MATERIAL HANDLING EFFICIENCY IN THE KALAMAZOO VALLEY PAPER INDUSTRY

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ABSTRACT

MATERIAL HANDLING EFFICIENCY IN THE KALAMAZOO VALLEY PAPER INDUSTRY: A CASE STUDY

By

Roy William Groulx

The purpose of this thesis is to present a set of guides to aid management in the paper making industry to control some costs in the area of material handling.

Six paper plants in the Kalamazoo Valley were studied to determine what percents of their production costs were being absorbed by the material handling function. Material handling labor and direct labor time involved in material handling activities were determined by time studies. Wage rates for these labor groups, as well as for the total work force were obtained from company records.

Equipment utilization was also subjected to time studies to determine to what extent the paper mills were using their material handling equipment. It was also determined by complete measurement how much of its available storage space each plant was actually using.

These data were used to compute the following four ratios, which had been devised by the Material Handling Division, Yale & Towne, Inc.:

1. Material handling labor ratio:

$$\text{MHLR} = \frac{\text{Wages of personnel assigned to material handling duties}}{\text{Total wages of plant operations force}}$$

2. Direct labor handling loss ratio:

$$\text{DLHLR} = \frac{\text{Direct labor wages attributable to unnecessary material handling}}{\text{Total direct labor wages}}$$

3. Space utilization efficiency:

$$\text{SUE} = \frac{\text{Cubic feet usefully occupied}}{\text{Net usable cubic feet of space}}$$

4. Equipment utilization ratio:

$$\text{EUR} = \frac{\text{Actual output}}{\text{Theoretical capacity}}$$

It was determined that the material handling function was absorbing 22.2 to 35.8 percent of the production costs at the six paper plants. From 8.5 to 19.9 percent of their direct labor payrolls was being used to handle material. Utilization of their equipment ranged from 22.6 to 55.6 percent while space utilization ranged from 34.4 to 66.6 percent. The high ratios for material handling labor can be traced to inadequate organization and poor planning. The high direct labor costs stem from poor methods and sloppy job analysis. The best direct labor ratio appeared in the plant that continually studied direct labor activities. The space utilization ratio was best in the plant that had suitable equipment and practiced use of the available vertical space. The equipment utilization ratio was best where concern was placed on maintenance and equipment suitability for the task. Summaries of individual plant inputs are compared with the averages for the industry and recommendations for management action are given.

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Roy William Groulx

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CHAPTER I

INTRODUCTION

Since the turn of the century, the study of material handling has progressed and broadened, and there has emerged a better understanding of the scope of the art and science involved in material handling. However, reference to material handling problems is not susceptible to a single definite answer but depends largely on the experience and judgment of the individual material handling engineer. Although this fact indicates that modern material handling is still an art, modern analytical methods are being perfected, and engineering data, formulas, statistics, and standards, which are beginning to approach the stage of science, are being developed. These factors are becoming increasingly helpful in arriving at more definite answers for the many aspects of the problem. Although material handling may always remain, to a large degree, an art, it will become increasingly scientific as its principles become better understood and applied.

To become more objective and more of a science, the material handling function needs an index of performance and a comparative standard. It is to this end that this research was conducted.

It is the purpose of this study to disclose the material handling costs that are included in direct labor and indirect labor charges that are generally not identified separately in the accounting process. Much of this cost, if known to the production people, could be eliminated or at least reduced. Material handling costs are generally included in indirect labor charges, and may not be segregated from other manufacturing costs in the accounting system. This failure to identify the large segment of labor costs attributable to material handling has hidden its effect from management.

A further purpose of this research is to identify material handling costs in the area of manufacturing that has been neglected, and which accounts for a considerable amount of all production costs, equipment and space utilization.

It is hoped that the development of ratios for each of the researched areas will guide management toward better decisions in the allocation of their resources.

Material is defined as any item in raw, in-process, or finished form which will become a physical part of the finished product before shipment from the plant.

Material handling has the following four characteristics(20):

1. Time - all materials and products are required at certain places at specific times.
2. Motion - movement of materials and products from one place to another are necessary to meet the above time requirements.
3. Quantity - required amounts of materials and products must be made available at the proper

place and at the proper time.

4. Space - space required to handle, process and store materials and products.

The material handling function totally integrates such widely varied ingredients such as the product mix, the environment, the work areas, the handling equipment, the work methods, and the industrial operation. Its total scope includes the transportation of raw materials, warehousing, shipping and distribution of the final products.

This research was restricted to material handling within the paper mill areas which completely supported the paper making process.

CHAPTER II

THE PROBLEM

Material handling costs incurred by direct and indirect labor in paper making plants are not easily identifiable due to their varied nature. It is possible that these costs are relatively excessive and could be subsequently reduced. Storage and operating space, used and unused is a major consideration in any facility. Space requirements and controlled inventories are greatly influenced by material handling.

Space costs money, whether it is used or unused(2). Considerable costs can be saved by taking full advantage of space in which much investment was involved. Equipment utilization, that is, to what extent is the material handling equipment being utilized, is also important. Knowledge of equipment utilization can lead to substantial savings in equipment investments, increased production capacity and greater efficiencies of operation.

Direct labor is defined as all labor whose wages can be traced to specific physical units of product. Direct labor efforts are often lost because direct labor, being more highly paid and skilled, is handling materials instead of performing its primary tasks(20).

Indirect labor is defined as all labor whose wages cannot be directly traced to specific physical units of product. In relation to this definition, it is apparent that material handlers incur indirect labor costs(20).

This study was restricted to that part of the paper making process involving the handling of direct materials, such as wood pulp and chemical additives. These direct materials eventually become an integral part of the finished product and their costs can, therefore, be assigned to specific physical product units.

Material handling also occurs at both ends of the operating system. It includes the transfer of raw materials from receiving, through storage into the actual processing system by direct labor, the handling of work in processing operations, and the handling of work in process between operations, and the handling of the finished product after all processing is completed.

Material handling at the input and output ends of the system is accomplished by the indirect labor specifically assigned to that task. In the processing system, material handling occurs where direct labor is engaged in secondary functions of handling materials. This secondary function of direct labor does not receive management's scrutiny for efficiency that it would receive as a primary function.

Since material handling is part of an integrated and highly complex system, its costs are often hidden and not readily isolated from the total operating costs. For this reason, management often tends to overlook these costs and they are assigned to some other aspect of the operation. Any tool that would allow these costs to be readily identified and quantified would enable management to better control them.

Ratios Used

The Material Handling Division of Yale and Towne, Inc.(29), has developed several ratios which allow us to quantify material handling costs in terms of relative dimensionless indices. Four of these Yale and Towne ratios are especially pertinent to this investigation of labor cost, space utilization and equipment utilization percentages within a given company.

The dimensionless quality of these ratios also makes them applicable to comparing the costs of totally unrelated operations.

The four Yale and Towne ratios used in this study are:

1. The Material Handling Labor Ratio (MHLR) is the ratio of the wages of personnel assigned to material handling duties, to the total wages of the plant operations force.

$$\text{MHLR} = \frac{\text{Wages of personnel assigned to material handling duties}}{\text{Total wages of plant operations force}}$$

This ratio measures the proportion of a plant's operating costs which are directly chargeable to material handling.

Use of the MHLR will enable management to:

A. Control basic material handling costs in relation to total costs.

B. Consider the extent to which the material handling system can be improved between operations and on an overall basis within the plant. It also can be used to help determine whether a material handling responsibility function should be established within the plant.

C. Gauge the success of a change in the handling system as to whether or not it meets the cost saving objectives.

D. Study long-term trends in the material handling function to justify or to alter earlier programs.

E. Determine how a specific plant compares to general practice in the industry.

2. The Direct Labor Handling Loss Ratio (DLHLR) is the ratio of direct labor wages attributable to unnecessary handling of materials, to the plant's total direct labor wages.

$$\text{DLHLR} = \frac{\text{Direct labor wages attributable to unnecessary material handling}}{\text{Total direct labor wages}}$$

It measures the relative amounts of direct labor costs lost due to workers handling materials when they should be doing their primary assignments. The DLHLR enables management to:

A. Check lost production costs in operations with high direct labor content and appraise the potential savings of better material handling methods.

B. Gauge the effect on material handling costs within production operations after the product, layout, processing method, and/or material handling methods are changed.

C. Determine if plant management has given skilled labor adequate attention to reduce unnecessary material handling that it is presently doing.

D. Determine how a specific plant compares to general practice in the industry.

3. Space Utilization Efficiency (SUE) is the ratio of cubic feet usefully occupied, to the net usable cubic feet of space in the building.

$$SUE = \frac{\text{Cubic feet usefully occupied}}{\text{Net usable cubic feet of space}}$$

This ratio measures how effectively the enclosed plant space is being utilized. The SUE enables management to make decisions concerning:

A. More economical use of present space.

B. Three dimensional use of space. Are materials being stacked to reasonable heights? Is thousands of dollars worth of cubic feet of space being wasted merely because high lift equipment is lacking?

C. Aisle space, lack of racks, cluttered, crowded, jammed, or chaotic storage areas.

D. How a specific plant compares with general practice in the industry.

4. Equipment Utilization Ratio (EUR) is the ratio of actual output to theoretical capacity of the equipment.

$$EUR = \frac{\text{Actual output}}{\text{Theoretical capacity}}$$

This ratio shows the extent to which material handling equipment is being used to its full potential. The EUR enables management to make decisions concerning:

A. Better handling facilities or techniques that will increase output significantly.

B. Capital investment justification.

C. "Bottleneck" operations.

D. How a specific plant compares to general practice in the industry.

The first two ratios, MHLR and DLHLR, are computed in dollars rather than time or numbers of employees in order to provide a standard measure for comparison.

Labor wage rates change over time within a given plant and differ among plants. Thus, ratios in terms of time or numbers of employees would not be comparable unless these wages were constant and uniform. Any wage scale change or difference would render these ratios useless for direct comparisons unless they are computed in monetary terms. Costs are a very specific measure of the skills and responsibilities assigned to a function.

Another advantage of using dimensionless ratios for the MHLR and the DLHLR is that they can be studied during periods of different price indices or wage scales and the wages involved need not be converted to a common base. The dimensionless ratios themselves establish the common base for comparison.

The SUE ratio can be best described and compared by defining it in terms of percent of space utilized. Further analysis can be expressed as actual costs. The EUR ratio is the actual output as a percent of theoretical capacity. This can be expressed in monetary terms.

Material Handling

As a member of the Engineering and Technology faculty at Western Michigan University with a teaching assignment in the Industrial Engineering Department, I teach a course in material handling. Much written material can be found on the subject, but evidence of the importance of material handling in industry is limited(4). The significance of material handling is often underestimated by management. It is common practice to divide material handling responsibilities among several centers such as finance, production and marketing. This crippling split in responsibilities is tantamount to neglecting the material handling function altogether since it opens the door for overlapping responsibilities and duplication of effort on the one hand, as well as gaps in responsibility and "buck passing" on the other. Centralizing the material handling function under one manager can overcome these hierarchical nightmares(7). Some firms centralize the entire materials management function under a materials manager, who is given responsibility for the total flow of materials and has a staff to implement this activity.

Material handling is everywhere. Material handling is common to all types of business and to all industries. It has been classed as the universal industrial problem, a problem that can never be eliminated but can always be improved. Many management people consider material handling as the last major frontier in the continuing search for ways to reduce costs.

Over the years, I have become aware of the material handling problems that exist in the many plants in which I have had the privilege of working, especially the paper mills in the Kalamazoo Valley. There are many practical methods of solving material handling problems but there have not been any "bench marks" established that a manager could use as guides in his decision-making processes. The four ratios, MHLR, DLHLR, SUE, and EUR will enlighten management and serve as guides for decision-making in the area of material handling.

CHAPTER III

THE PAPER INDUSTRY

Paper manufacturing in the United States is an old established industry in its late maturity or market decline stage of its life cycle. Competition among firms is intense. All paper is essentially the same and none of the firms can claim any significant differentiations in product or break-through in manufacturing technology. Profit margins are slim and the market structure is an oligopoly(24, 25, 26).

Paper ranks about tenth among all United States industries in size, and it is the only one among the ten that is fully competitive in the foreign market(26). A few new paper products such as disposable paper clothing and paper air filters for automobiles and air-conditioners are causing some competition with other industries, but the vast majority of sales consists of the standard paper products which are highly competitive within the paper industry.

The major divisions in the industry can be made in terms of paper and board. Paper itself can be classified as either white bleached paper, krafts and sulfites, or kraft grades such as corrugated and grocery sacks. The markets for paper products are classified as cultural (printing and writing paper), broad usage (packaging, boxes, etc.), and sanitary tissue. A paper firm can have either of two main forms: integrated (it owns forests) and non-integrated (it does not own forests). As in all oligopoly situations, paper firms are large and their means of production (paper mills) are large.

Companies cannot afford to build new mills at present prices and profit margins. Small mills are not being built because of economics of scale. The problems involved in the industry are solvable for a large company, but totally impossible for a small or medium-sized company. This situation leads to only one possibility for a paper firm which wants to expand its production capacity - the large company makes additions and extension to its existing old plants.

Paper companies are becoming extremely profit conscious, resisting any proposal for change unless it is almost certain to increase their profits. In the past the industry was highly production oriented. The motto was, "Keep the machines running no matter what". Currently, however, the machines are run at a "sustainable" level of operation. Domestic plants produce 53 million tons of the 58 million tons of paper used annually in the United States. Five million tons are imported(26).

Plant Orientation

The selected companies in this study accomplish pulping, paper making, and paper finishing operations. Their annual sales range from 17 million to 200 million dollars. Their raw material consists of coarse semi-processed pulp; chemicals such as titanium, dyes and sulfites; "broke", which is simply paper shreds and scraps; and finally, water. Railroads, trucks and pipelines transport the raw materials to the plants, and railroads and trucks carry the finished products to the distribution channels of the plants. These channels consist of paper converting companies such as newspapers, printing companies, and manufacturers of all types of finished paper products.

Paper mills operate on the job shop system (Figure 1). Specific customer orders are relayed to the mill by teletype from the corporation's central office, which may be located in a distant part of the country. Some mills have the capability to turn out several thousand different product items ranging from two-thousand-pound rolls of paper to small writing tablet sheets. There are countless finishes, sheet sizes, colors, weights, and qualities of paper that can be combined. Each combination presents a new handling problem. The equipment and operations must be reset for each order and this includes every process from the mixing of the pulp, water and chemicals to the cutting, packaging, and shipping of the product. The orders from customers are taken and filled in such rapid succession that there is seldom more than a four-day inventory buildup. Since the operation of the Fourdrinier (paper machine) is fully automatic and continuous as long as a given order is being

	Material receiving and storage	Automatic process of paper manufacturing	Cutting and packaging paper	Storage and shipping
→ → → → → → → → → → → → → → → →	Wood pulp bales Chemical additives Broke* Operating supplies	Continuous mixing of raw materials and operating automatic paper making equipment	Cutting production sized rolls to individual order size requirements	1500# rolls to palletized sheets → → →
Direct Labor		Preparation and mixing of raw materials - operating automatic paper making equipment - rerolling of paper rolls - reworking broke	Cutting - packaging and weighing of order unit sizes	
Direct Labor Loss	Direct labor involved in material handling operations listed below rather than primary tasks			
Indirect Labor in Material Handling	Unloading of raw materials - storing raw materials → → → → → →	Transporting raw materials to point of usage - transporting and storing broke → → → → → → → → → → → → → →	Transport paper from storage to cutters or packaging - transport cut paper to packaging, transporting and storing broke → → → → → → → → → → → →	Transport packaging to storage - transport from storage to shipping - load shipping carriers → → → Flow

*Broke - Scrap or waste from production operations

Figure 1. -- Schematic paper manufacturing operations

filled, the transportation of the materials to the machine and the handling of the semi-finished product after it leaves the machine can be studied intensively.

CHAPTER IV

PROCEDURE

This investigation was designed to discover the proportion of paper mill labor costs attributable to material handling, both direct labor costs and indirect labor costs, and also material handling equipment utilization and space utilization.

In view of management's generally subjective judgments regarding material handling costs, and the many informal investigations that I had made in this subject matter area over the past 16 years, I made the following hypotheses:

1. In the paper manufacturing industry, the material handling costs incurred by indirect labor generally amount to 25% of total production costs.
2. Approximately 10% of direct labor is absorbed in the material handling activity in the paper manufacturing industry.
3. Material handling equipment utilization in the paper manufacturing industry amounts to about 60% of capacity.
4. Space utilization is about 50% in the paper making industry.

Six paper companies in the Kalamazoo area representing the major paper producers in the United States were selected for this study.

Interviews

The manager and industrial engineer in each plant was interviewed. Each of the interviewees was extremely interested in my study, but some of them did not agree with my general hypothesis regarding the high costs of material handling. A questionnaire was prepared to be filled out by each interviewed manager. A check list of questions was also used for the initial interviews. The resulting information was used to select mill operations that could be compared (see Appendix).

During the interviews, the six plant managers indicated that they welcomed the opportunity to benefit from a study such as this. The managers were, without exception, extremely cooperative and responsive and said that they would assist in any way possible in carrying out this study. All managers and their subordinates opened up their records and facilities in an unbelievable manner to aid me in this study.

Plant Tours

After interviewing the plant manager or industrial engineer at each of the plants, a tour of the production facilities was conducted through the courtesy of the respective plant manager. The tours included seeing warehouses; receiving and shipping platforms, the paper making machines; giant mixers which blend pulp, broke, water and chemicals; forklifts; overhead cranes; and weighing and packaging machines. Every plant (mill) visited had "evolved" over the last fifty or sixty years and, therefore, consisted of several seemingly unrelated buildings ranging in age from sixty years old to quite modern. These buildings were usually attached to each other at odd angles since the available space to expand was seldom located where the designer of a new facility would desire it. This random plant layout often constitutes a definite, serious constraint on the potential efficiency of nearly all production operations, but most of all, material handling.

Data Collection

The data on wages of material handlers, and wages of the total operations work force were obtained from plant records. All job classifications were checked and verified(31). Management, in no case ever held back any information. All wage rates were multiplied by the number of minutes the material handler spent in doing his job(31). All of these data were summarized for all material handlers. All times were verified by actual stop watch studies using statistically sound sampling techniques.

Likewise, data on total direct labor wages were obtained from plant records.

Work sampling techniques were used to obtain data for computing the Direct Labor Handling Loss Ratio. The objective was to determine the costs to the company of direct labor's material handling activities within a reasonable level of confidence, by observing direct labor workers as they did their jobs.

There were two basic questions to be resolved in formulating the work sampling plan:

1. Which workers will be observed and how many?
2. When will the chosen workers be observed and how often.

Work sampling utilizes statistics in taking randomly assigned instantaneous observations of a job over a protracted period of time(7). The accuracy of this technique is dependent on the number of observations taken, precision of sampling process, and the precision of measurement in the observed activities. The main problem is determining the number of observations needed for the accuracy desired. Reducing the number of observations will result in a lower cost for the study.

To minimize the cost of the study and, at the same time, maximize the efficiency of the sample designs, I used all the prior knowledge I had of the populations from which my samples were to be drawn. The goal was to reduce the standard error for a given sample size, or reduce the necessary sample size for any given standard error.

Sampling Methods

Workers in paper mills are highly amenable to stratified sampling. They can be stratified by work shifts, job classification and by plant departments. It can be ascertained, within a significant level of confidence, whether or not, the three 8-hour work shifts can be considered the same within each department and whether or not all workers within a job classification spend an equal proportion of their time on material handling. If all work shifts are the same, then one shift can be chosen to represent all three, or the sampling can be distributed among all three shifts. Since all of the mills ran continuously, there were three shifts and each one must be compared to the other two. This leads to three combinations of shifts, or three hypotheses to be verified for each department. Proving that two shifts are similar does not infer that the third shift is similar to either of the first two because shifts might be operating quite differently.

Sampling from all shifts and comparisons between workers within a given job classification proved that workers in the same job classification, regardless of shift, were alike in times spent on material handling. Thus, I was free to choose from any shift and a worker in a given job classification could be used to represent all workers within the same job classification.

The precision of the test is a function of the number of observations taken or sample size. Some minimum sample size is required to estimate the universe parameter, $\bar{P}'$, with a given level of precision. This precision can be described by a maximum allowable error, E, which is set at an acceptable level by the researcher.

The maximum allowable error used in this study was set at 10% at a confidence level of 95%.

Standard statistical procedures were used in arriving at sample sizes to meet the desired precision.

The standard error of the population:

$$\sigma'_{\bar{P}'} = \sqrt{\frac{\bar{P}'(1 - \bar{P}')}{\sqrt{n}}}$$

where $\bar{P}'$ = the true average for the population

and $\sigma'_{\bar{P}'}$ = the true standard error with respect to the true average

and n = the sample size required to give the true standard error

and σ = standard error of the sample

Substituting:

$$\sigma = \sigma'_{\bar{P}'}$$

we get the standard error of the average

$$\sigma_{\bar{P}} = \frac{\sigma}{\sqrt{n}}$$

For my research the sample size was determined as follows:

The general equation

$$n = \left(\frac{(Z)}{(E)}\right)^2 \bar{P} \quad (1 - \bar{P})$$

where

Z = 1.96 (a multiple of the standard error as found in a table of areas under the normal curve for a given confidence level)

E = 10% (maximum allowable error)

becomes:

$$n = \left(\frac{(1.96 \; \sigma_{\bar{P}})}{(0.10 \; \bar{P})}\right)^2$$

where $\sigma_{\bar{P}}$ is obtained from a small random sample estimate.

For a confidence interval of 95% Z = 1.96. $\bar{P}$ was determined by taking a small "pilot sample" of direct workers to determine a rough estimate of $\bar{P}$. This estimate was then refined during the study period after more observations were taken. This method is flexible because, after the data have been gathered, an estimate of $\bar{P}$ can be calculated from the pilot study, we have further verification that the sample is adequate. If the new $\bar{P}$ is different, we can use the larger for conservatism, leading to a larger n; or we can temper the result with management's judgment and/or the ultraconservative $\bar{P}$ = 0.5 value.

If we hypothesized that P = 0.15

$$n = \left[\frac{(1.96)}{(0.1)}\right]^2 \quad (0.15) \quad (0.85)$$

n = 49

Therefore a sample of 50 observations would be adequate.

The calculation of the sample size for comparing two work shifts within a department and two workers with a job classification was done by the same analysis.

The observer monitored the randomly chosen workers at randomly picked times during a work shift. These random times were established by using a random number table. Operators chosen were clocked for a complete cycle of events. Material handling times were recorded. Based on the sample, the proportion of time he was doing material handling was expressed as a percent of his total working time.

CHAPTER V

RESULTS

Standards for Material Handling Operations

In general, none of the plants studied had any type of definite, current or usable work standards for any of its material handling operations. The primary reason for this lack of attention was that managers did not consider material handling in the plant to be of sufficient importance to warrant the development of such standards, even though they estimated that material handling costs account for fifteen to twenty percent of total production costs. They were unaware of any easily quantifiable methods of analyzing material handling functions. They believed that the wide varieties of material handling operations in their plants simply did not lend themselves to enforceable standards since these functions depended so heavily on human operators, such as fork truck drivers, lift operators, railroad car loaders, etc. However, the companies did have established standards for production rates for their automated paper machines, since these did lend themselves readily to such standards.

None of the plants had ever conducted any type of formal investigation into their material handling operations and costs. This was probably due to the fact that they simply do not consider material handling to be one of their primary cost problems. Each plant has a budget for capital expenditures, including material handling equipment, but much of this equipment (for example: battery powered fork-lifts and pallet dollies) is between thirty and forty years old. All managers agreed that direct labor workers engage in material handling, but do not know to what extent. Occasionally, serious accidents occur which are directly related to material handling.

Major Problem Areas

The key plant personnel interviewed agreed, in general, that their major problem areas were the following, in order of priority:

1. Maintaining an economical, efficient and continuous production rate with the manufacturing equipment (equipment productivity).
2. Maintaining an acceptable level of quality in product (quality control).
3. Scheduling production runs on the manufacturing equipment so as to minimize change over down time and maximize production utility.
4. Material handling, usually due to spoilage problems caused by movement of the paper rolls or paper stacks from one operation to another.

All interviewees shared the common attitude that they "are interested" in material handling operational costs, but the item is low on their priorities list. Consequently, it received little direct attention.

Material Handling Responsibility Centers

None of the mills studied had a specific identifiable material handling responsibility center. In trying to find and determine the importance of material handling in the organizational hierarchy in each of the plants, it was found that the responsibility level varied considerably among the different plants. This level ranged from plant industrial engineers, who usually were not able to allocate any time to the problem, to first line supervisors in charge of material handlers. The interviewees formed a consensus of opinion, independently of each other, that the lack of a material handling responsibility center was due to the fact that the function was not considered to be a major problem area. Therefore, priorities were given by them to what they considered more productive areas of concern.

General Plant Situations

Every mill has several buildings which are spread over a considerable area. These facilities have "evolved" over a period of eighty years, and instead of tearing down antiquated buildings, the plants make use of their old buildings, therefore, they are old and dysfunctional. Many of the buildings now used as warehouses have ceilings less than seven feet high. One warehouse has a fire sprinkler system which hangs from its low ceilings, and occasionally a fork lift truck severs one of the pipes. The ensuing flood destroys much of the paper and chemicals stored there. The oldest of the buildings are used as warehouses. These, in general, are not located centrally, but rather in various corners of the complexes. One elevator services most of the warehouses.

The general condition of the wood floors in the storage areas does not permit the use of the proper equipment to do the job. Many of the floors had to be shored up to permit limited use of the available space. In most of the plants studied the storage areas are a definite fire hazard. There appeared to be a considerable amount of waste paper that was completely by-passed.

The material flow pattern in use did not result in the most efficient routing. Fork trucks traveled torturous routes which, in many instances, doubled the distances that should have been traveled had consideration been given to the flow patterns.

Material Handling Labor Ratio

The Material Handling Labor Ratio was computed by classifying the material handling work force into one of two categories:

1. Persons concerned entirely with moving materials. In this category, their total wages apply.
2. Persons whose work is only partly devoted to material handling activities. In this category, their wages are multiplied by the percentage of time actually spent on material handling.

The percents of material handling labor time spent in various job classifications in each of the six plants studied are presented in Table 1.

TABLE 1. -- Material handling labor in all plants
Material Handling Department

Job Classification	Percent of time spent on material handling						
	Plant A	Plant B	Plant C	Plant D	Plant E	Plant F	Average for six plants
Lead tractor driver	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Tractor drivers	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Swing tractor drivers	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Spare hands	--	45.0	--	25.0	30.0	--	33.3
Unloader	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Utility spare hand	80.0	85.0	81.0	75.0	72.5	80.5	78.7
General beater helper	58.2	65.0	100.0	75.0	80.0	88.6	77.4
Roll stockman	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Roll handler	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Shipping clerk	24.0	18.2	16.0	14.0	75.0	22.0	28.2
Core storage	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Rewinder	16.0	15.0	--	10.0	18.0	14.7	14.7
Stockman	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Group leader	9.0	30.0	25.8	27.0	60.0	35.0	31.1
Janitor	9.0	32.6	8.0	--	10.0	12.5	13.5

All hourly wages for each job category were determined from the current union labor agreement contract with all adjustments taken into account(31). Overtime pay and vacation pay were not included.

The percents of the paper making production costs that go into material handling are listed in Table 2.

TABLE 2. -- Material Handling Labor Ratio for six paper plants in the Kalamazoo Valley.

Plant	Wages of personnel assigned to material handling duties	Wages of total operating work force	Ratio (MHLR)
			Percent
E	$246,518	$ 684,520	35.8
A	80,775	246,266	32.8
B	595,400	2,049,435	28.5
C	162,580	570,900	28.5
D	277,424	1,083,140	25.6
F	131,412	592,760	22.2
Average	--	--	28.89

The MHLR measures the proportion of the company's labor force that has been assigned to material handling activities. It answers the question: How big a job is material handling in our company? It also explores the question: How much effort do we plan to put into the broad function of material movement and storage, as distinct from production?

My null hypothesis that $\overline{P}_1 = 25\%$ was tested as follows:

$$\sigma_{\overline{P}_1 - \overline{P}_2} = \frac{\sqrt{\overline{P}_1(1 - \overline{P}_1)}}{\sqrt{n_1}} + \frac{\sqrt{\overline{P}_2(1 - \overline{P}_2)}}{\sqrt{n_2}}$$

$$= \frac{\sqrt{.25\ (1 - 25)}}{\sqrt{100}} + \frac{\sqrt{.2889\ (1 - .2889}}{\sqrt{80}}$$

$$= \sqrt{.043\ +\ .00256}$$

$$= \sqrt{.04556}$$

$$= .213$$

$$Z = \frac{\overline{P}_2 - \overline{P}_1}{\sigma_{\overline{P}_1 - \overline{P}_2}}$$

$$= \frac{.2889 - .25}{.213}$$

$$= \frac{.0389}{213}$$

$$= .182$$

Since .182 is less than 1.96 the null hypothesis cannot be rejected since $\overline{P}_1$ is not significantly different from $\overline{P}_2$ at the 95 percent confidence level.

The MHLR ranges from 22.2 to 35.8 percent. This means that company F is saving 13.6 percent of their total production costs

($592,760), or $80,615 more would go into handling material if plant F had an efficiency ratio like plant E.

Direct Labor Handling Loss Ratio

All direct labor jobs were studied to determine how much of their time was spent on material handling. This percentage was multiplied by their wage rate to establish a cost for the handling aspect of that job classification.

The percents of direct labor time spent on material handling in various departments in each of the six plants studied are presented in Tables 3 through 6.

TABLE 3 -- Percent of direct labor time spent on material handling in the Hydraupulper Department in all plants

Job Classification	Percent of time spent on material handling						
	Plant A	Plant B	Plant C	Plant D	Plant E	Plant F	Average 6 plants
Leadman	0.0	40.0	0.0	5.0	18.0	0.0	17.2
Panel operator	0.0	--	--	--	--	--	0.0
Helper	63.2	65.0	81.0	25.0	50.0	25.0	25.0
Baler man	16.6	--	100.0	25.0	25.0	80.0	48.3
Stock handler	23.2	80.0	100.0	--	60.0	10.0	8.0
Spare man	80.0	80.0	11.0	25.0	25.0	--	52.5
Spare man beater	--	--	--	25.0	--	--	65.0
Broke hustler	72.5	45.0	--	10.0	15.0	10.0	45.0
Janitor	7.0	10.0	10.1	9.5	10.0	25.0	10.0
General clean-up	11.0	15.0	--	--	--	--	15.0
Trainees	83.0	88.0	--	--	--	--	88.0
Pulperman	23.5	65.0	100.0	7.3	--	10.0	55.0
Beater engineer	--	15.0	4.1	--	--	--	9.5

TABLE 4 -- Percent of direct labor time spent on material handling in the Stock Preparation Department in all plants

Job Classification	Percent of time spent on material handling						
	Plant A	Plant B	Plant C	Plant D	Plant E	Plant F	Average 6 plants
Beater engineer	3.8	15.0	2.7	0.0	18.0	0.0	6.6
Furnisher helper	18.0	65.0	--	25.0	60.0	6.0	34.8
Washer operator	20.0	--	--	10.0	12.0	5.0	11.7
Washer helper	59.8	--	11.0	10.0	--	--	20.2
Spare hand-oiler	10.0	--	--	25.0	--	--	17.5
Stock digger	--	80.0	100.0	--	20.0	90.0	72.5
Size & claymaker	23.5	--	6.3	--	7.0	20.0	14.2
Broke & stockman	72.5	45.0	100.0	10.0	40.0	10.0	41.2
Bleach and size	--	--	10.0	25.0	--	--	17.5
Utility man	--	15.0	--	25.0	--	--	20.0
Beater helper	79.9	80.0	--	25.0	50.0	10.0	48.9
Valve puller	--	--	12.7	--	--	--	12.7
Baler	--	--	--	--	25.0	--	25.0

TABLE 5 -- Percent of direct labor time spent on material handling in the Paper Machine Department in all plants

Job Classification	Percent of time spent on material handling						
	Plant A	Plant B	Plant C	Plant D	Plant E	Plant F	Average 6 plants
Machine tender	0.0	0.0	0.0	0.0	5.0	0.0	0.8
Back tender	0.0	0.0	0.0	0.0	8.0	0.0	1.3
Third hand	10.3	80.0	0.0	5.0	40.0	25.0	26.7
Fourth hand	14.1	80.0	81.0	9.3	80.0	25.0	48.2
Fifth hand	20.6	80.0	--	--	70.0	25.0	48.9
Utility man	82.1	--	--	25.0	--	--	53.5
Swipe	9.0	--	20.0	0.0	20.0	15.0	12.8
Oiler	0.0	--	0.0	0.0	0.0	0.0	0.0
Utility & cleanup	25.0	--	25.0	0.0	25.0	--	18.7
Coreman	80.5	90.0	40.0	--	--	10.0	55.1
Trainees	--	80.0	--	--	--	--	80.0
Material process operator	--	80.0	--	--	--	--	80.0
Sixth hand	--	80.0	--	--	--	--	80.0
Spare hand	--	25.0	--	25.0	--	100.0	50.0
Material helper	--	80.0	--	25.0	--	--	52.5
Paper tester	0.0	5.0	0.0	0.0	20.0	0.0	4.1
Core cutter	--	--	--	--	30.0	--	30.0

TABLE 6. -- Percent of direct labor time spent on material handling in the Calendering and Rewinding Department in all plants

Job Classification	Percent of time spent on material handling						
	Plant A	Plant B	Plant C	Plant D	Plant E	Plant F	Average 6 plants
Calender operator	5.0	5.0	7.0	9.0	16.0	9.0	7.5
Calender helper	15.0	15.0	17.0	9.0	25.0	9.8	14.3
Rewinder operator	18.0	17.0	15.0	11.0	18.0	19.2	16.7
Rewinder helper	15.0	15.0	15.0	9.0	55.0	12.5	20.2

The percents of the total direct labor cost spent on material handling are listed in Table 7.

This ratio gives a general indication of direct labor effort lost because skilled workers are handling materials instead of performing primary tasks. It raises such questions as: Are we paying direct labor wages for indirect labor work? Are highly skilled people being diverted from their primary production duties because they must move materials? Do our handling techniques and equipment free our direct workers for their primary efforts?

TABLE 7 -- Direct labor loss to material handling in six paper plants in the Kalamazoo Valley

Company	Wages for direct labor handling	Wages for total direct labor	Ratio (DLHR)
A	$ 33,098	$ 165,491	19.9
B	216,080	1,119,540	19.3
E	47,843	336,420	14.3
F	59,931	433,560	13.2
C	56,240	464,560	12.14
D	68,485	805,716	8.5
Average	--	--	14.6

The null hypothesis that the average DLHR was 10% was tested in the same manner as the MHLR, and showed that Z = 1.075. Therefore, since 1.075 is less than 1.96, the null hypothesis cannot be rejected.

The DLHR ranges from 8.5 to 19.9 percent. If company D had an efficiency as poor as company A it would mean a loss to the direct labor effort of $91,851.

Equipment Utilization Ratio

The study included only material handling equipment and not production equipment.

An average of 608 observations was made at each mill. Each piece of equipment was observed to be working or idle. The total number of times a particular class of equipment was observed working was divided by the total number of observations for that particular class of equipment.

The average utilization for major types of equipment at all plants is listed in Table 8.

TABLE 8. -- Average percent of utilization for major material handling equipment items in six paper plants in the Kalamazoo Valley.

Equipment item	Average utilization
	Percent
Lift truck	45
Elevators	12
All carts	54
Tractors and tubs	63
Powered hand trucks	16
Cranes	15
Hoppers	51
Hoists	6
Skids and pallets	31

The average utilization of all material handling equipment in each company is presented in Table 9.

TABLE 9. -- Percent utilization of material handling equipment in six paper plants in the Kalamazoo Valley.

Plant	Utilization of material handling equipment (EUR)
	Percent
A	55.6
D	46.1
C	44.0
E	25.6
F	25.0
B	22.6
Average	36.5

The null hypothesis that the average utilization was 60 percent was tested in the same manner as the MHLR and showed that $Z = 4.8$. Therefore since 4.8 is greater than 1.96, the null hypothesis must be rejected. That is, an average utilization of 36.5 percent is significantly different from 60 percent at the 5 percent significance level.

The EUR shows the extent to which material handling equipment is being used to its full potential. By establishing this efficiency index, management can consider whether development of better handling facilities or techniques will cut costs and increase output significantly. As a result of this study several of the managers involved are now conducting investigations which, in one instance, has resulted in a major overhaul of their material handling equipment policies.

Space Utilization Efficiency

The average space utilization for each plant is presented in Table 10.

TABLE 10. -- Average space utilization by six paper plants in the Kalamazoo Valley.

Plant	Average space utilization (SUE)
	Percent
D	66.6
F	59.0
A	52.3
B	46.2
C	39.5
E	34.4
Average	49.7

The null hypothesis that the average space utilization is 50 percent was tested in the same manner as the MHLR and showed that Z = .007 for a sample size of 100 which was greatly exceeded. Therefore since .007 is less than 1.96 the null hypothesis cannot be rejected.

This SUE measures how effectively the enclosed space is being utilized. Buildings require a substantial capital investment. Is full advantage being taken of the space in which considerable funds have been invested? The average utilization in this study was obtained by complete measurement of all storage facilities that supported the paper making process. Net usable cubic feet of space means how much space is potentially available for productive use. Space utilization ranged from 34.4 to 66.6 percent. It appears that space might not be a problem. This, however, is not the case. Plant D appears to have more usable space than plant E. Plant E and C are very weak in storage planning and use of the "cube." This situation generally plagued all of the plants. With the exception of plant D, space was wasted. Wasted space created excessive travel distances and added costs to the MHLR by requiring larger numbers of trucks and truck operators.

All ratios are the averages determined over a 10-week study period for each mill. This lengthy study period was necessary to include variances in inventory levels.

CHAPTER VI

DISCUSSION

Each of the six plants studied received a copy of the findings of the researched ratios. The plant manager in each case expressed a desire for this information. Without exception they asked that I not divulge their mill's ratios to any of the other studied mills. They also agreed to having the findings published anonymously, so that they could compare their operations with others in the industry.

The plant manager is primarily interested in product quality and in maximizing profits by reducing operating costs. Any tool which will enable him to improve his analysis of costs and to reduce them will merit his immediate and serious consideration. These findings will also serve as starting points for the industrial engineer's allocation of resources.

The four ratios, as previously described, give the plant manager a direct and immediately useable tool by which he can gauge the plant's relative material handling efficiency and effectiveness. Comparisons can be made among individual handling operations within a plant or among handling operations in two or more plants. By applying these ratios, a plant manager may determine, in quantitative form, whether his material handling costs are excessive and deserve serious attention in an attempt to lower them.

Application of the tools provided by this investigation will lead management to one or more of the following actions:

A. The investigation of one or more of the material handling operations within the plant.

B. The investigation of material handling on a plant-wide basis to find out if excessive costs exist relative to the operation.

C. An estimation of the extent to which material handling costs can be reduced - relatively and actual amounts; and a decision whether or not further investigation is worthwhile.

D. Determine whether material handling has been receiving the management attention it warrants and whether the emphasis on it should be increased, decreased, or not considered at all.

There are many factors that influence these decisions. A tight money market could easily be the reason to over-rule optimum material handling methods due to limited amounts of capital investment funds available. A very old plant might require substantial overall improvements to put into effect any real material handling efficiencies, thus the total cost might be prohibitive.

This study was conducted during a period of economic recession when production and shipments were generally down. In 1970, the paper making industry experienced the largest year to year downturn since 1951-52 and its operating ratio fell to 88 percent(26).

In regards to this implied message, there would appear to be no greater challenge at this time than to look into those areas of management that are reducing profits. Management must use its available capital with far greater skill under present conditions than ever before. A good hard look should be given to the material handling function since it alone is absorbing one-third of the production costs.

Many of the differences found in the MHLR can be attributed to the organizational structure. Where the function of material handling just exists without any centralized coordination the ratio is high. In company F, no centralized organization is present but the superintendent of production has taken on reducing material handling as a personal crusade because he is aware of the high costs in this area.

Another predominant factor that accounts for high production costs is the condition and age of the equipment used. Company E had many pieces of obsolete equipment, with much of it in poor repair or not operating at all. This situation was common throughout all of the mills. All of the companies could use a preventative equipment maintenance program.

In the equipment area, many of the mills are using inappropriate equipment. For example, in company A, the fork lift loads are being handled by fork lifts that are far below the rated capacity to handle their normal unitized loads. This condition is brought on because of ceiling clearance requirements in their operating areas.

Another major problem evidenced in all the mills was the lack of layout planning. This is evidenced by the tremendously long hauls that must be made to get material into storage and to get the material out of storage and into the production processes.

All mills have a tremendous bottleneck where multi-storey activity takes place. Lack of efficient and adequate elevator capacity is adding thousands of dollars to material handling costs each year.

All companies would benefit considerably by conducting a training session in equipment operation for their employees. In this area, a tremendous amount of the product was ruined because of either lack of concern or inadequate operating knowledge.

It is quite apparent that every mill could reduce the amount of equipment that it has if action were taken to get the right kind of equipment for the job and to take steps to determine a better materials flow pattern. It would also reduce costs to have a competent person responsible for the entire material handling function.

This study revealed the inappropriateness of many mill buildings for operations to achieve a high level of efficiency, because of their rickety and rambling nature. However, some savings in costs could be achieved by an objective analysis of the situation.

The labor in all mills is unionized; therefore, all job classifications are "sacred", that is, a certain classification allows a worker to do only certain specified tasks.

Generally where the DLHLR is high, the lead man and others in the heirarchy progression tend to not involve themselves as much in the material handling aspects of their classification as did those on the lower end of the progression heirarchy. It was noted that the fourth and fifth hands were relegated to do most of the handling activity. The fact is that fewer laborers would be needed if those higher in the progression heirarchy would involve themselves more in the handling activity where needed.

Another significant area for reducing material handling costs is evident in plant D. Of the companies studied, this is the only plant that has a full complement of industrial engineers. A constant monitoring of its direct labor is taking place. The direct labor involvement in non-essential work for their classifications is becoming evident.

The union contract agreement(31) shows that the average wage rate for the paper machine department is $3.88 per hour(Table 11).

TABLE 11. -- Wage rates for labor on the paper machines

Job Classification	Rate per hour (effective 5/1/71)
Machine tender	$4.43
Back tender	4.05
Third hand	3.76
Fourth hand	3.63
Fifth hand	3.56

In contrast the material handling personnel from the material handling pool receives $3.45 per hour. Where the direct labor classification shows a very high percent of its work being material handling, a change in classification could mean eleven cents per hour savings if the fifth hand were reclassified. This could save $760.00 per worker per year. One company has seven fifth hands. Similar savings could be projected up the progression line to other classifications.

Another problem area was evident in methods employed in the material handling by direct labor. Basic equipment and engineered equipment leaves much to be desired. Companies A, B, E, and F should look seriously at their in-process handling techniques.

Another high cost area, evidently not of very much concern, is that of safety. One lost time accident is enough to seriously affect profits. Many examples of potentially dangerous conditions exist in all of the mills. A large percentage of these dangers could be eliminated with little or no investment. A tour to check on provisions for ensuring safety would be the proper way to start.

The Equipment Utilization Ratio is a problem in all of the mills. Companies E, F, and B are plagued with old dilapidated, obsolete equipment, and they have no planned maintenance. As a result, they have much more equipment than would be necessary if all were operable. Company A uses all of its equipment a greater percent of the time than the other mills because it is using inadequate equipment.

The existing conditions and methods used in most of the mills necessitate inadequate equipment and equipment that is used only a small percentage of the time. (see table 8) It is imperative that the equipment used be within the weight limitations of the building features. A universal example of a building restriction would be the elevators in every mill. Much of the equipment used on the upper floors had to be limited in size to keep from over-loading the elevators.

All mills need a re-organization of their material handling equipment pool. The best material handling equipment utilization value of 55.6% leaves a lot to be desired from the available equipment.

The Space Utilization Efficiency Ratio indicates that a building problem faces all companies except company D. Most buildings, as indicated before, do not lend themselves to efficient storage. Most storage facilities are disconnected from the processing area by barriers, such as elevators, another building, or railroad tracks, or have poor surfaces, inadequate door opening sizes, weak structures, insufficient aisles, low ceilings, and poor storage procedures. One bright spot exists in plant C where "first-in-first-out" storage, and good material flow were incorporated.

One manager summed up his problems by saying, "There seems to be no pride left in the paper making industry. The owner-manager has left the scene." He also implied that today's managers were expected to make a profit with equipment, machinery, and physical facilities that were tuned to paper making forty years ago.

CHAPTER VII

CONCLUSIONS

The material handling functions in six paper plants in the Kalamazoo Valley appear to be a very fruitful area for cost reduction. The costs accounted for by the material handling activities range from 22.2 to 35.8 percent of the wages of the total operating work force. If all of the companies could operate their material handling departments as efficiently as the most efficient one, (Plant F) the following savings would result:

TABLE 11 - Potential savings material handling labor

Plant	Wages of total operating work force	Material handling labor ratio, percent	Potential savings percent	Potential savings per year
E	$ 684,520	35.8	13.6	$ 93,094
A	246,266	32.8	10.6	26,104
B	2,049,435	28.5	6.3	129,114
C	570,900	28.5	6.3	35,966
D	1,083,140	25.6	3.4	36,826
F	592,760	22.2	-	-

The direct labor savings for the material handling activity would result in the following savings if all plants were as efficient as plant D:

TABLE 12 -- Potential savings direct labor

Plant	Wages for direct labor handling	Direct labor handling ratio percent	Potential savings percent	Potential savings per year
A	$ 33,098	19.9	11.4	$ 3,773
B	216,080	19.3	10.8	23,336
E	47,843	13.2	4.7	2,248
F	59,931	13.2	4.7	2,816
C	56,240	12.1	3.6	2,047
D	68,485	8.5	-	-

To obtain the savings indicated would be possible because even the best plant ratios in either case, (22.2% MHLR and 8.5 percent DLHLR) would lend themselves to significant savings if an objective analysis and cost reduction program were installed.

A look at the possible savings involved in equipment utilization would imply that company A with the best utilization, 55.6 percent, could theoretically get by with 17 fork lifts rather than 30. This would mean a tremendous savings in investment, maintenance, operators and operating costs. Even more spectacular savings could result in plant B which has only a 22.6 percent utilization. This means that they could theoretically do the job with one-fourth of the available equipment.

The space utilization ratios ranging from 34.4 to 66.6 percent, means that from one-third to two-thirds of all available space is not being used. An objective analysis of the costs for maintaining this unused space could result in savings in taxes, protection (fire, theft, etc.), utilities (heat, lights, etc.), insurance premiums, general maintenance and other savings in operating costs by not perpetuating unsuited and unused storage areas.

The paper making journalists are constantly writing about paper management's dilemma, the high cost of production versus highly competitive paper prices (24, 25, 26). I submit that management should take this often repeated message seriously and turn some of their unrealized potential into real savings in production costs. Changes to save 2% of the production costs involved in the material handling function would mean an average yearly savings of $17,425 for each of the six Kalamazoo Valley plants. This amount could very well provide the salary for a good industrial engineer.

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APPENDIX

List of Companies Studied

The Brown Company, Kalamazoo, Michigan

The Weyerhaeuser Paper Company, Plainwell, Michigan

The Kalamazoo Paper Company, Kalamazoo, Michigan

Allied Paper Company, Kalamazoo, Michigan

Simpson Lee Paper Company, Vicksburg, Michigan

Georgia Pacific Corporation, Kalamazoo, Michigan

Sample of Letter Requesting Permission to Visit a Plant's Facilities

Dear Mr. ____________________:

The function of material handling has a tremendous impact upon the success or failure of any business enterprise. Many times the costs for this activity could be lessened if it were isolated and studied objectively. We would like to ascertain what these costs are. You may have some or all of this data readily available, then again more data may be needed which we would like to accumulate and work out with your industrial engineers.

After fact finding, the data will be evaluated and productivity indices established. The scope of our study will include seven local paper manufacturers. The results will appear anonomously in our paper with realistic indices established for direct materials handling labor and indirect materials handling labor, with appropriate points for improvements noted.

Your company will receive a copy of the study.

We sincerely hope that you will permit us to gather and analyze this data. It appears to us that the resultant management guides would be very helpful in your plant operations.

Sincerely yours,

____

QUESTIONNAIRE

1. Gross Sales ______________________________

2. Product Types and Sales Volume (%)

____________________ ______________________

____________________ ______________________

____________________ ______________________

3. Plant, Buildings and equipment Rent _________ Own _________

4. Form of raw material ______________________________

   Carrier used ______________________________

   Unloading method ______________________________

5. Form of finished goods ______________________________

   Carrier used ______________________________

   Loading method ______________________________

6. Do you have any demurrage charges? ______________________________

7. Where is material handling responsibilility center in organizational structure ______________________________

8. Is material handling scheduled maintenance program set-up? Yes _________ No ___________

9. Types of manufacturing operations

___________________________ ______________________________

___________________________ ______________________________

___________________________ ______________________________

___________________________ ______________________________

10. Annual capital expenditures for equipment ______________________

11. Annual capital expenditures for material handling equipment ______________________

12. Is your material handling equipment more than ten years old? Yes ________ No ________

13. Do you have production workers engaged in material handling? Yes ________ No ________

14. Are methods stabilized so that time-motion studies would be valuable? Yes ________ No ________

15. Are Pre-determined times available with trained personnel to use them? Yes ________ No ________

16. Is a standardized economic yardstick method applied in the plant? Yes ________ No ________

17. Is the yardstick used for manufacturing as well as material handling? Yes ________ No ________

18. Salary payroll in plant ________________________

19. What material handling tasks are being done by direct labor (%) ________________________

20. Total direct labor in wages ($) ________________________

21. Total wages of operating workforce($) ________________________

22. Total wages of personnel assigned solely to material handling ($) ________________________

23. Do you have any employee accidents due to handling of materials? ________________________

24. Estimate of probabilities that material handling accounts for the following percentages of total production costs:

RANGE (%)	PROBABILITIES
0 - 5	
5 - 10	
10 - 15	
15 - 20	
20 - 25	
25 - 30	
30 - 35	
35 - 40	
40 - 45	
45 - 50	
50 - and up	

INITIAL INTERVIEW FORM

Name of Plant

Name of Manager or representative interviewed

Location

CHECKLIST

1. Introductions and getting his interest - copy of study to him.
2. Are plant records available to outsiders?

   Brochures, Annual Reports, Pamphlets.
3. Have any studies of material handling costs been made?

   What? How? When? By whom?

   Are detailed flow charts available?
4. Diagram of Plant Organization structure.
5. To what extent is automation used in materials handling?

   Problems?____

   Downtime?____

COMPUTATION FORM FOR MATERIALS HANDLING LABOR RATIO DATA

$$\frac{\text{Materials handling}}{\text{Labor ratio}} = \frac{\text{Materials handling labor}}{\text{All labor}}$$

Our material handling labor consists of labor assigned solely to material handling duties	Number Persons	Payroll Per Year
1. Material Handling Equipment Operators		$
A. Non powered trucks		
B. Powered industrial trucks		
(1) Walkie platform and pallet trucks		
(2) Forklift & platform trucks		
(3) Tractor trailer systems		
(4) Mobile cranes		
(a) Operators		
(b) Riggers		
(5) Tractor shovels, bulldozers, etc.		
C. Cranes, hoists, and other overhead equipment		
D. Conveyor loaders and unloaders		
E. Intraplant motor trucks		
F. Intraplant railroads		
G. Elevators		
H. Manual handling labor (such as palletizing)		
TOTAL		$

COMPUTATION FORM FOR MATERIAL HANDLING LABOR RATIO DATA (Continued)

Our material handling labor consists of labor assigned solely to material handling duties	Number Persons	Payroll per year
2. Workforce for activities devoted to:		$
A. Receiving dock		
B. Shipping dock		
C. Raw materials storage		
D. Finished goods storage		
E. Distribution warehousing		
F. Scrap and salvage operations		
G. Miscellaneous		
TOTAL		$

3. Activities partially devoted to, or supporting the material handling function	Number persons	Annual payroll	Percent changeable material handling	Net annual cost for material handling
A. Tool room and supplies issue		$		$
B. Maintenance of material handling equipment				
C. Production control, particularly dispatching and expediting				
D. Packaging operations				
E. Inventory control records				
F. Inspection				
G. Traffic				
TOTAL		$		$

COMPUTATION FORM FOR MATERIAL HANDLING LABOR RATIO DATA (Continued)

Annual Material Handling Labor Cost:

1. Material handling equipment labor ____________________
   Payroll $

2. Material handling activities labor ____________________
   Payroll $

3. Activities partially chargeable ____________________
   Payroll $

ITEM A
(Total material handling labor) ____________

ITEM B
(Total annual payroll) ____________
Ordinarily computed by taking operating payroll and omitting general administrative and sales payroll.

$$\text{Material handling labor ratio} = \frac{\text{Material handling labor}}{\text{Total payroll}}$$

$$= \frac{\text{Item A}}{\text{Item B}} = \frac{\$\_\_\_\_\_\_\_\_}{\$} = \_\_\_\_\_\_\_\_ \%$$

DATA COLLECTING FORM FOR DLHLR......

To test hypothesis that worker #1 is similar to worker #2 ($P_1 = P_2$)

Workers to observe

Firm____________________ Shift __________

1. ________________
   (Name)

Department _______________ Job Classification__________

2. ________________
   (Name)

Observation Number	Week	Day	Minute	Worker #1		Worker #2	
				Not material handling	Material handling	Not material handling	Material handling
1							
2							
3							
100							

+Where r + y - n: and $P_1 = \frac{r_1}{r_1+y_1}$: $P_2 = \frac{r_2}{r_2 = y_2}$

++If worker is observed to be idle, ignore that observation and take another observation in its place.

CONSOLIDATION FORM FOR COMPUTING THE DLH RATIO

Firm____________________________ Date____________________________

Department________________________ Shift __________________________

A	B	C	D	
Job Classification	Percent of time spent on material handling per shift	Average annual payroll for classification within department	Dollars spent on material handling in classification	Comments
	Shift 1. 2. 3.			
TOTALS				

EQUIPMENT UTILIZATION RATIO

Equipment (Description) ____________________

OBSERVATIONS	Time	Record	Time	Record	Time	Record	Time	Record	Time	Record	Time	Record
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												

W Totals

NW Totals

Record W for working

Record NW for not working

$$EUR = \frac{\text{Actual output}}{\text{Theoretical output}}$$

SPACE UTILIZATION EFFICIENTY

NON-PRODUCTION USE OF SPACE DATE______________

Area				
Length				
Width				
Height				
Cubic Feet				

Calculations:

$$SUE = \frac{\text{Usefully occupied cubic feet}}{\text{Net usable cube}}$$

Usable cube = Usable cube - Space used for necessities

Plant dimensions

L =

W =

H =

Volume =

OPERATING COSTS

The operating costs for this project are shown below:

Date: April 1971 - Project time span: September 1969 to April 1971

Data gathering time span: 52 weeks (three semesters plus one session)

OPERATION	TIME	PAY RATE	NUMBER WORKERS	DIRECT COSTS	
Research Staff					
1. Staff planning	60 hrs	$5/hr	1	$ 300	
2. Travel		10¢/mi	1 (500 mi)	50	
3. Preparing initial report	90 hrs	$5/hr	1	450	
Sub total					$ 800
Field Costs					
1. Field 80x3 data collectors x 6 companies x $2/hr				$2,880	
2. Staff (5 hrs/wk)	250 hrs	$5/hr	1	1,250	
3. Travel	25 wks	10¢/mi		750	
Sub Total					$4,880
Data Handling					
1. Editing	2 wks	$5/hr	1 (40 hr/wk)	$ 400	
2. Tabulating	2 wks	$5/hr	1 (40 hr/wk)	400	
3. Computing	1 wk	$5/hr	1 (40 hr/wk)	200	
Sub Total					$1,000
Preparing Report					
1. Typing	2 wks	50¢ page	200 pages	$ 100	
2. Miscellaneous			Paper, etc.	25	
Sub Total					$ 125
Total Cost					$6,805
Contingencies					680
					$7,485