by Albemarle Paper Company personnel. The time period is actually too short however, and data for a longer period should be used in any follow-up studies. A new headbox was installed on the machine in the summer of 1967, which changed many of the running characteristics of the machine making it impossible to use data prior to this study period. Personnel of the company did not want to release production data dealing with runs after December 1st. The standards developed here deal strictly with historical running experiences on salable paper.

As described in Chapter I, the theoretical production in pounds per inch per hour on the Hollywood machine using a ream size of 24 x 36 inches, 500 count, can be described by:

$$P' = \frac{S\ W}{600}$$

where: P' = net production in pounds/inch/hour
S = machine speed in feet per minute
W = basis weight in pounds
600 = conversion factors

In the investigation of historical production data it was noted that the actual production in pounds of net salable paper per inch of actual trim per hour of production was less than the amount given by the formula. From prior studies in the Albemarle Paper Company (1) the large number of paper grades produced were separated into six major groups having similar characteristics (See APPENDIX I).

It was decided to write a FORTRAN IV program (APPENDIX A) capable of accepting data on up to 400 past production runs in the order that the runs were made (APPENDIX D shows the data used), and establishing production standards on this historical basis. APPENDIX D contains the grade (or group number), the basis weight, the width of trim in inches, the machine speed in feet per minute, the running time in hours and minutes, and the net production in pounds. The program combines the data into the six major groups by ascending order of basis weights. Based upon pounds of production and associated speeds the weighted average speeds for each group and basis weight are then calculated. These become the historical or standard speeds in feet per minute. The historical weighted average net pounds per inch per hour is then found in the same manner and becomes standard. Based upon each final weighted average speed, theoretical production is calculated using the formula just developed. The deviation of the weighted average production from this theoretical figure was then obtained (this may be converted to a per cent by multiplying by 100). Since a qualitative measure of the accuracy of these standards is the number of production runs in each one, the number of these runs was also shown in the computer output under the column called "COUNT" (APPENDIX F). The standards thus developed by the computer sub-program, "STDS", based upon the raw historical data of four months of production are shown in APPENDIX F.

Since it was realized from the start that some of the base data had been erroneously recorded by the Hollywood Mill production personnel, the deviation from theoretical columns were checked for any deviations shown as being negative, which would indicate an actual production greater than theoretically possible based upon the data. Whenever such points were noted, they were checked carefully and eliminated prior to the final computer run in this report. This corresponds to eliminating points falling below a lower control limit on a fraction defective control chart as will be discussed later. Twenty-four such production runs were eliminated from the four month study period. In addition the deviations might be expected to fall within some general grouping under normal operating conditions and those exceeding such a grouping would indicate either errors in recording the data or some other assignable cause. Since determining assignable causes was impossible at this time, a statistical quality control chart for attributes was felt to offer an approach to further eliminate abnormal deviations.

Many quality characteristics can be classified only by placing them into two groups - those conforming to the specifications and those not conforming - which may be termed classification by attributes. The control charts associated with this type of classification are called control charts for fraction defective and are used as a tool to disclose the presence of assignable causes of variation in some sampling procedure (8). The fraction defective, p, may be defined as the ratio of the number of defective items found in an inspection to the total number of articles actually inspected; and this is normally expressed as a decimal fraction although this is often converted to a per cent defective.

Since p is described by the number defective in a certain sample size, n, it may be described as:

$$p = \text{number defective} / \text{number inspected}.$$

The standard deviation, sigma, of the fraction defective is given by:

$$\text{sigma} = \sqrt{p' \ (1 - p') \ / \ n} \qquad (8)$$

where p' is the actual fraction defective and is assumed to be represented by the observed fraction defective average, $\bar{p}$. For the case here a three sigma upper control limit was decided on and therefore the upper control limit becomes:

$$UCL = \bar{p} + 3 \text{ sigma}$$

The lower control limit, LCL, will not be used here as will be explained later. The assumption of p' being accurately represented by $\bar{p}$ rests on all fraction defectives falling within the control limits. However, judgement may rule in favor of this assumption despite there being points outside the limits (8).

The rational process of the fraction defective control charts was felt to offer the best tool for the elimination of questionable data. In order to adapt the situation in this problem to analysis by such a method several assumptions had to be made. The first major assumption made was that the deviation from theoretical for each group and basis weight within the group could be considered to be a fraction defective, since it was a deviation from a desired value, Secondly, the n value for the situation for each group would be the total number of points (the total of the "COUNT" column in the output as shown in APPENDIX F) within that group. With these assumptions and the assumption that any points falling outside the control limits would not affect the consideration of $\bar{p}$ approximating p' the fraction defective for each group would become the sum of all the deviations from theoretical for each group divided by the sum of the

"COUNT" column for that group. This would give $\bar{p}$. The upper control limit, UCL, is also developed. A large deviation indicates production far below the theoretically expected production. Since those above the theoretical values (below a LCL of zero) had already been eliminated, a LCL is not shown. Therefore, any deviation from theoretical which is greater than the UCL would be suspect of having some assignable cause such as an error in recording the base data and would therefore be checked and discarded as necessary. Individual checking was necessary since a particular deviation may have resulted from the combined data from several production runs and all of them may not have been questionable.

This procedure was followed and seventeen items were discovered to have deviations greater than their respective upper control limits and were therefore eliminated. This brought to total forty-one questionable production runs that were discarded from this study, but this in no way implies that the remaining data is to be trusted without question. This procedure has only eliminated those runs having obviously questionable data.

The items thus eliminated were done on a prior computer run and therefore do not show up in this report either in the raw historical data in APPENDIX D or in the final standards in APPENDIX F. However, once the initial questionable data was discarded and another run was made on the computer, a new $\bar{p}$ was developed as shown on the output in APPENDIX F along with the corresponding upper control limit, UCL. This was included in the final output for this study as a demonstration of how the program works. The UCL shown in this report should not be applied to the deviations from theoretical again. The plots of the <u>original</u> $\bar{p}$ and <u>original</u> UCL with <u>all</u> the deviations are shown in APPENDIX G. From these fraction defective control charts in APPENDIX G the points outside the UCL were checked and eliminated as required and therefore do not show up in the final standards.

The final standards information (APPENDIX F) as developed after the elimination of the questionable data was also plotted. The weighted average speeds (standard speeds) and the corresponding theoretical productions are shown on the six graphs in APPENDIX H. The machine speeds for each group in general follow a curve similar to a negative exponential and the curves for the corresponding theoretical productions form curves "mirroring" the speed curves. It should be noted that the curves are not smooth since many factors would cause slight deviations and would depend on the particular conditions on the paper machine during the run(s). Whenever a speed deviation from the expected smooth curve is noted, a corresponding deviation is noted in the theoretical production as would be expected. The apparently larger deviations are simply due to the particular scales used. The deviations of the actual production from the theoretical production were already plotted in the fraction defective control charts for the previous run and were not plotted again for this reason. The weighted average productions (standard productions) are shown in the "STANDARD NET PRODUCTION" column of APPENDIX F.

The program was so designed that up to ten production runs for a given day could be compared with the historical standards in order to determine how close they were met. The actual data for the production runs of December 1, 1967, as shown in APPENDIX B, was entered. In addition three pieces of dummy information in group six were entered in order to demonstrate other features of the program. The final raw input data is shown in APPENDIX C. This data was sorted into ascending order by groups and had the theoretical production for each run calculated based on reported speed and basis weight. The deviation from the theoretical for each production run was then found and compared with the historical deviation as determined in the standards. Comparing deviations rather than production was felt to be more valid due to speed changes on individual runs. Such changes should not affect the deviations as much as the production. The final output is shown in APPENDIX E. The three dummy inputs in group six have basis weights falling below, above, and between known points in the group six production standards. When falling below or above, no standards could be computed and the output indicates "------" for standard speed, standard deviation, and difference. It also signals the fact that the point was outside the historical range by printing "NOT IN STANDARDS". The point falling between known points had its values compared with a historical standard based on a linear interpolation between two known points of weighted average speeds and two known points of weighted average productions. In the "DIFFERENCE" column a negative difference indicates that the run for that particular grade had fallen below the historical standard deviation. Such is the case for the sack grade (code 0506) as shown. In addition, any deviation from theoretical that is greater than the corresponding UCL in the standards could be easily checked and therefore signal that an investigation for an assignable cause is necessary.

Since each basis weight in each group may have its particular running characteristics and problems, the discrete method developed was felt to be superior to that of attempting to work with smooth, continuous curves for either speeds, theoretical productions, or actual productions. With more data than was used in this investigation it may be expected that the various curves would tend to smooth out somewhat.

RECOMMENDATIONS FOR FURTHER WORK

This study was concerned with a low-production specialty paper machine with many unique characteristics. Every specialty mill is somewhat unique unto itself but it is not inconceivable that the general approach developed in this study could, with minor modifications, be applied to other paper machines of this type and to those involved in high-production of only a few products.

Since considerable difficulty was encountered in this study with questionable data, the procedures for obtaining the data should be carefully reviewed in order to eliminate as much of the bad as possible before starting the studies. Data for a fairly long period should be used, if possible, in order to obtain the best results. Of course, caution should be used in order that data before and after major machine modifications would not be mixed.

If used in actual practice, updating procedures should be incorporated either in the program or in the data processing prior to the computer run. For example, only the more recent data for each basis weight in each group should be used to aid in keeping the standards abreast of the machine capabilities. Many of the features in the program in APPENDIX A could be eliminated with a careful data processing procedure in actual practice and thereby reduce the computer processing time considerably.

As the standards are developed in actual practice, the runs from each day then become additions to the historical data for use in the next computer run and standards development.

EXAMPLE PRODUCTION PROBLEM

The following simple example shows how the standards in APPENDIX F could be used by production personnel in making an estimate of machine running time on a particular order of paper.

An order for 20,000 pounds of 189 pound basis weight Verigood blotting paper is to be made in 35 inch wide rolls. How long will it take to produce the order?

By checking in APPENDIX I, the product code for Verigood is found to be 0113, which places it in Production Standards Group 01 as found in APPENDIX F. By checking down the basis weight column for 189 pound paper, it is found that the standard speed at which the paper has been produced is 153 feet per minute so the initial machine setup should be at that speed. The standard production is 46.03 pounds/inch/hour. Since the Hollywood machine is able to produce an eighty inch wide sheet of paper, the required 35 inch wide rolls could be made from a final trim width of 70 inches. This would mean that the machine should produce

(70 inches) (46.03 pounds/inch/hour)

or 3,222.1 pounds per hour. This would indicate a run time on the order of

(20,000 pounds)/(3,222.1 pounds/hour)

or 6.21 hours.

VII. SUMMARY AND CONCLUSIONS

The purpose of this study was to explore a method for developing and setting production standards for a low-production fourdrinier paper machine producing a wide range of specialty paper types over a wide range of basis weights. The approach was based primarily on noted deviations of actual production from production indicated from the application of the formula (or nomograph) describing the theoretical production possible.

The study clearly shows that the theoretical production was not met in any case although this was due to a variety of reasons such as the inability of making the calculations based on continuous, accurate basis weight values and machine running speed values. The deviations of the actual from the theoretical were shown to vary somewhat from basis weight to basis weight as well as between the six major groups. In general the plot of machine speeds was similar to a negative exponential curve and the corresponding theoretical productions formed curves mirroring them.

Using FORTRAN IV on an IBM 360, a program capable of accepting and analyzing historical data in order to develop production standards was developed. The program is also capable of comparing production runs on a particular day with the historical standards.

With minor changes such a program and approach should be able to be applied in not only the particular situation under study but in other specialty mills and in high-production mills using the fourdrinier paper machine.

The final computer outputs indicate production standards and provide a means of comparing production runs against them. They also provide a means of pointing out questionable runs, which should then be checked out for assignable causes. The standards would provide a basis for standard cost accounting by product and by run in addition to other benefits such as providing a measure of crew and machine performances. Changes in the machine could also be quickly checked as to their effectiveness. New products could be more accurately priced with such a costing system in operation; and products being made at a loss could be more easily identified. Other advantages could be derived from a good, tested production standards procedure such as was developed in this investigation.

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APPENDIX A

LISTING OF PROGRAMS

```
C
      INTEGER GRADE, C
      REAL M, MIN
      DIMENSION GRADE(10), BASIS(10), TRIM(10), SPEED(10), HR(10),
     1          MIN(10), PROD(10), ACPROD(10), ATPROD(10), DEVIAT(10),
     2          TIME(10), NAME(10), M(10), TOTL(6)
      DIMENSION BW(6,400), AVGSP(6,100), AVPROD(6,100), THPROD(6,100),
     1          PERCNT(6,100), STDNET(6,100), COUNT(6,100), DIFF(6,100)
      EQUIVALENCE (MIN,M), (HR,TIME)
      COMMON BW, AVGSP, AVPROD, THPROD, PERCNT, TOTL, COUNT
C     READ UP TO 10 TYPES OF PAPERS FOR ONE DAY OF PRODUCTION.
      DO 10 IJ=1,10
      READ (5,1000) GRADE(IJ), NAME(IJ), BASIS(IJ), TRIM(IJ), SPEED(IJ),
     1              HR(IJ), MIN(IJ), PROD(IJ)
      IF (GRADE(IJ).EQ.00) GO TO 11
      N = 10
   10 CONTINUE
      GO TO 12
   11 N = IJ - 1
C     WRITE OUT RAW INPUT DATA FOR PRODUCTION RUN OF THAT DAY.
   12 WRITE (6,100)
  100 FORMAT (1H1,22HRAW INPUT DATA FOR DAY,//,1X,5HGRADE,4X,4HNAME,4X,
     1        9HBASIS WT.,4X,8HIN. TRIM,4X,5HSPEED,4X,5HHOURS,4X,4HMIN.,
     2        4X,10HPRODUCTION,//)
      DO 200 I = 1,N
      WRITE (6,300) GRADE(I), NAME(I), BASIS(I), TRIM(I), SPEED(I),
     1              HR(I), MIN(I), PROD(I)
  200 CONTINUE
  300 FORMAT (2X,I3,5X,I3,6X,F5.0,7X,F6.2,6X,F5.0,3X,F4.0,6X,F4.0,4X,
     1        F8.0)
C     CONVERT HOURS AND MINUTES TO DECIMAL PARTS OF HOURS.
   13 DO 20 I=1,N
      M(I) = MIN(I) / 60.
      TIME(I) = HR(I) + M(I)
   20 CONTINUE
C     PUT ALL DATA INTO ASCENDING ORDER BY PAPER GRADES.
      DO 30 I=1,N
      IP1 = I + 1
      IF(IP1.GT.N) GO TO 30
      DO 30 J=IP1,N
      IF (GRADE(I).LE.GRADE(J)) GO TO 30
      TEMP1 = GRADE(I)
      TEMP2 = NAME(I)
      TEMP3 = BASIS(I)
      TEMP4 = TRIM(I)
      TEMP5 = SPEED(I)
      TEMP6 = TIME(I)
      TEMP7 = PROD(I)
```

```
      GRADE(I) = GRADE(J)
      NAME(I) = NAME(J)
      BASIS(I) = BASIS(J)
      TRIM(I) = TRIM(J)
      SPEED(I) = SPEED(J)
      TIME(I) = TIME(J)
      PROD(I) = PROD(J)
      GRADE(J) = TEMP1
      NAME(J) = TEMP2
      BASIS(J) = TEMP3
      TRIM(J) = TEMP4
      SPEED(J) = TEMP5
      TIME(J) = TEMP6
      PROD(J) = TEMP7
   30 CONTINUE
      DO 40 I=1,N
C     COMPUTE LBS PER INCH PER HOUR FOR EACH RUN.
      ACPROD(I) = PROD(I) / TRIM(I) / TIME(I)
C     COMPUTE THEORETICAL LBS PER IN. PER HR. BASED ON SPEED.
      ATPROD(I) = (SPEED(I) * BASIS(I)) / 600.
C     COMPUTE PERCENT DEVIATION OF ACTUAL FROM THEORETICAL.
      DEVIAT(I) = (ATPROD(I) - ACPROD(I)) / ATPROD(I)
   40 CONTINUE
C     CALL SUBROUTINE STDS TO COMPUTE STANDARDS.
      CALL STDS
      WRITE (6,2000)
C     COMPARE NEW DATA WITH STANDARDS.
   41 DO 50 I=1,N
      J = 1
      C = 01
   42 IF (GRADE(I).EQ.C) GO TO 43
      C = C + 01
      J = J + 1
      GO TO 42
   43 JX = TOTL(J)
      K = 1
   44 IF (BASIS(I).EQ.BW(J,K)) GO TO 45
      IF (BASIS(I).LT.BW(J,K)) GO TO 46
      IF (BASIS(I).GT.BW(J,K)) GO TO 47
C     COMPUTE STANDARD NET PRODUCTION FOR INPUT RUN.
   45 DIFF(J,K) = PERCNT(J,K) - DEVIAT(I)
      WRITE (6,3000) GRADE(I), NAME(I), BASIS(I), TRIM(I), SPEED(I),
     1               AVGSP(J,K), TIME(I), ACPROD(I), DEVIAT(I),
     2               PERCNT(J,K), DIFF(J,K), PROD(I)
      GO TO 50
   46 WRITE (6,4000) GRADE(I), NAME(I), BASIS(I), TRIM(I), SPEED(I),
     1               TIME(I), ACPROD(I), DEVIAT(I), PROD(I)
      GO TO 50
```

```
   47 IF (BASIS(I).LT.BW(J,JX)) GO TO 48
      WRITE (6,4000) GRADE(I), NAME(I), BASIS(I), TRIM(I), SPEED(I),
     1               TIME(I), ACPROD(I), DEVIAT(I), PROD(I)
      GO TO 50
   48 IF (BASIS(I).LT.BW(J,K+1)) GO TO 49
      K = K + 1
      GO TO 44
C     LINEAR INTERPOLATION BETWEEN TWO KNOWN STANDARDS TO FIND SPEED.
   49 US = AVGSP(J,K+1) - (((BW(J,K+1) - BASIS(I)) * (AVGSP(J,K+1) -
     1     AVGSP(J,K))) / (BW(J,K+1) - BW(J,K)))
C     COMPUTE THEORETICAL LBS PER IN. PER HR. BASED ON SPEED.
      TP = (US * BASIS(I)) / 600.
C     LINEAR INTERPOLATION BETWEEN TWO KNOWN STANDARDS TO FIND PRODUCTION.
      SAP = AVPROD(J,K+1)-(((BW(J,K+1)-BASIS(I))*(AVPROD(J,K+1)-
     1    AVPROD(J,K))) / (BW(J,K+1)-BW(J,K)))
C     COMPUTE PERCENT DEVIATION OF ACTUAL FROM THEORETICAL.
      PC = (TP - SAP) / TP
      DIFFER = PC - DEVIAT(I)
      WRITE (6,3000) GRADE(I), NAME(I), BASIS(I), TRIM(I), SPEED(I), US,
     1               TIME(I), ACPROD(I), DEVIAT(I), PC, DIFFER, PROD(I)
   50 CONTINUE
C     WRITE OUT FINAL STANDARDS INFORMATION.
      JG = 00
      DO 60 J=1,6
      TPCNT = 0.
      TCNT = 0.
      WRITE (6,5000)
      JG = JG + 01
      JX = TOTL(J)
      DO 59 K=1,JX
      WRITE (6,6000) JG, BW(J,K), AVGSP(J,K), AVPROD(J,K), THPROD(J,K),
     1               PERCNT(J,K), COUNT(J,K)
      IF (K.EQ.48.OR.K.EQ.96) WRITE (6,5000)
      TPCNT = (COUNT(J,K) * PERCNT(J,K)) + TPCNT
      TCNT = COUNT(J,K) + TCNT
   59 CONTINUE
C     COMPUTE VALUES FOR P CONTROL CHART FOR PERCENT DEVIATIONS.
      PBAR = TPCNT / TCNT
      SIGMA = ((PBAR * (1.-PBAR))/TCNT)**.5
      UCL = PBAR + (3.)*(SIGMA)
      WRITE (6,7000) TPCNT, TCNT, PBAR, UCL
   60 CONTINUE
      CALL EXIT
 1000 FORMAT (I2,I2,2X,F3.0,2X, F5.2, 2X, F3.0, 2X, F2.0, F2.0, 2X,F6.0)
 2000 FORMAT (1H1,16HDAILY PRODUCTION,///9X,5HBASIS,3X,6HINCHES,2X,5HSPE
     1ED,3X,8HSTANDARD,3X,4HTIME,3X,10HPRODUCTION,2X,9HDEVIATION,2X,8HST
     2ANDARD,16X,7HLBS NET,/,1X,5HGRADE,3X,6HWEIGHT,3X,4HTRIM,3X,6HF.P.M
     3.,3X,5HSPEED,5X,4HHRS.,3X,9HLBS/IN/HR,3X,8HFROM TH.,3X,9HDEVIATION
```

```
     4,2X,10HDIFFERENCE,2X,10HPRODUCTION,/,9X,7H(24X36),//)
3000 FORMAT (1X,I2,I2,3X,F5.0,3X,F6.2,3X,F5.0,4X,F5.0,3X,F6.2,4X,F6.2,
    15X,F7.4,4X,F7.4,5X,F7.4,4X,F8.0)
4000 FORMAT (1X,I2,I2,3X,F5.0,3X,F6.2,3X,F5.0,4X,5H-----,3X,F6.2,4XF6.2
    1,5XF7.4,5X,6H------,6X,6H------,4X,F8.0,4X,16HNOT IN STANDARDS)
5000 FORMAT (1H1,20HPRODUCTION STANDARDS,///,9X,5HBASIS,5X,8HSTANDARD,
    15X,23HSTANDARD NET PRODUCTION,4X,11HTHEORETICAL,4X,14HDEVIATION FR
    2OM,/,1X,5HGROUP,3X,6HWEIGHT,3X,11HSPEED (FPM),6X,15HLBS / IN. / HR
    3.,9X,10HPRODUCTION,6X,11HTHEORETICAL,7X,5HCOUNT,/,9X,7H(24X36),//)
6000 FORMAT (1X,I3,5X,F5.0,6X,F5.0,13X,F6.2,16X,F6.2,10X,F7.4,9X,F4.0)
7000 FORMAT (//,59X,6HTOTALS,11X,F7.4,9X,F4.0,//,75X,7HP-BAR =,F7.4,
    1         //,77X,5HUCL =,F7.4)
     END
```

```
      SUBROUTINE STDS
      INTEGER GRADE ,C
      REAL M,MIN
      DIMENSION GRADE(400), BASIS(400), TRIM(400), SPEED(400), HR(400),
     1          MIN(400), PROD(400), TIME(400), M(400), C(6), KTOT(6),
     2          TOTL(6)
      DIMENSION BW(6,400), TR(6,400), S(6,400), TI(6,400), P(6,400),
     1          WTSP(6,100), TPROD(6,100), WPROD(6,100), AVGSP(6,100),
     2          APROD(6,100), AVPROD(6,100), THPROD(6,100),
     3          PERCNT(6,100), STDNET(6,100), BSWT(6,100), COUNT(6,100)
      EQUIVALENCE (MIN,M), (HR,TIME)
      COMMON BW, AVGSP, AVPROD, THPROD, PERCNT, TOTL, COUNT
      DATA C(1), C(2), C(3), C(4), C(5), C(6) / 01,02,03,04,05,06 /
C     READ UP TO 400 OLD DATA CARDS FOR STANDARDS.
C
C     WARNING - A MAXIMUM OF 100 IN ANY ONE GROUP CAN BE ACCEPTED.
C
      DO 10 IJ=1,400
      READ (5,1000) GRADE(IJ), BASIS(IJ), TRIM(IJ), SPEED(IJ), HR(IJ),
     1              MIN(IJ), PROD(IJ)
      IF (GRADE(IJ).EQ.00) GO TO 11
      N = 400
   10 CONTINUE
      GO TO 12
   11 N = IJ - 1
C     WRITE OUT RAW HISTORICAL DATA.
   12 WRITE (6,100)
  100 FORMAT (1H1,19HRAW HISTORICAL DATA,//,1X,5HGRADE,4X,
     1        9HBASIS WT.,4X,8HIN. TRIM,4X,5HSPEED,4X,5HHOURS,4X,4HMIN.,
     2        4X,10HPRODUCTION,//)
      DO 200 I = 1,N
      WRITE (6,300) GRADE(I), BASIS(I), TRIM(I), SPEED(I), HR(I), MIN(I)
     1              ,PROD(I)
      IF (I.EQ.48.OR.I.EQ.96.OR.I.EQ.144.OR.I.EQ.192.OR.I.EQ.240.OR.
     1I.EQ.288.OR.I.EQ.336.OR.I.EQ.384) WRITE (6,100)
  200 CONTINUE
  300 FORMAT (2X,I3,5X,F5.0,8X,F6.2,6X,F5.0,4X,F4.0,4X,F4.0,4X,F8.0)
C     CONVERT HOURS AND MINUTES TO DECIMAL PARTS OF HOURS.
   13 DO 20 I=1,N
      M(I) = MIN(I) / 60.
      TIME(I) = HR(I) + M(I)
   20 CONTINUE
C     PLACE ALL DATA INTO SIX MAJOR PAPER GRADE TYPES.
      DO 30 I=1,6
      K = 0
      DO 30 J=1,N
      IF (C(I).NE.GRADE(J)) GO TO 30
      K = K + 1
```

```
      BW(I,K) = BASIS(J)
      TR(I,K) = TRIM(J)
      S(I,K) = SPEED(J)
      TI(I,K) = TIME(J)
      P(I,K) = PROD(J)
      KTOT(I) = K
   30 CONTINUE
C     COMBINE DATA WITHIN EACH GROUP.
      DO 41 I = 1,6
      N = KTOT(I)
      DO 41 J = 1,N
      WTSP(I,J) = 0.
      TPROD(I,J) = 0.
      WPROD(I,J) = 0.
      TOTL(I) = 0.
   41 CONTINUE
      DO 50 I=1,6
      N = KTOT(I)
      L = 1
   44 DO 45 J = L,N
      IF (BW(I,J).EQ.0.0) GO TO 49
      VALUE = BW(I,J)
      GO TO 47
   45 CONTINUE
   47 BSWT(I,L) = BW(I,J)
C     COUNTER OF NUMBER WITHIN EACH BASIS WEIGHT.
      COUNT(I,L) = 1.
C     RUNNING SUM OF SPEED TIMES PRODUCTION.
      WTSP(I,L) = (S(I,J) * P(I,J)) + WTSP(I,L)
C     RUNNING SUM OF NET PRODUCTION.
      TPROD(I,L) = P(I,J) + TPROD(I,L)
C     COMPUTE WEIGHTED AVERAGE SPEED FOR EACH BASIS WEIGHT.
      AVGSP(I,L) = WTSP(I,L) / TPROD(I,L)
C     COMPUTE ACTUAL LB/IN/HR PRODUCTION.
      APROD(I,J) = P(I,J) / TR(I,J) / TI(I,J)
C     RUNNING SUM
      WPROD(I,L) = (APROD(I,J) * P(I,J)) + WPROD(I,L)
C     RUNNING SUM OF WEIGHTED AVERAGE LB/IN/HR PRODUCTION.
      AVPROD(I,L) = WPROD(I,L) / TPROD(I,L)
C     THEORETICAL LB/IN/HR BASED ON WEIGHTED AVERAGE SPEED.
      THPROD(I,L) = (AVGSP(I,L) * BSWT(I,L)) / 600.
C     DEVIATION OF ACTUAL FROM THEORETICAL.
      PERCNT(I,L) = (THPROD(I,L) - AVPROD(I,L)) / THPROD(I,L)
C     COUNTER OF NUMBER OF BASIS WEIGHT POINTS WITHIN EACH GROUP.
      TOTL(I) = TOTL(I) + 1.
      BW(I,J) = 0.0
      MN = J + 1
      IF (MN.GT.N) GO TO 50
```

```
      DO 48 K = MN, N
      IF (BW(I,K).NE.VALUE) GO TO 48
C     COUNTER OF NUMBER WITHIN EACH BASIS WEIGHT.
      COUNT(I,L) = COUNT(I,L) + 1.
C     RUNNING SUM OF SPEED TIMES PRODUCTION.
      WTSP(I,L) = (S(I,K) * P(I,K)) + WTSP(I,L)
C     RUNNING SUM OF NET PRODUCTION.
      TPROD(I,L) = P(I,K) + TPROD(I,L)
C     COMPUTE WEIGHTED AVERAGE SPEED FOR EACH BASIS WEIGHT.
      AVGSP(I,L) = WTSP(I,L) / TPROD(I,L)
C     COMPUTE ACTUAL LB/IN/HR PRODUCTION.
      APROD(I,K) = P(I,K) / TR(I,K) / TI(I,K)
C     RUNNING SUM
      WPROD(I,L) = (APROD(I,K) * P(I,K)) + WPROD(I,L)
C     RUNNING SUM OF WEIGHTED AVERAGE LB/IN/HR PRODUCTION.
      AVPROD(I,L) = WPROD(I,L) / TPROD(I,L)
C     THEORETICAL LB/IN/HR BASED ON WEIGHTED AVERAGE SPEED.
      THPROD(I,L) = (AVGSP(I,L) * BSWT(I,L)) / 600.
C     DEVIATION OF ACTUAL FROM THEORETICAL.
      PERCNT(I,L) = (THPROD(I,L) - AVPROD(I,L)) / THPROD(I,L)
      BW(I,K) = 0.0
   48 CONTINUE
   49 L = L + 1
      IF (L.LE.N) GO TO 44
   50 CONTINUE
C     INSURE THAT ALL OF THE BW ARRAY IS WIPED OUT.
      DO 51 I = 1,6
      N = KTOT(I)
      DO 51 J = 1,N
      BW(I,J) = 0.0
   51 CONTINUE
C     PLACE BSWT ARRAY INFORMATION INTO BLANK BW ARRAY.
      DO 52 I = 1,6
      K = KTOT(I)
      DO 52 J = 1,K
      BW(I,J) = BSWT(I,J)
   52 CONTINUE
C     PUT ALL DATA IN ASCENDING ORDER BY BASIS WEIGHTS WITHIN EACH GROUP
      DO 60 I=1,6
      NI = KTOT(I)
      DO 60 LI=1,NI
      IP1 = LI + 1
      IF(IP1.GT.NI) GO TO 60
      DO 60 J=IP1,NI
      IF (BW(I,LI).LE.BW(I,J)) GO TO 60
      TEMP1 = BW(I,LI)
      TEMP2 = AVGSP(I,LI)
      TEMP3 = AVPROD(I,LI)
```

```
      TEMP4 = THPROD(I,LI)
      TEMP5 = PERCNT(I,LI)
      TEMP6 = COUNT(I,LI)
      BW(I,LI) = BW(I,J)
      AVGSP(I,LI) = AVGSP(I,J)
      AVPROD(I,LI) = AVPROD(I,J)
      THPROD(I,LI) = THPROD(I,J)
      PERCNT(I,LI) = PERCNT(I,J)
      COUNT(I,LI) = COUNT(I,J)
      BW(I,J) = TEMP1
      AVGSP(I,J) = TEMP2
      AVPROD(I,J) = TEMP3
      THPROD(I,J) = TEMP4
      PERCNT(I,J) = TEMP5
      COUNT(I,J) = TEMP6
   60 CONTINUE
C     ELIMINATE ZEROS IN FINAL ARRAY.
      DO 70 I = 1,6
      IX = 0
      NX = KTOT(I)
      DO 66 J = 1,NX
      IF (BW(I,J).EQ.0.0) GO TO 66
      K = J
      DO 65 L = K,NX
      IX = IX + 1
      BW(I,IX) = BW(I,L)
      AVGSP(I,IX) = AVGSP(I,L)
      AVPROD(I,IX) = AVPROD(I,L)
      THPROD(I,IX) = THPROD(I,L)
      PERCNT(I,IX) = PERCNT(I,L)
      COUNT(I,IX) = COUNT(I,L)
   65 CONTINUE
      GO TO 70
   66 CONTINUE
   70 CONTINUE
 1000 FORMAT(I2, 4X, F3.0, 2X, F5.2, 2X, F3.0, 2X, F2.0, F2.0, 2X, F6.0)
      RETURN
      END
```

APPENDIX B

SAMPLE RECORDING SHEET

Machine Tender: 7-3 Powell
3-11 Smith
11-7 Roberson

Clerk: Gibson

ALBEMARLE PAPER COMPANY
HOLLYWOOD PAPER MACHINE
DAILY PRODUCTION SUMMARY

Date December 1, 1967

A* Lot No.	B Order No.	C Customer	D* Grade 1) Code	D* Grade 2) Name	E Color	F* Basis Weight 1) 24 x 36 a) Nom.	F* 1) 24 x 36 b) Lab.	F* 2) 19 x 24 a) Nom.	F* 2) 19 x 24 b) Lab.	G* Avg. Calip.	H* Avg. Trim	I* Avg. Speed F.P.M.	J* Rolls 1) No.	J* Rolls 2) Width	J* Rolls 3) Diam.	K* Sheets 1) Width	K* Sheets 2) Leng.	L* Run Time Hr	L* Run Time Min	M* Op Dnt Hr	M* Op Dnt Min	N* Non Op Dnt Hr	N* Non Op Dnt Min	O* Net Production
---	---	---------	0303	3A-1 Filter	White	62	62	---	---	---	70.25	146	11	70.25	32.5	---	---	4	15	-	-	14	00	4,150
---	---	---------	0506	F/B White Sack	White	50	50	---	---	---	75.50	360	8½	75.50	40.0	---	---	4	45	1	00	-	-	9,545
				14:00 - REPAIRS TO MACHINERY - PUT ON WIRE																				
				1:00 - CHANGE OF PRODUCTS																				
																	Totals	9	00	1	00	14	00	13,675

FORM NO. 78

APPENDIX C

RAW INPUT DATA FOR DAY WITH DUMMY DATA

RAW INPUT DATA FOR DAY

GRADE	NAME	BASIS WT.	IN. TRIM	SPEED	HOURS	MIN.	PRODUCTION
6	10	237.	70.00	84.	1.	0.	2300.
6	10	410.	70.00	35.	1.	0.	1650.
6	10	60.	70.00	250.	1.	0.	1700.
3	3	62.	70.25	146.	4.	15.	4150.
5	6	50.	75.50	360.	4.	45.	9545.

APPENDIX D

RAW HISTORICAL DATA

(August 1, 1967 to December 1, 1967)

RAW HISTORICAL DATA

GRADE	BASIS WT.	IN. TRIM	SPEED	HOURS	MIN.	PRODUCTION
5	50.	69.50	350.	4.	40.	8430.
3	85.	70.75	132.	4.	20.	5725.
1	113.	77.25	248.	4.	0.	13240.
5	51.	65.50	350.	7.	30.	11110.
5	40.	74.13	380.	1.	15.	1880.
1	195.	77.25	142.	2.	25.	8335.
1	227.	77.25	130.	5.	10.	16930.
1	189.	77.25	155.	1.	40.	5380.
1	284.	79.00	83.	2.	20.	6385.
1	231.	77.25	130.	1.	10.	4975.
1	189.	77.25	155.	1.	40.	5380.
1	284.	79.00	83.	2.	20.	6385.
1	149.	74.00	200.	2.	50.	8920.
3	63.	63.00	178.	11.	10.	10065.
3	145.	59.00	146.	0.	25.	780.
3	162.	59.00	130.	8.	20.	15960.
1	189.	77.25	152.	1.	10.	2740.
1	189.	81.00	152.	1.	0.	3180.
1	189.	77.25	152.	1.	15.	4930.
1	193.	77.25	152.	3.	20.	11255.
1	193.	73.50	152.	2.	35.	8530.
1	193.	77.25	152.	11.	45.	42580.
5	60.	75.75	330.	9.	45.	14910.
5	51.	72.00	348.	1.	45.	3980.
3	113.	77.50	215.	8.	35.	22915.
3	74.	63.00	157.	1.	30.	1481.
4	82.	79.25	350.	6.	35.	6015.
5	52.	72.00	350.	1.	0.	2850.
5	52.	77.50	350.	5.	15.	10310.
5	52.	78.00	350.	2.	0.	3970.
4	96.	80.00	225.	6.	10.	14335.
3	190.	78.00	100.	11.	15.	25415.
3	190.	79.50	100.	5.	45.	13640.
6	125.	74.00	155.	2.	45.	5940.
6	235.	74.00	89.	0.	40.	1330.
6	235.	74.00	89.	11.	5.	26045.
1	193.	68.25	120.	13.	40.	33135.
1	193.	69.00	120.	9.	55.	22225.
1	193.	69.00	120.	4.	40.	10490.
5	52.	65.50	361.	11.	10.	20720.
5	51.	65.50	351.	2.	25.	4640.
5	51.	74.25	351.	2.	35.	5760.
3	125.	78.00	95.	17.	35.	23810.
3	121.	78.00	95.	3.	40.	5040.
3	85.	79.50	135.	5.	0.	6195.
3	62.	68.50	152.	12.	20.	10665.
1	193.	77.25	152.	11.	35.	42390.
5	50.	79.00	350.	2.	50.	6840.

RAW HISTORICAL DATA

GRADE	BASIS WT.	IN. TRIM	SPEED	HOURS	MIN.	PRODUCTION
1	193.	77.25	152.	2.	15.	7270.
3	64.	73.50	172.	11.	10.	14690.
3	61.	75.50	160.	12.	45.	15245.
5	63.	60.00	340.	2.	40.	4715.
5	50.	75.75	361.	18.	5.	38835.
3	61.	73.50	160.	12.	0.	12840.
3	62.	73.50	160.	5.	45.	6440.
1	231.	79.00	123.	1.	15.	2855.
1	231.	76.50	123.	1.	15.	2555.
1	193.	77.25	150.	8.	30.	29235.
1	193.	77.25	150.	6.	0.	18800.
5	92.	77.00	250.	5.	30.	14735.
6	315.	74.00	54.	3.	15.	5615.
3	165.	59.00	130.	24.	0.	44185.
1	193.	77.25	150.	2.	55.	9395.
1	195.	77.25	135.	3.	15.	9795.
1	189.	77.25	125.	3.	45.	10975.
4	82.	79.00	230.	9.	30.	16185.
2	125.	76.30	87.	8.	0.	7400.
6	208.	80.00	85.	2.	35.	5895.
6	144.	79.20	142.	1.	50.	4340.
1	120.	80.00	165.	3.	0.	7380.
5	90.	58.00	226.	2.	20.	3775.
3	61.	73.50	150.	24.	0.	26245.
3	62.	73.50	150.	2.	30.	3035.
3	62.	70.00	150.	11.	55.	11910.
5	50.	75.50	350.	2.	20.	4615.
1	189.	77.25	160.	4.	10.	13100.
4	72.	77.50	260.	6.	50.	11390.
4	72.	79.00	260.	8.	30.	18570.
4	70.	79.00	260.	1.	0.	2340.
5	50.	75.50	350.	4.	45.	10295.
5	50.	79.50	350.	1.	55.	3945.
3	106.	77.50	200.	9.	30.	21630.
4	72.	75.50	250.	8.	40.	15035.
4	72.	79.25	250.	1.	30.	2825.
3	162.	69.25	130.	13.	50.	31460.
3	162.	67.50	130.	10.	15.	21275.
3	75.	59.00	140.	4.	30.	3935.
3	75.	59.00	140.	5.	15.	4990.
6	223.	74.00	80.	14.	45.	25515.
6	225.	74.00	82.	3.	45.	8335.
6	78.	74.25	200.	5.	50.	9440.
6	115.	74.25	150.	5.	10.	10470.
6	115.	74.25	146.	6.	25.	11255.
6	255.	71.88	87.	8.	30.	19410.
3	63.	73.50	160.	0.	40.	935.
3	164.	59.00	130.	17.	20.	32905.

RAW HISTORICAL DATA

GRADE	BASIS WT.	IN. TRIM	SPEED	HOURS	MIN.	PRODUCTION
1	189.	77.25	155.	0.	50.	3580.
4	80.	79.00	220.	3.	0.	6520.
4	82.	79.00	220.	8.	5.	20270.
3	63.	73.50	160.	2.	30.	2780.
5	50.	79.50	350.	2.	0.	4415.
5	60.	75.75	332.	5.	55.	8645.
5	50.	79.75	332.	7.	25.	15950.
1	189.	77.25	155.	5.	35.	19845.
1	189.	77.25	152.	2.	50.	11445.
5	50.	79.25	350.	19.	40.	36135.
6	310.	74.00	60.	1.	10.	2590.
6	265.	72.00	75.	2.	10.	4040.
1	152.	77.50	203.	2.	15.	6870.
1	227.	77.25	123.	5.	10.	17470.
1	189.	77.25	152.	0.	40.	2165.
3	128.	69.75	100.	7.	30.	9830.
6	250.	71.88	87.	1.	20.	3380.
6	240.	71.83	87.	8.	30.	20470.
3	125.	69.50	100.	5.	0.	7195.
3	125.	69.75	100.	16.	40.	23660.
1	152.	77.25	190.	0.	35.	1400.
1	189.	77.25	152.	4.	20.	16070.
1	227.	60.00	120.	0.	25.	1000.
1	227.	72.00	135.	0.	35.	1260.
1	132.	55.00	220.	5.	30.	14305.
1	189.	77.25	150.	2.	50.	10460.
1	152.	77.25	210.	1.	35.	6060.
1	189.	77.25	152.	2.	15.	8250.
3	75.	71.25	115.	4.	25.	3410.
3	63.	71.50	142.	1.	35.	1535.
3	85.	71.56	132.	6.	20.	7055.
3	125.	76.31	100.	9.	35.	5265.
5	50.	65.50	340.	5.	30.	8930.
4	80.	79.00	200.	5.	0.	10600.
4	90.	79.00	208.	16.	0.	36415.
5	50.	65.50	340.	1.	15.	2160.
1	189.	77.25	165.	17.	30.	61900.
1	189.	77.25	150.	1.	40.	5040.
1	155.	77.25	190.	2.	5.	7110.
6	125.	74.00	200.	2.	0.	5420.
6	235.	74.00	67.	8.	10.	14695.
6	235.	74.00	80.	7.	20.	17955.
3	63.	73.50	175.	4.	30.	5545.
3	165.	59.00	130.	9.	10.	17445.
3	162.	59.00	130.	8.	30.	17480.
2	120.	77.50	120.	4.	10.	7155.
6	144.	80.00	150.	2.	25.	4590.
6	144.	79.00	150.	9.	50.	27340.

RAW HISTORICAL DATA

GRADE	BASIS WT.	IN. TRIM	SPEED	HOURS	MIN.	PRODUCTION
1	189.	77.25	125.	4.	40.	15910.
1	189.	77.25	150.	0.	45.	1985.
1	189.	77.25	150.	1.	15.	5255.
6	82.	79.50	228.	2.	30.	5825.
6	80.	79.50	228.	1.	10.	2250.
6	100.	75.00	200.	1.	20.	3130.
6	70.	76.88	275.	12.	15.	26730.
6	70.	76.88	275.	6.	20.	14495.
4	80.	79.00	228.	4.	30.	11280.
4	108.	78.00	170.	8.	0.	17390.
2	54.	78.00	285.	3.	55.	5520.
2	119.	78.00	123.	5.	55.	10205.
2	119.	73.25	123.	4.	15.	7325.
3	162.	59.00	135.	9.	20.	20580.
2	117.	78.50	180.	8.	0.	20030.
2	117.	78.50	180.	0.	30.	1410.
1	189.	77.25	145.	3.	0.	8845.
3	125.	79.88	95.	12.	30.	17720.
4	85.	79.00	210.	2.	45.	6460.
3	75.	71.50	115.	1.	35.	1430.
3	75.	59.00	155.	5.	15.	5770.
3	75.	59.00	155.	13.	55.	16105.
1	189.	73.50	155.	1.	25.	5010.
1	227.	73.50	123.	3.	40.	12560.
4	80.	79.00	235.	2.	10.	3640.
4	50.	76.00	285.	3.	10.	5315.
4	70.	81.00	225.	2.	50.	5205.
4	70.	79.50	225.	1.	0.	1740.
5	50.	78.50	360.	14.	20.	20480.
5	50.	78.50	360.	5.	5.	11970.
5	50.	78.00	360.	14.	35.	31665.
5	50.	76.00	346.	13.	30.	26545.
5	50.	76.00	341.	4.	10.	8590.
6	144.	76.25	150.	8.	55.	21985.
3	125.	78.00	100.	0.	30.	650.
3	125.	77.25	98.	21.	0.	32185.
5	60.	77.50	340.	1.	0.	2340.
5	60.	77.50	340.	3.	30.	6860.
5	50.	69.50	361.	19.	35.	35060.
5	51.	77.25	361.	4.	45.	9410.
1	190.	75.00	100.	2.	40.	6110.
6	358.	71.88	41.	3.	35.	5775.
6	365.	71.88	52.	2.	10.	4825.
6	240.	71.88	88.	3.	50.	9210.
6	240.	71.88	88.	5.	20.	13320.
6	235.	71.88	92.	8.	50.	21110.
6	110.	71.88	198.	6.	40.	16345.
6	230.	71.88	85.	0.	40.	1280.

RAW HISTORICAL DATA

GRADE	BASIS WT.	IN. TRIM	SPEED	HOURS	MIN.	PRODUCTION
1	189.	77.25	155.	0.	35.	1875.
1	189.	77.25	155.	2.	45.	9285.
4	90.	78.00	200.	5.	15.	10845.
1	227.	77.25	125.	1.	20.	4535.
1	152.	77.25	192.	1.	25.	4470.
1	189.	77.25	150.	5.	0.	17250.
1	152.	77.25	190.	3.	10.	11415.
1	152.	77.25	190.	1.	0.	3040.
3	61.	73.50	162.	2.	10.	2270.
3	61.	73.50	162.	6.	30.	6965.
3	108.	75.00	208.	9.	35.	24910.
3	61.	73.50	162.	6.	50.	7775.
1	189.	77.25	160.	1.	0.	3810.
1	189.	77.25	160.	12.	55.	50420.
1	189.	77.25	160.	1.	55.	7355.
1	189.	77.25	160.	7.	50.	30445.
1	189.	77.25	152.	2.	30.	9155.
1	189.	77.25	152.	1.	55.	6730.
5	50.	48.00	357.	9.	0.	11945.
5	50.	48.00	361.	2.	45.	3670.
5	50.	48.00	350.	3.	40.	5160.
5	50.	75.00	350.	8.	20.	18350.
5	50.	65.50	350.	10.	15.	20425.
4	80.	74.00	237.	0.	35.	1545.
4	80.	74.00	237.	3.	15.	7505.
4	70.	80.00	266.	3.	35.	9770.
4	90.	79.00	190.	2.	30.	5500.
4	70.	79.00	266.	8.	15.	14780.
4	80.	79.00	228.	3.	30.	6740.
4	70.	79.00	247.	6.	0.	13330.
5	60.	75.50	360.	2.	0.	5240.
5	50.	55.50	360.	2.	0.	3340.
5	50.	72.00	360.	2.	20.	5020.
4	70.	77.50	280.	4.	20.	10500.
3	162.	59.00	147.	4.	10.	8340.
3	162.	59.00	133.	13.	15.	25910.
5	50.	78.50	350.	9.	45.	21300.
5	50.	78.50	350.	4.	55.	11275.
1	114.	78.00	225.	2.	35.	7855.
1	189.	77.25	150.	3.	15.	12385.
1	189.	73.50	150.	2.	20.	8160.
1	227.	73.50	125.	2.	35.	9125.
3	70.	66.25	130.	5.	50.	5065.
3	70.	68.75	130.	5.	25.	5240.
4	90.	79.00	190.	4.	50.	9770.
4	70.	79.00	245.	18.	5.	38980.
5	50.	79.50	350.	3.	25.	8730.
5	50.	78.50	350.	12.	5.	27950.

RAW HISTORICAL DATA

GRADE	BASIS WT.	IN. TRIM	SPEED	HOURS	MIN.	PRODUCTION
3	75.	59.00	156.	6.	15.	6880.
3	75.	59.00	156.	22.	15.	23420.
1	302.	50.00	85.	0.	45.	1370.
1	227.	79.50	123.	0.	50.	3040.
1	227.	50.00	123.	0.	50.	2500.
1	189.	77.50	150.	0.	55.	2610.
5	40.	69.00	355.	11.	0.	5755.
5	40.	77.00	355.	14.	25.	22335.
1	189.	77.25	140.	5.	40.	18530.
1	189.	77.25	140.	1.	35.	5310.
1	189.	77.25	152.	8.	50.	30785.
5	60.	72.00	310.	3.	30.	7650.
1	189.	77.25	144.	4.	10.	14465.
1	189.	80.00	144.	0.	20.	900.
1	152.	77.25	195.	5.	10.	18415.
6	125.	74.00	165.	2.	15.	5700.
6	235.	74.00	80.	8.	40.	21610.
6	240.	80.00	77.	0.	30.	1340.
6	315.	74.00	54.	3.	45.	7455.
5	60.	72.00	332.	14.	45.	33900.
3	162.	59.00	133.	7.	40.	16935.
3	162.	59.00	133.	5.	0.	10535.
5	40.	60.75	360.	17.	20.	22575.
5	40.	77.00	361.	22.	40.	30100.
5	40.	78.00	361.	9.	0.	13275.
3	61.	73.50	160.	6.	0.	6455.
2	181.	72.00	84.	9.	20.	13060.
5	60.	75.50	361.	6.	25.	17015.
5	50.	72.50	360.	4.	10.	8840.
5	50.	71.50	360.	1.	25.	3055.
1	152.	77.25	200.	2.	25.	8990.
1	189.	77.25	150.	1.	45.	5180.
6	94.	80.00	200.	2.	15.	5530.
6	144.	80.00	125.	5.	15.	11435.
6	144.	80.00	125.	7.	40.	19135.
6	275.	80.00	58.	5.	30.	10715.
6	406.	80.00	40.	8.	30.	15230.
6	406.	80.00	40.	3.	30.	6680.
5	60.	72.00	290.	18.	30.	36035.
5	60.	72.00	290.	8.	0.	16655.
3	162.	59.00	125.	11.	15.	22025.
3	162.	59.00	125.	5.	20.	10920.
3	85.	72.00	132.	9.	20.	11985.
5	50.	67.50	360.	6.	35.	13740.
5	50.	78.50	360.	6.	20.	13300.
5	50.	65.50	350.	5.	45.	10085.
3	61.	63.25	174.	7.	30.	7620.

APPENDIX E

DAILY PRODUCTION OUTPUT WITH DUMMY DATA

DAILY PRODUCTION

GRADE	BASIS WEIGHT (24X36)	INCHES TRIM	SPEED F.P.M.	STANDARD SPEED	TIME HRS.	PRODUCTION LBS/IN/HR	DEVIATION FROM TH.	STANDARD DEVIATION	DIFFERENCE	LBS NET PRODUCTION	
3 3	62.	70.25	146.	153.	4.25	13.90	0.0787	0.1042	0.0255	4150.	
5 6	50.	75.50	360.	353.	4.75	26.62	0.1128	0.0733	-0.0395	9545.	
610	60.	70.00	250.	-----	1.00	24.29	0.0286	------	------	1700.	NOT IN STANDARDS
610	237.	70.00	84.	85.	1.00	32.86	0.0097	0.0287	0.0190	2300.	
610	410.	70.00	35.	-----	1.00	23.57	0.0144	------	------	1650.	NOT IN STANDARDS

APPENDIX F

PRODUCTION STANDARDS OUTPUT

PRODUCTION STANDARDS

GROUP	BASIS WEIGHT (24X36)	STANDARD SPEED (FPM)	STANDARD NET PRODUCTION LBS / IN. / HR.	THEORETICAL PRODUCTION	DEVIATION FROM THEORETICAL	COUNT
1	113.	248.	42.85	46.71	0.0826	1.
1	114.	225.	38.98	42.75	0.0881	1.
1	120.	165.	30.75	33.00	0.0682	1.
1	132.	220.	47.29	48.40	0.0229	1.
1	149.	200.	42.54	49.67	0.1434	1.
1	152.	197.	45.04	49.81	0.0959	8.
1	155.	190.	44.18	49.08	0.0999	1.
1	189.	153.	46.03	48.20	0.0450	39.
1	190.	100.	30.55	31.67	0.0353	1.
1	193.	143.	41.99	45.86	0.0842	11.
1	195.	138.	41.60	44.92	0.0738	2.
1	227.	125.	44.92	47.41	0.0524	9.
1	231.	126.	40.97	48.65	0.1579	3.
1	284.	83.	34.64	39.29	0.1183	2.
1	302.	85.	36.53	42.78	0.1461	1.
				TOTALS	5.4654	82.

P-BAR = 0.0667

UCL = 0.1493

PRODUCTION STANDARDS

GROUP	BASIS WEIGHT (24X36)	STANDARD SPEED (FPM)	STANDARD NET PRODUCTION LBS / IN. / HR.	THEORETICAL PRODUCTION	DEVIATION FROM THEORETICAL	COUNT
2	54.	285.	18.07	25.65	0.2956	1.
2	117.	180.	32.16	35.10	0.0838	2.
2	119.	123.	22.70	24.39	0.0693	2.
2	120.	120.	22.16	24.00	0.0768	1.
2	125.	87.	12.12	18.12	0.3311	1.
2	181.	84.	19.43	25.34	0.2331	1.
				TOTALS	1.2426	8.

P-BAR = 0.1553

UCL = 0.5395

PRODUCTION STANDARDS

GROUP	BASIS WEIGHT (24X36)	STANDARD SPEED (FPM)	STANDARD NET PRODUCTION LBS / IN. / HR.	THEORETICAL PRODUCTION	DEVIATION FROM THEORETICAL	COUNT
3	61.	159.	15.10	16.12	0.0632	8.
3	62.	153.	14.13	15.78	0.1042	4.
3	63.	171.	15.23	17.99	0.1535	5.
3	64.	172.	17.90	18.35	0.0244	1.
3	70.	130.	13.60	15.17	0.1035	2.
3	74.	157.	15.67	19.36	0.1906	1.
3	75.	150.	17.64	18.81	0.0622	8.
3	85.	133.	17.02	18.79	0.0938	4.
3	106.	200.	29.38	35.33	0.1685	1.
3	108.	208.	34.66	37.44	0.0743	1.
3	113.	215.	34.45	40.49	0.1493	1.
3	121.	95.	17.62	19.16	0.0802	1.
3	125.	98.	18.51	20.32	0.0889	7.
3	128.	100.	18.79	21.33	0.1192	1.
3	145.	146.	31.73	35.28	0.1007	1.
3	162.	131.	33.99	35.42	0.0405	11.
3	164.	130.	32.18	35.53	0.0945	1.
3	165.	130.	31.50	35.75	0.1188	2.
3	190.	100.	29.27	31.67	0.0757	2.
				TOTALS	5.2288	62.

P-BAR = 0.0843

UCL = 0.1902

PRODUCTION STANDARDS

GROUP	BASIS WEIGHT (24X36)	STANDARD SPEED (FPM)	STANDARD NET PRODUCTION LBS / IN. / HR.	THEORETICAL PRODUCTION	DEVIATION FROM THEORETICAL	COUNT
4	50.	285.	22.08	23.75	0.0701	1.
4	70.	253.	27.53	29.56	0.0687	8.
4	72.	256.	24.49	30.75	0.2036	4.
4	80.	223.	28.29	29.73	0.0484	7.
4	82.	242.	25.00	33.10	0.2448	3.
4	85.	210.	29.74	29.75	0.0005	1.
4	90.	202.	27.82	30.33	0.0829	4.
4	96.	225.	29.06	36.00	0.1928	1.
4	108.	170.	27.87	30.60	0.0893	1.
				TOTALS	3.1212	30.

P-BAR = 0.1040

UCL = 0.2713

PRODUCTION STANDARDS

GROUP	BASIS WEIGHT (24X36)	STANDARD SPEED (FPM)	STANDARD NET PRODUCTION LBS / IN. / HR.	THEORETICAL PRODUCTION	DEVIATION FROM THEORETICAL	COUNT
5	40.	359.	18.61	23.96	0.2232	6.
5	50.	353.	27.27	29.43	0.0733	33.
5	51.	353.	26.57	30.01	0.1146	5.
5	52.	356.	28.06	30.86	0.0906	4.
5	60.	321.	28.56	32.06	0.1093	10.
5	63.	340.	29.47	35.70	0.1745	1.
5	90.	226.	27.89	33.90	0.1772	1.
5	92.	250.	34.79	38.33	0.0923	1.
				TOTALS	6.2309	61.

P-BAR = 0.1021

UCL = 0.2185

PRODUCTION STANDARDS

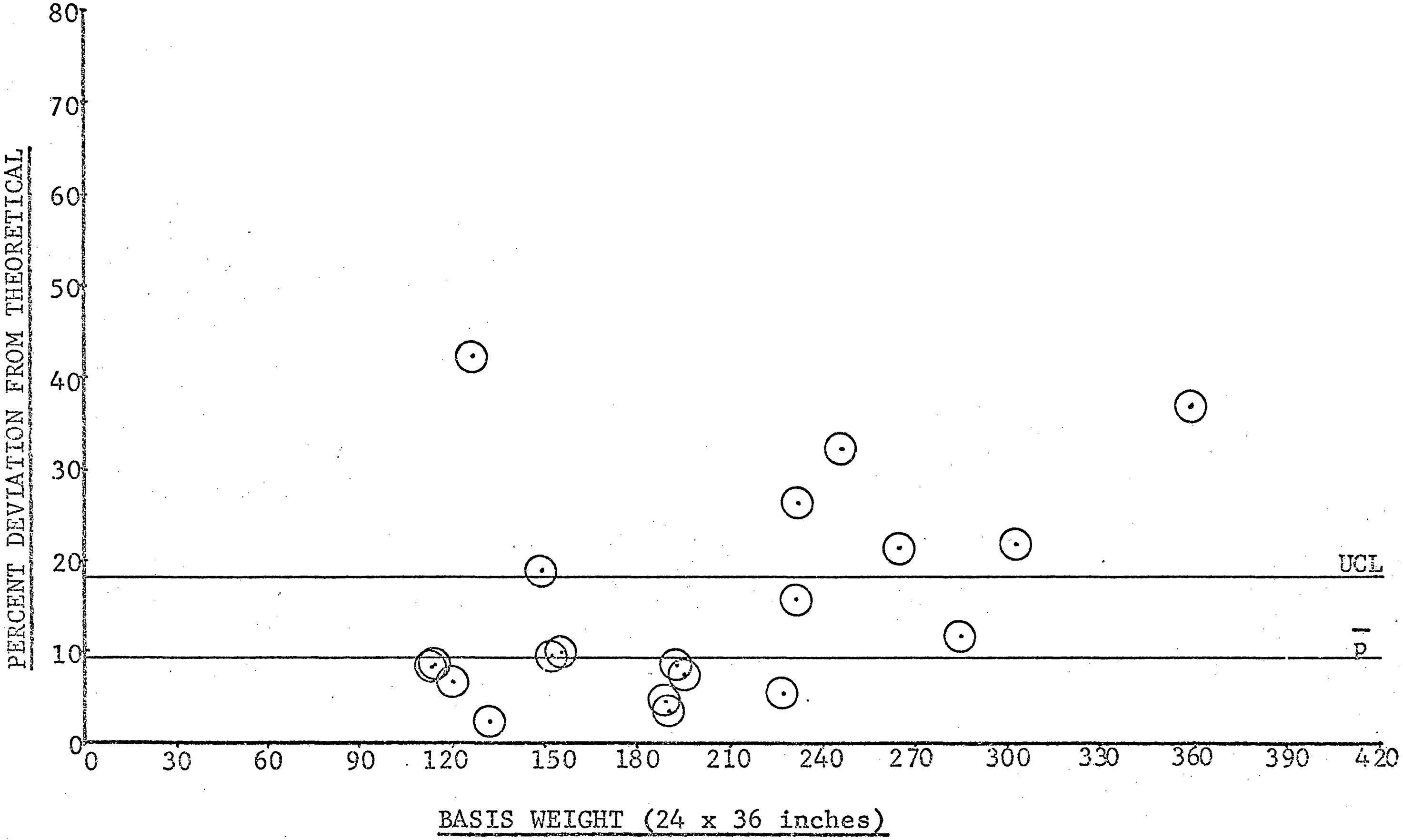
GROUP	BASIS WEIGHT (24X36)	STANDARD SPEED (FPM)	STANDARD NET PRODUCTION LBS / IN. / HR.	THEORETICAL PRODUCTION	DEVIATION FROM THEORETICAL	COUNT
6	70.	275.	28.87	32.08	0.1002	2.
6	78.	200.	21.80	26.00	0.1617	1.
6	80.	228.	24.26	30.40	0.2020	1.
6	82.	228.	29.31	31.16	0.0594	1.
6	94.	200.	30.72	31.33	0.0195	1.
6	100.	200.	31.30	33.33	0.0610	1.
6	110.	198.	34.11	36.30	0.0604	1.
6	115.	148.	25.39	28.35	0.1044	2.
6	125.	173.	33.24	35.97	0.0759	3.
6	144.	141.	31.75	33.84	0.0618	6.
6	208.	85.	28.52	29.47	0.0320	1.
6	223.	80.	23.38	29.73	0.2138	1.
6	225.	82.	30.04	30.75	0.0232	1.
6	230.	85.	26.71	32.58	0.1802	1.
6	235.	83.	31.58	32.51	0.0287	6.
6	240.	87.	33.86	34.88	0.0293	4.
6	250.	87.	35.27	36.25	0.0271	1.
6	255.	87.	31.77	36.97	0.1408	1.
6	265.	75.	25.90	33.13	0.2182	1.
6	275.	58.	24.35	26.58	0.0839	1.
6	310.	60.	30.00	31.00	0.0323	1.
6	315.	54.	25.35	28.35	0.1057	2.
6	358.	41.	22.42	24.46	0.0835	1.
6	365.	52.	30.98	31.63	0.0206	1.
6	406.	40.	22.84	27.07	0.1561	2.
				TOTALS	3.4405	44.

P-BAR = 0.0782

UCL = 0.1996

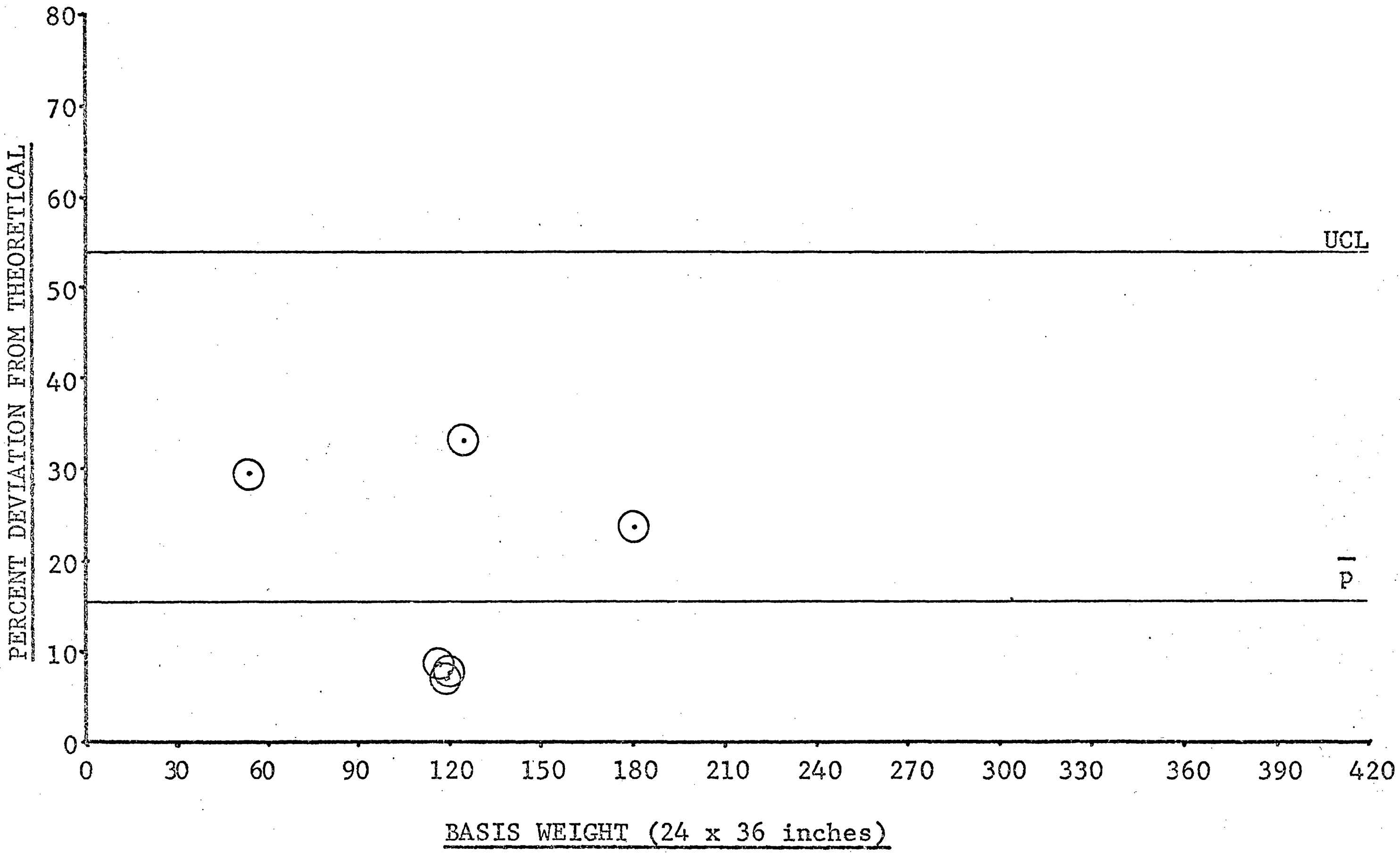
APPENDIX G

FRACTION DEFECTIVE CONTROL CHARTS



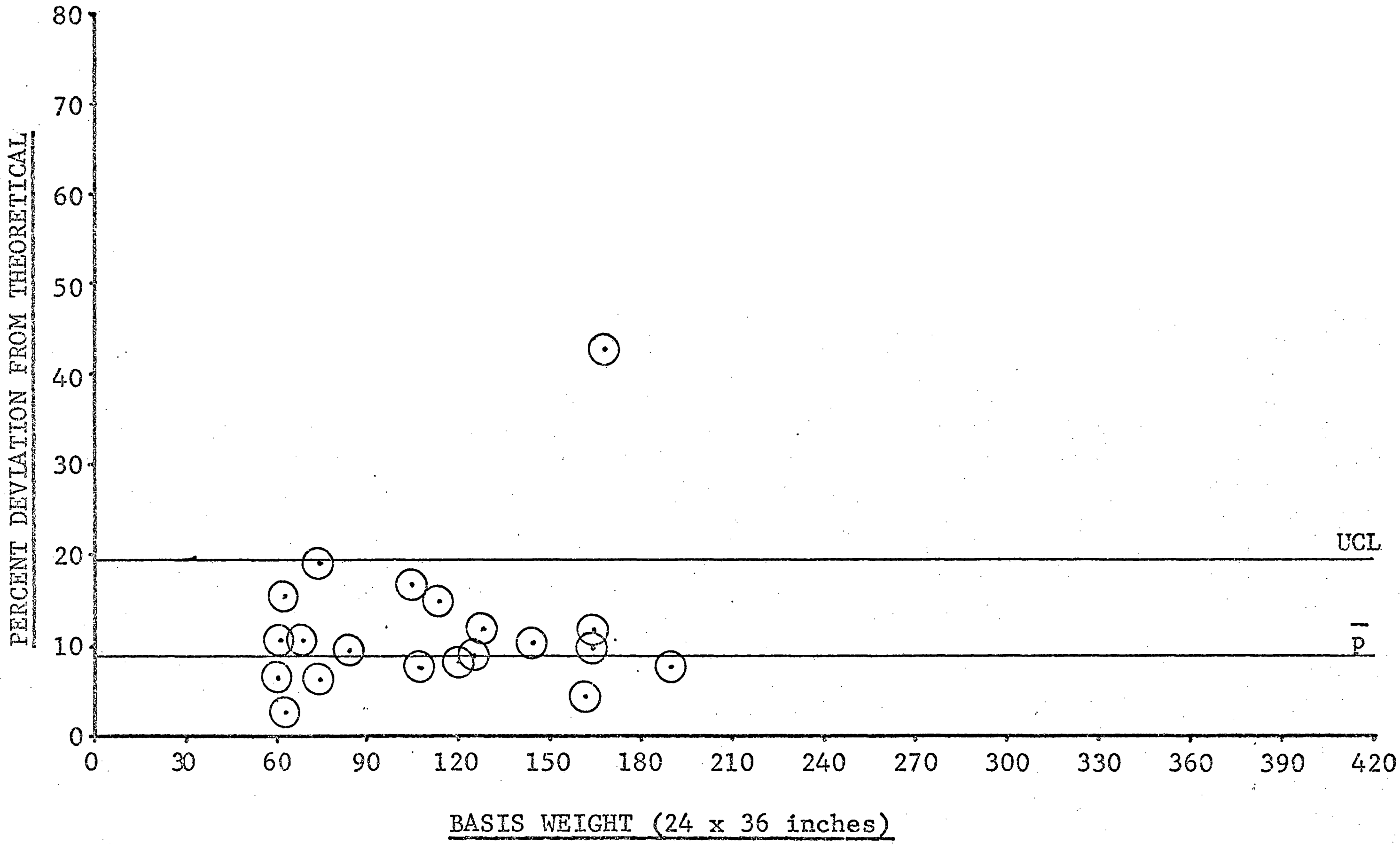
GROUP NUMBER 01

$\bar{p}$ = 9.26%
UCL = 18.33%



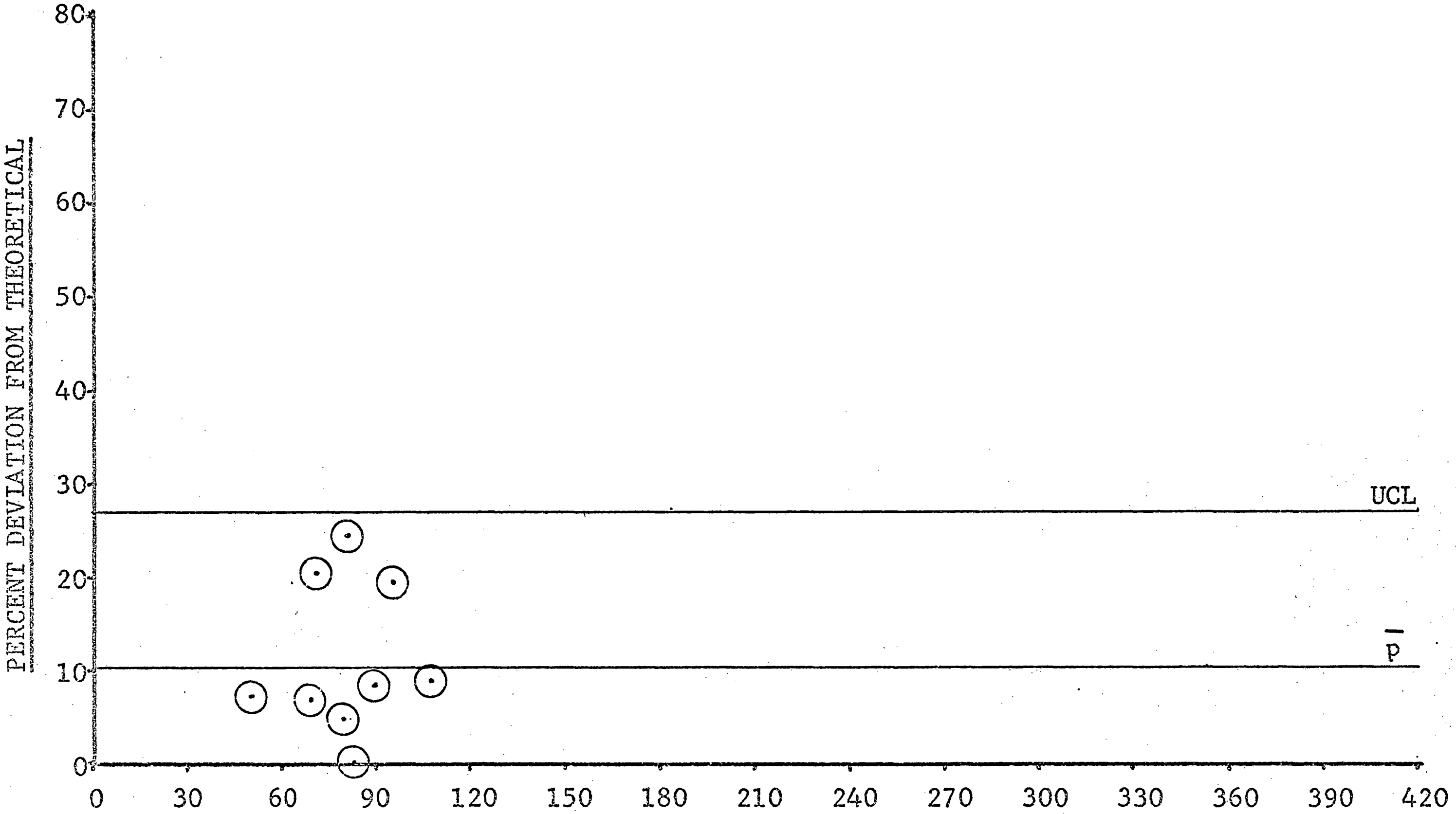
GROUP NUMBER 02

$\bar{p}$ = 15.53%
UCL = 53.95%



GROUP NUMBER 03

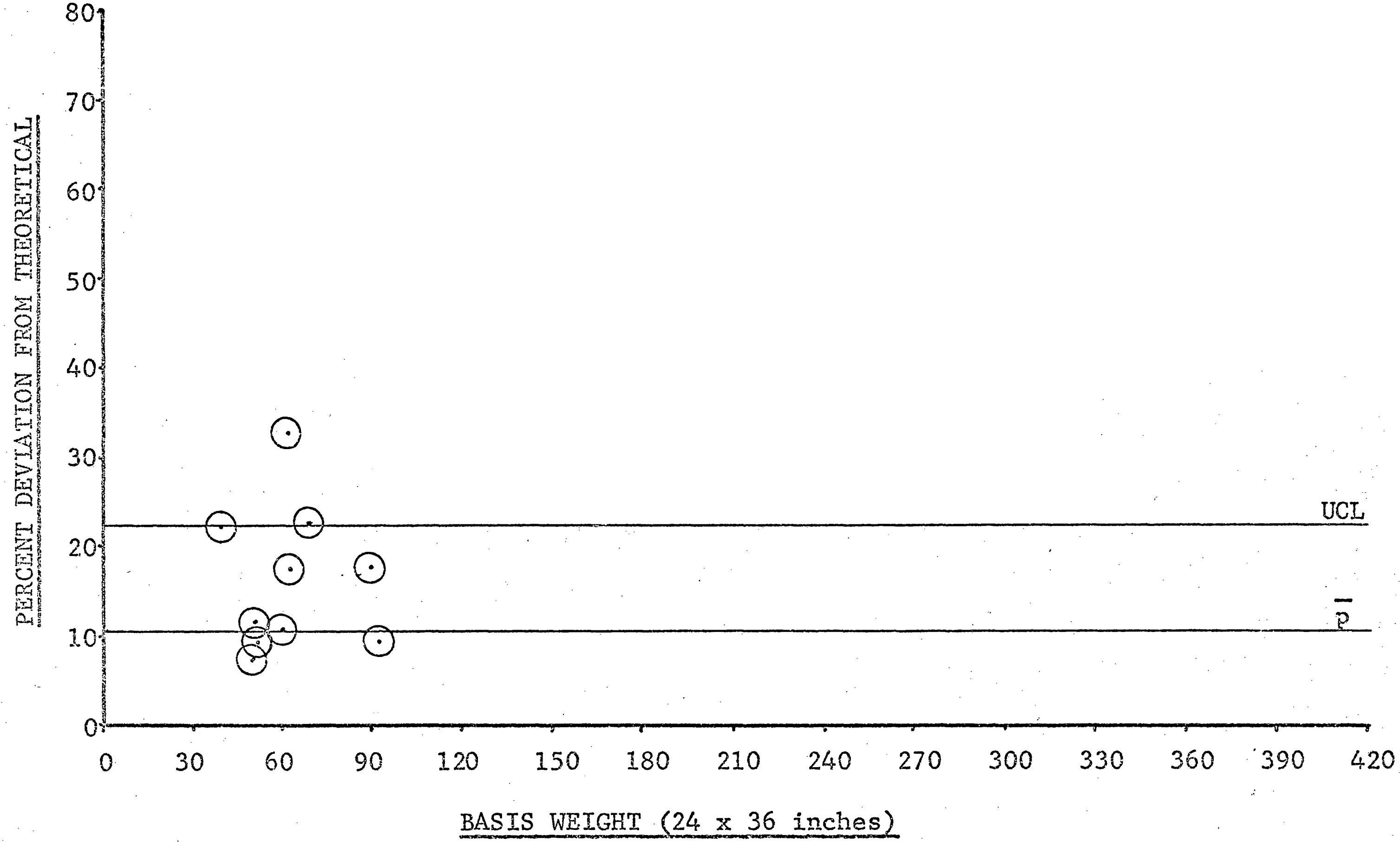
$\bar{p}$ = 8.98%
UCL = 19.78%



BASIS WEIGHT (24 x 36 inches)

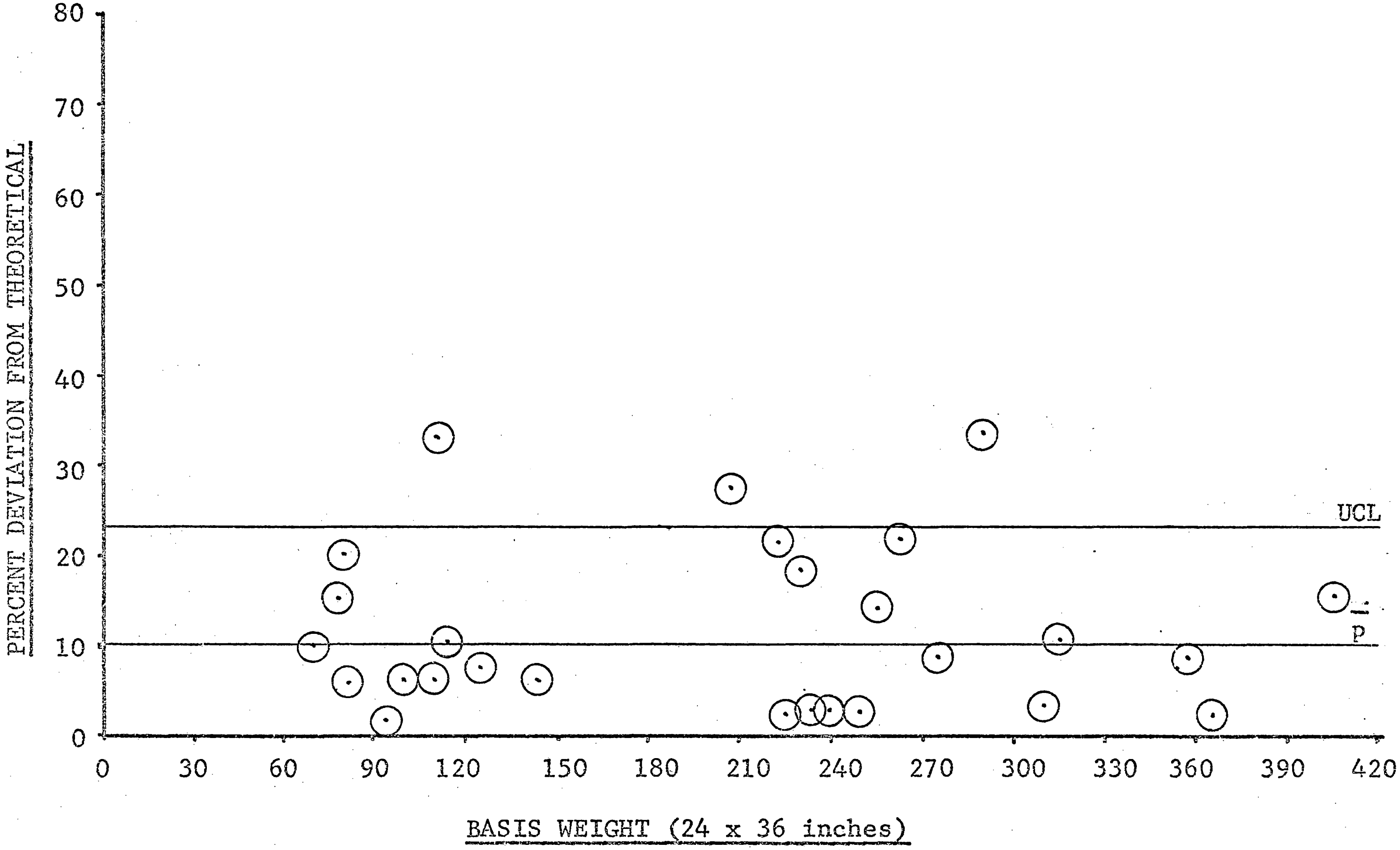
GROUP NUMBER 04

$\bar{p}$ = 10.40%
UCL = 27.13%



GROUP NUMBER 05

$\bar{p}$ = 10.77%
UCL = 22.49%

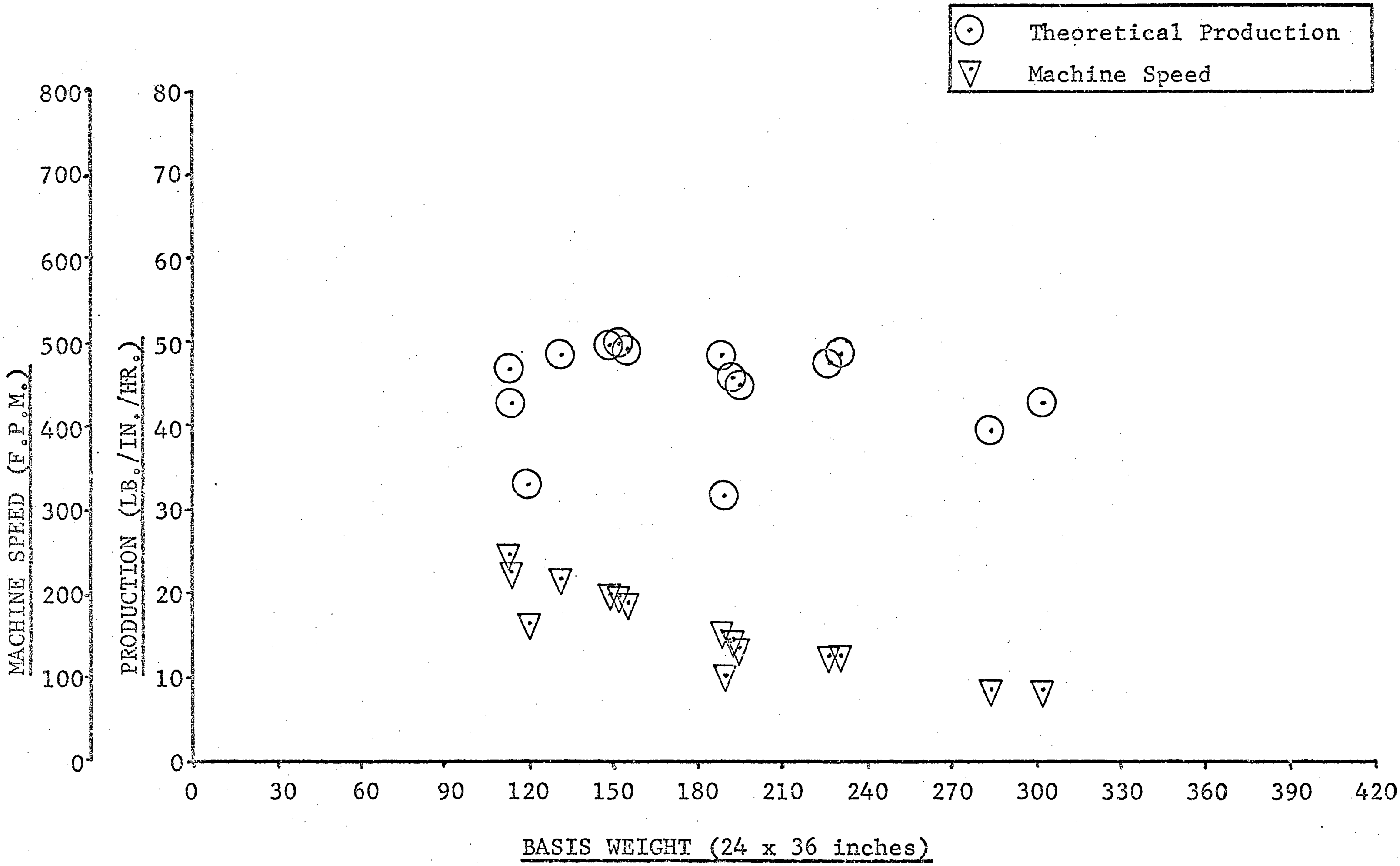


GROUP NUMBER 06

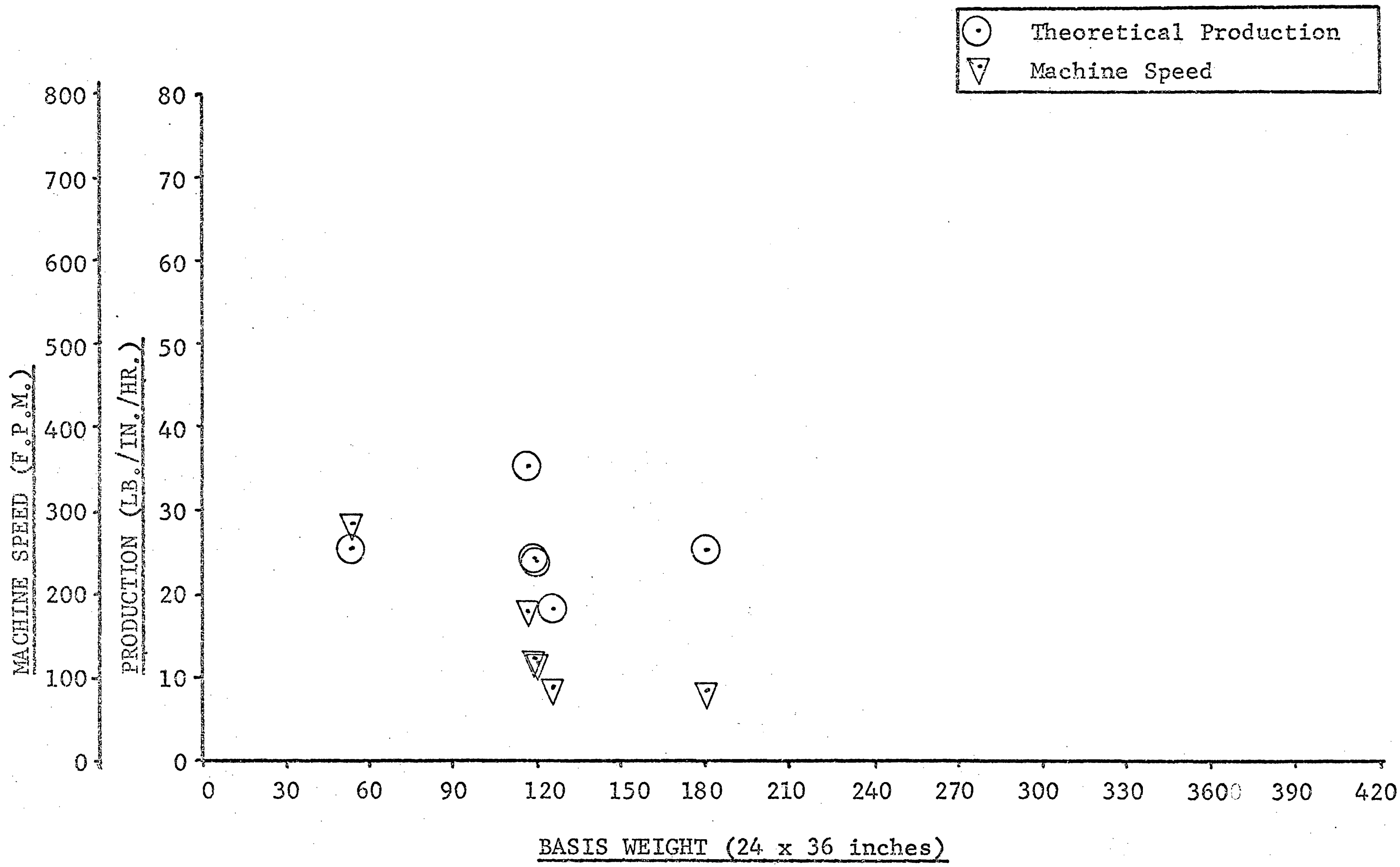
$\bar{p}$ = 10.33%
UCL = 23.51%

APPENDIX H

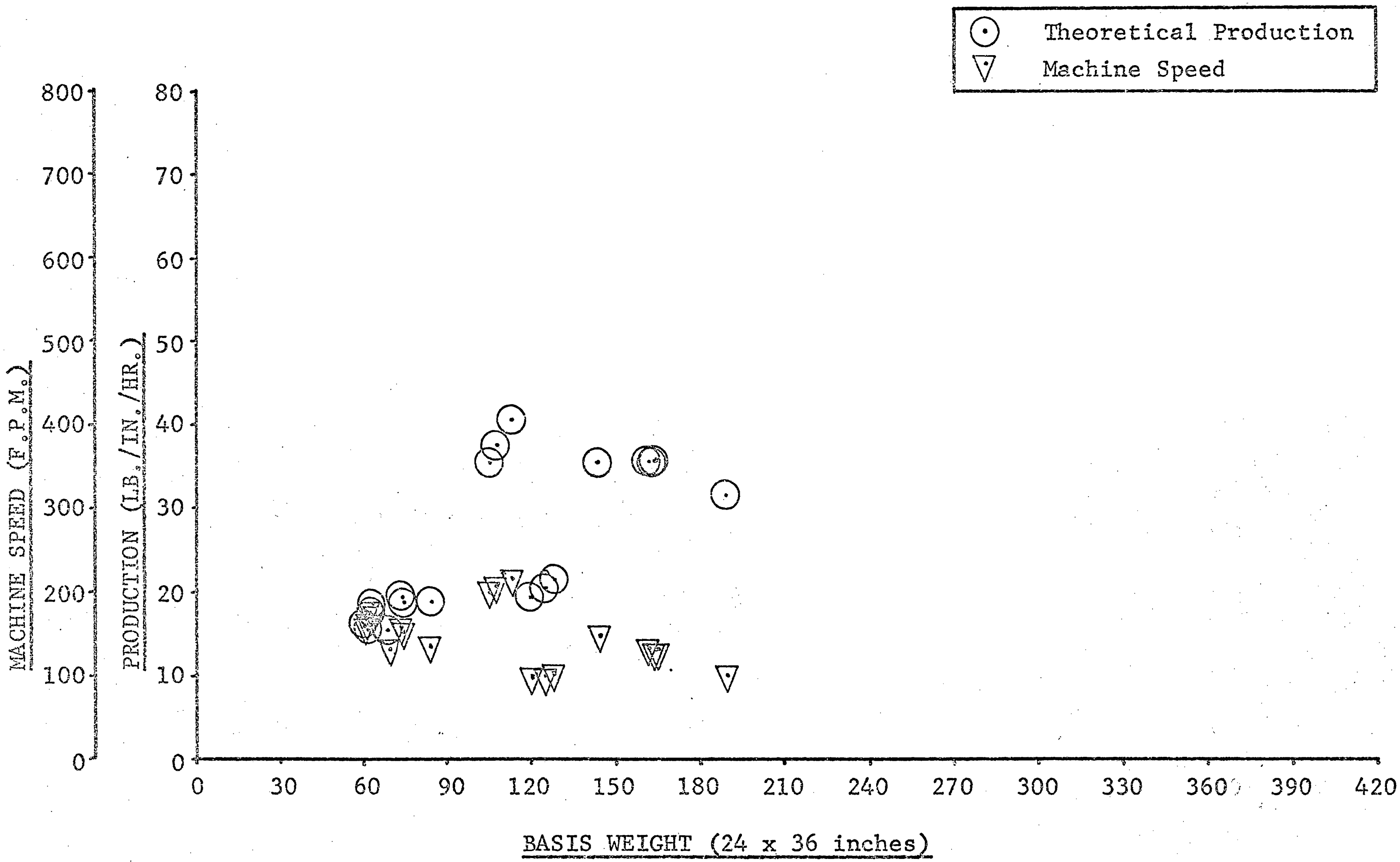
GRAPHS OF MACHINE SPEEDS AND THEORETICAL PRODUCTION



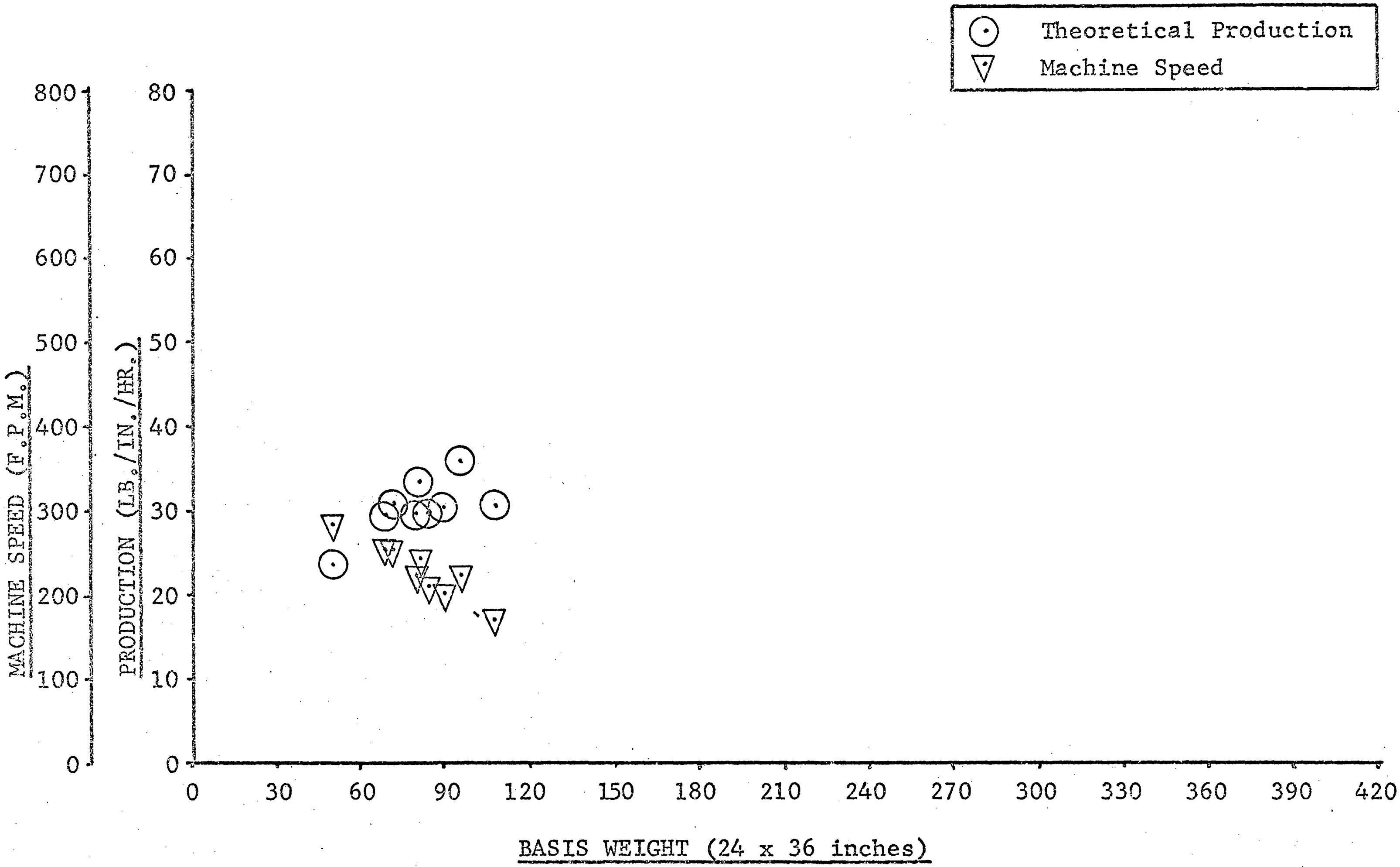
GROUP NUMBER 01



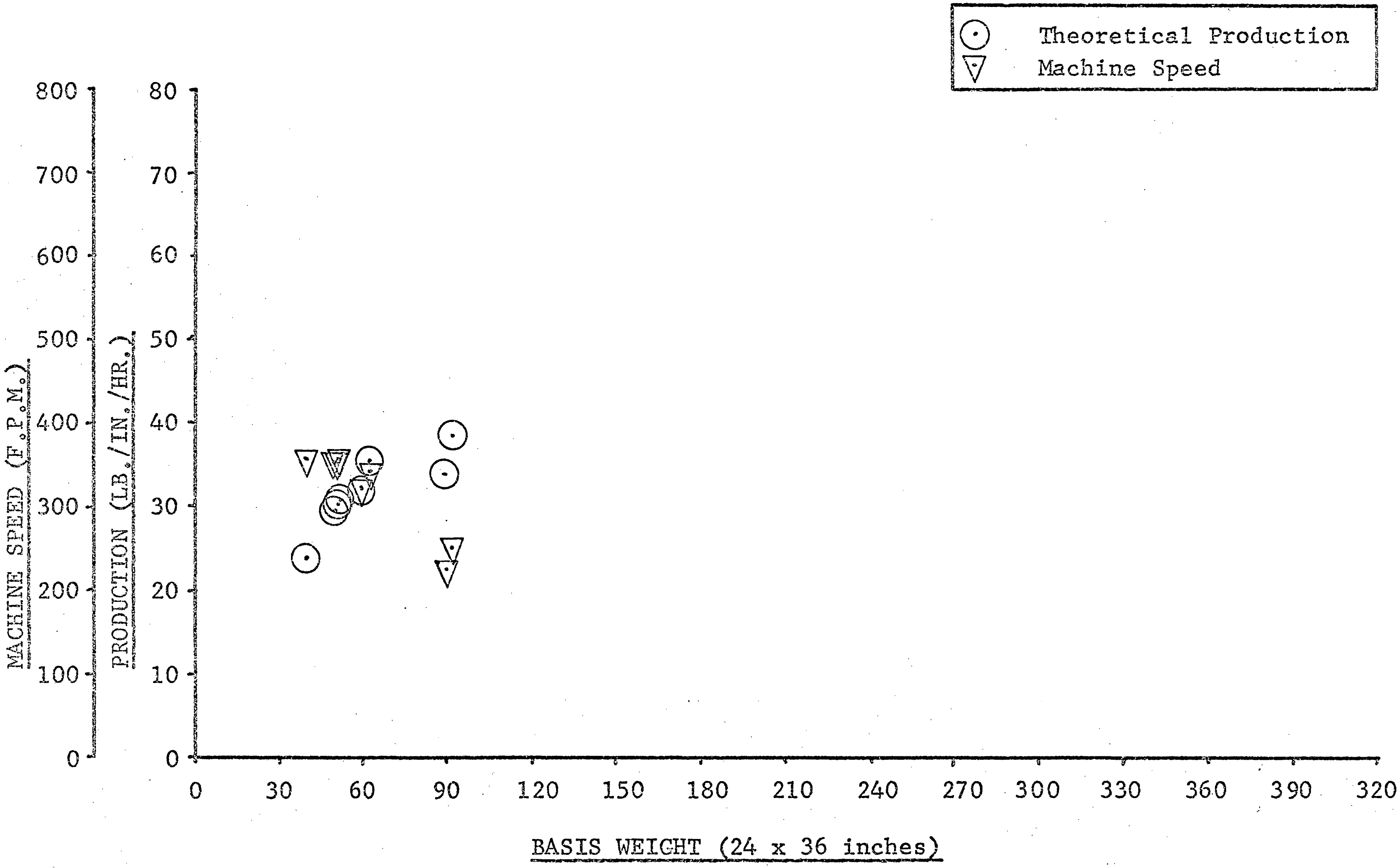
GROUP NUMBER 02



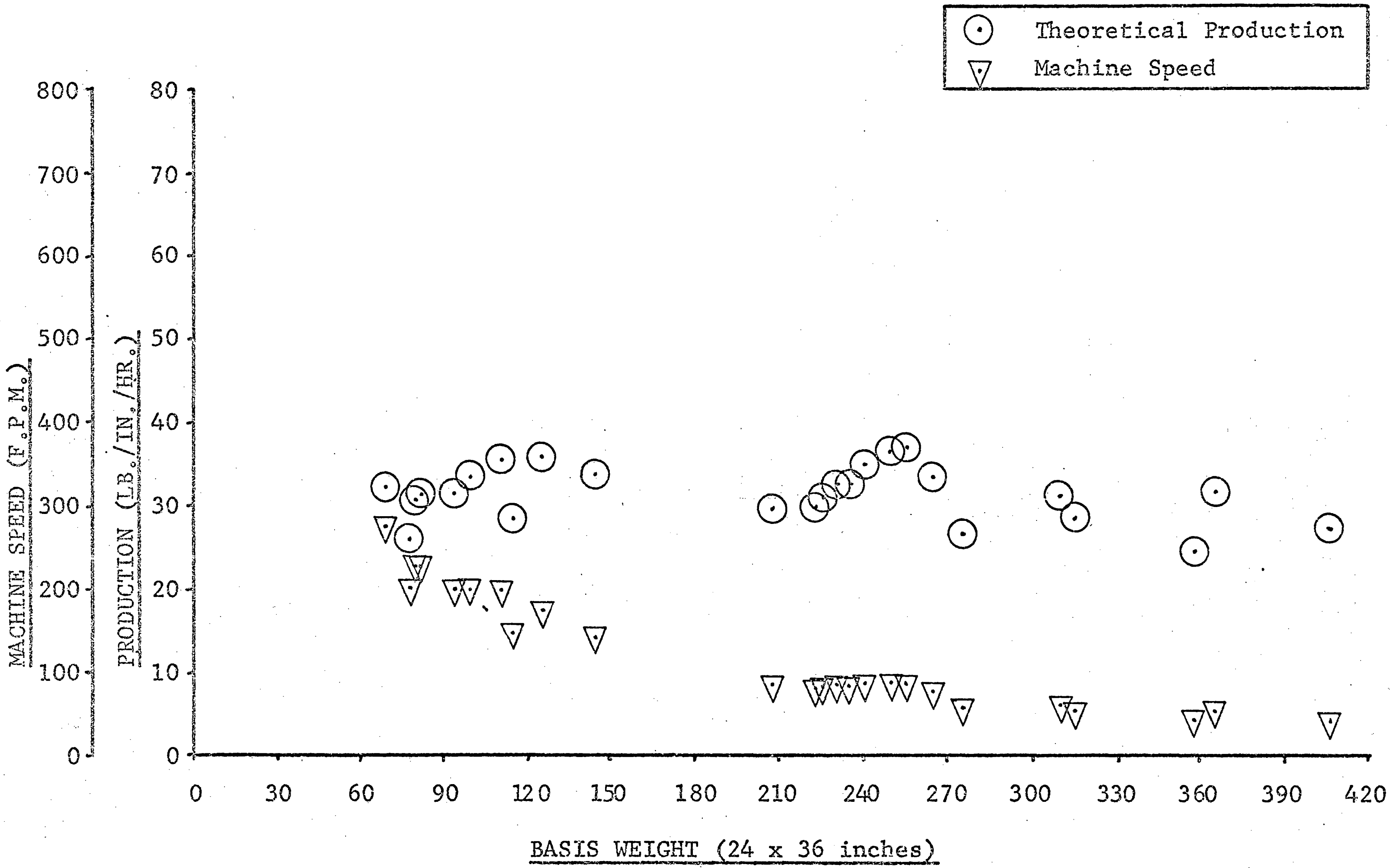
GROUP NUMBER 03



GROUP NUMBER 04



GROUP NUMBER 05



GROUP NUMBER 06

APPENDIX I

LISTINGS OF PRODUCTS BY GROUPS AND CODES

GROUP NUMBER 01

BLOTTING TYPES

PRODUCT CODE	PRODUCT NAME
0101	Blotting
0102	Felt Molding
0103	Ground Rolls
0104	Ground Wood Tablet
0105	Interliner
0106	Matrix
0107	Photo World
0108	Pulp Test
0109	Reliance
0110	Saturated Blotting
0111	Soft Blotting
0112	Special Blotting
0113	Verigood
0114	(eliminated)
0115	Natural Kraft Saturating or Natural Kraft Filter
0116	Seed Germinating
0117	Natural Cushion Stock
0118	Embossing
0119	½ Tone

GROUP NUMBER 02

CREPED FILTERS

PRODUCT CODE	PRODUCT NAME
0201	Crepe Filter
0202	White Crepe Filter
0203	Special Crepe Filter
0204	GR 83 Crepe
0205	GR 84
0206	GR 54 Crepe Filter

GROUP NUMBER 03

FILTER TYPES

PRODUCT CODE	PRODUCT NAME
0301	9000 Filter
0302	Micron Filter
0303	3A1 Filter
0304	3A4 Filter (Wool Flock)
0305	3A2 Filter
0306	3B1 Full Flow Filter
0307	3C2 Filter
0308	M & J Filter
0309	Banana Filter
0310	3E1 Air Filter
0311	3C1 Special Kraft Filter
0312	GR64056 White Filter
0313	3B6 Filter (Cotton Linters)
0314	3B5 Filter
0315	Coaster Stock
0316	3B11 Filter

GROUP NUMBER 04

CREPED KRAFTS

PRODUCT CODE	PRODUCT NAME
0401	Crepe Tape
0402	Kraft Crepe
0403	H82 Kraft

GROUP NUMBER 05

KRAFT PAPERS

PRODUCT CODE	PRODUCT NAME
0501	Tire Wrap
0502	Textile Wrap
0503	Coin Wrap
0504	Kraft Wrap
0505	Shopping Bag
0506	Sack
0507	Dry Wax
0508	Wet Wax
0509	Tube Stock

GROUP NUMBER 06

GASKET TYPES

PRODUCT CODE	PRODUCT NAME
0601	Battery Board
0602	Gasket
0603	Cover
0604	Album

APPENDIX J

GLOSSARY OF SOME PAPER MILL TERMS

BASIS WEIGHT - the weight in pounds (English system) of one ream of a certain size sheet of paper.

BREAST ROLL - a roll that supports the wire at the slice at the headbox.

BROKE - partly or completely manufactured paper that does not leave the machine room as salable paper.

CALENDER - a machine and its auxiliaries capable of producing a calendering action.

CALENDERING - the basic action occurring when subjecting the web of more or less plastic material to pressure in its passage between two or more sets of adjacent rolls, the effect on the material being a change in the surface properties, usually improved smoothness, as well as luster or shine.

CALIPER - the thickness of paperboard expressed in thousandths of an inch and written as a decimal of an inch (i.e.: 0.014 inches is 14 points).

COUCH ROLL - a roll that drives the wire, aids in removing water, and transfers the paper from the wire to press sections.

DRYERS - closed hollow heated cylinders that dry the paper by contact with its hot outer surface.

FELT - a woven fabric of yarns, usually woolen, in a continuous band.

FORMATION - that quality which describes the structure of a sheet of paper (the manner in which the fibers are interlaced).

FOURDRINIER PAPER MACHINE - a machine for making papers in an endless web.

HEADBOX - a device which receives stock (stuff) and delivers it onto the wire through the slice.

MACHINE DIRECTION - the direction of paper travel on the papermaking machine.

NIP - the point of contact between two rolls.

PRESS SECTION - the part of the wet end of the paper machine after the wire that removes water mechanically by presses.

REAM - a paper measure of a number of sheets (normally 480 or 500 sheets of paper in a ream of paper).

SLICE - the part of the headbox that delivers the stuff onto the wire in a uniform manner and with random orientation of the fibers.

STOCK - see stuff.

STUFF - wood pulp, chemicals, and other ingredients of paper in approximately a 98 per cent water solution at the headbox. Also called stock.

SUCTION BOXES - suction devices that remove water from the wire by a difference in pressure between the top and bottom surfaces of the paper sheet.

TABLE ROLLS - rolls that support the wire and aid in water removal by their action on the wire while turning (removes about 70% of the water along with the wire).

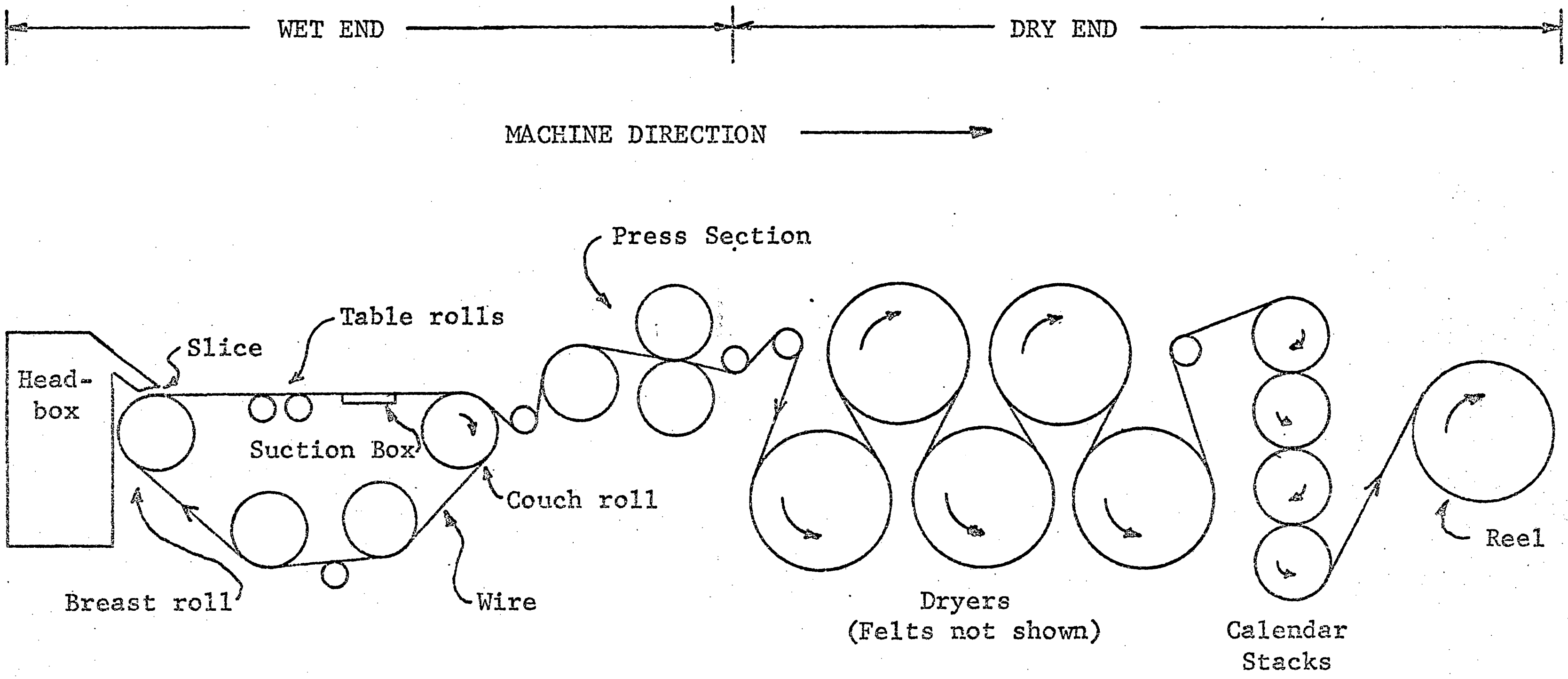
TAPPI - The Technical Association of the Pulp and Paper Industry.

WET END - the section of a paper machine where the water content is very high and consists of the headbox, wire, press sections, and associated parts.

WIRE - a sheet of fine wire gauze joined by a seam to form a continuous band to take the mixture of fiber and water from the slice and drain water from it leaving a well-formed sheet of paper on its surface.

APPENDIX K

SCHEMATIC OF A FOURDRINIER PAPER MACHINE



SCHEMATIC OF A FOURDRINIER PAPER MACHINE

A METHOD FOR DEVELOPING PRODUCTION STANDARDS FOR A FOURDRINIER PAPER MACHINE PRODUCING SPECIALTY PAPER GRADES

(Winston Blaker Bolling)

Abstract

The purpose of this study was to explore a method for developing production standards for a low-production fourdrinier paper machine producing a wide range of specialty paper types. The approach was based primarily on noted historical deviations of actual production from production indicated from the use of formulas or nomographs describing the theoretical production possible. Using FORTRAN IV on an IBM 360, a program capable of accepting and analyzing historical data in order to develop production standards was developed. The program is also capable of comparing production runs on a particular day with the historical standards. A similar approach could be applied in both specialty mills and in high-production mills using the fourdrinier paper machine. The production standards developed from such a method would provide a basis for standard cost accounting by product and by production run, would permit evaluation of changes in the machine, and would provide a means to evaluate machine and crew performances. Quality control chart methods incorporated in the computer program

would also aid in pointing out production runs with extreme deviations from the historical standards of production in order that checks could be made for assignable causes.