REFERENCE NOTES

for

ROUGH MILL YIELD WORKSHOPS

North Carolina State University

Raleigh, N. C.

1968

Assembled and Published by
Wood Products Section
Extension Forestry Department
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POTENTIALS FOR INCREASED PROFITS
THROUGH ANALYSIS OF YIELDS AND OPERATIONAL PROCEDURES.

by: H. C. Moser

We in the lumber conversion industry are the heirs of ancient
skills and traditions. Our forebears of thousands of years ago
sought to refine wood to useful products. Primitive man, with primiti-
te tools, fashioned useful wooden implements for battle, for the
hunt, for agriculture, for the household. Over the countless generations
better tools were evolved and better products were made. Now we have
woodworking methods, machines and product designs geared for mass pro-
duction. We saw logs, yard lumber, inspect it, sort it, stock it, kiln
dry it and bring it into our mills with out a single fingerprint on it.
Some shops turn out thousands of cabinets a day and are marvels of
efficiency, rivaling anything that the metal-working industry can claim
in automation.

The objective of all of this is to reduce labor, to turn out our
product at minimum cost. This is good — to cut costs. But in our pre-
occupation with mechanical labor savers there is a danger that we under-
value the significance of the bigger costs represented by the raw material
itself — the lumber we use. The relative significance of these costs —
lumber and labor — needs emphasis.

One board foot of a clear-face cutting of say maple or any cabinet
wood can easily be worth 50 cents when it leaves the rough mill. With
labor at say $2.00 per hour a man can devote an entire day to saving a
mere 35 board feet of lumber and come out ahead. It may be said that
the ratio of lumber cost to labor cost in the rough mill is an average
10 to 1 as an average. A saving of one percent of the raw material is
equal to a saving of 10 percent of the labor required to work it up.
So while we concern ourselves mightily with the attainment of mechani-
cal efficiency and labor saving, perhaps it would be more profitable
to take a little more time to do the job and try to put more wood in
the product and less in the wood hog. There is real danger that over-
devotion to mechanization can seriously reduce lumber yields.

It goes without saying that wood workers have always realized
the effect of net yield on cost. But the technique of attaining

* Paper presented at Rough Mill Yield and Operations Seminar, North
Carolina State University, Raleigh, N. C., December 1, 1966
maximum yield somehow seems to have been considered in the nature of an occult art, disclosed only to the initiated. There has been a tendency to put the responsibility on the man at the saw as the possessor of black magic. As a matter of fact, the sawyer has relatively little influence on the yield factor. He has an influence, yes, but once the board is on the saw table and cutting bill is spelled out his choices are limited. He can only hunt in between the defects for the pieces he is told to get and he cannot shift the defects about. He cannot get something that is not there.

Net lumber yield is largely fore-ordained in the planning and is only secondarily affected by operations on the cutting room floor.

Before we examine further the planning aspects of lumber conversion, let me point out the yield must be viewed in terms of dollars. Expressions in terms of board feet or percentages are only a means for financial evaluation. What we are seeking is least cost of the net footage. Whether the yield factor be 50 percent or 70 percent takes on significance only when related to the dollar cost of the rough lumber. A 50 percent yield from $100 lumber is obviously more advantageous than a 70 percent yield from $200 lumber. It is to get this optimum adjustment between net product and lumber cost that is the objective sought. The purpose certainly will be to utilize the cheapest lumber which will yield the desired cuttings without excess labor.

Here enters the problem of forecasting the yields which can be obtained for a given cutting bill from standard grades of hardwood lumber. Profits of the business are very greatly affected by the correct selection of lumber to be cut. The manufacturer who would minimize his lumber costs must have a meaningful measure by which he can pre-judge the dollar cost of his cuttings. Use of the optimum grade or blend of grades of lumber is the most effective of all influences in minimizing lumber costs and hence of improving rough mill profit.

In the past there has been little specific systematic, generally available, information on which such estimates could be based. This most critical of all decisions affecting lumber conversion - the choice of grade to be cut has been a seat-of-the-pants determination in many woodworking shops. It remains so, widely, to this day. As a consequence much high grade lumber is used where a lower grade would do the job at less cost.

I do not mean to imply that the planner in the past has had to rely only on the Ouija board for his information. National Hardwood
Lumber Association grading rules define lumber grades on the concrete principle of the presence of a specific percentage of clear face cuttings in a given board, and a graduated scale of the number of minimum size of cuttings for certain grades. I assure you are familiar with these stipulations which are indicative of what may be produced from each of these grades.

The length, width and grade of the cuttings to be taken are the principal factors which determine the proper grade of lumber from which the parts should be produced - all weighed in relation to lumber cost. Lumber cost is especially significant when the length of cutting is borderline between two lumber grades.

Some years ago Mr. C. D. Dosker formulated a rule of thumb as a guide in choosing proper lumber grades. His observations have been published, and I will not attempt to detail them all here. To indicate their nature, I will paraphrase a few of the simpler principles:

"Generally speaking, No. 2 Common lumber is not used for a clear cutting longer than 30" and for a core cutting longer than 43". No. Common lumber may not generally be used economically for a clear 2 face cutting longer than 43". Of course, there would be exceptions to this, such as the proportion of long cuttings to the total footage of short cuttings. Clear one face cuttings as long as 60" can be obtained freely from No. 1 Common lumber but the average width will be narrow."

Note that 30" clear cuttings are indicated for No. 2 Common lumber in spite of the National Hardwood Lumber Association grading rule which says that minimum size cuttings in the lumber grade can be as short as 24". Similarly, 43" clear two sides and 60" clear one side cuttings are suggested for No. 1 Common, which also authorize cuttings as short as 24". This is because the grade rule cuttings are minimum sizes and the limitation of the number of allowable cuttings to attain the overall clear area forces the presence of several cuttings larger than the minimum.

Mr. Dosker goes on the explain where lumber grades can be blended to advantage for various cutting combinations and how special product grade specifications should be taken into account. These principles are derived basically from the provisions of National Hardwood Lumber Association grading rules amplified by broad experience in lumber conversion. Knowledgeable lumber converters have utilized these principles and many have reduced them to formal yield tables for their particular situations, taking into account their own empirical experience for their particular shop.
Admittedly these approaches to the forecast of utility have been less than adequate. There always has entered an element of random judgment or plain conjecture. Conscientious analysis of cutting orders has enabled experienced planners to do a reasonably satisfactory job of production planning and scheduling. But this is an art that cannot be fully reduced to formal statistical terms and the industry has been handicapped thereby.

We now have hope that the era of guessing at yields is approaching an end. A basis for sound advance assessment of yields appears to be developing in the yield studies such as have been published here at North Carolina State and which are underway at the Forest Products Laboratory. Really comprehensive and readily usable planning standards thus developed are critically needed and will make a most substantial contribution to increased profit in the rough mill.

Although the computer may give us data forecasting what maximum yields can be expected for any combination of lumber grade and dimension cuttings, and hence enable us to calculate the comparative anticipated costs, it will not replace personal skills in many phases of planning nor operating skills on the rough mill floor. The computer, for example, will not necessarily tell us which combinations of the several required cuttings should best be attempted at one time. Normally there will be a choice of combinations, and the man who plans the cutting bill will continue to exercise strong influence on the yield actually attained. Commonly the number of items to be cut from a given lot of lumber will be greater than the sawyers can handle at one time. And the footage proportion of items will differ so that one item will be cut out before another. As the operation proceeds, therefore, it becomes a changing kaleidoscope. Skill in planning these changes at the saws so that the best available combination of cutting is always scheduled at the table is a key factor in securing yield. Here again, emphasis is on the planning.

Usually the longest and most difficult items should be cut first so that offal can be re-cut to smaller sizes and so that the least possible quantity of lumber will have to be worked to get the long cuttings. When an item is cut out, its place at the saws is taken by another which will maintain an optimum balance of cutting sizes and product grades. Real planning skill is required here.

I have said that net lumber yield, in terms of dollar cost, is foreordained in the planning. This is true. But aside from the scheduling of the lumber and establishment of the sequence of cuttings there are many other operational practices which bear on the yield obtained. There are differences of opinion among
competent managers in the industry as to the significance of some of these practices. Without claiming that we are necessarily right or that they apply in everybody's shop, I would like to mention a few of the things which we try to do in our shop, believing that we thereby improve yields.

We believe in sorting much of our lumber before it hits the saws. Sorting is done at various stages of production and for various purposes.

First, incoming lumber is sorted for length in the yard. This makes for straighter and flatter boards in air-drying and kiln-drying. It simplifies inventory controls. It improves efficient utilization of dry kilns. It reduces stick breakage. Most important of all, sorting for length makes it possible to charge into the mill the length of lumber best suited to the cutting schedule. This can have a major effect on yield. For example, if the principal cutting is 50 inches long, only one cutting can be obtained from an 8 foot board with 46 inches left over which must be channeled into other, frequently less desired cuttings. The use of 10 foot lumber in this case will increase the proportion of the 50 inch cuttings obtained, will reduce the amount a rough lumber handled, and minimize the accumulation of shorter cuttings or waste. Generally speaking, the cutting of random length lumber will reduce yield unless a wide range of cutting lengths is available in proportions which will allow taking any cut which appears at the stock saw.

The lumber grading rules of National Hardwood Lumber Association specify the proportion of clear area and minimum size of clear cutting for each lumber grade. Guidelines are thus established as to cutting lengths obtainable. But the rules are not all concerned with the many variables which commonly enter into the specification for particular end products to be desired from the lumber. For maximum yield a refinement of these grades is frequently called for and the lumber can be advantageously reclassified ahead of the saws.

Specifications which must be faced in varying degree include uniformity of color, grain direction and character of grain, thickness, width of solids, density, freedom from either sapwood or heartwood. The sorting of the lumber to fit these special requirements not only tends to improve yield but also makes for a higher quality of product and expedites the flow of material through the saws.

Assume, for example, the end product is a bedroom chest of maple from No. 1 Common lumber. The top and drawer fronts require uniform light color, well matched for grain. The sides have a less stringent requirement in this regard. Other parts may allow disolor. It will
be a distinct advantage to bring the best of the common lumber to
to the saws first and cut out the difficult items.

To make sorting of this kind possible, lumber is rough-planed
first and the sorting is done at the roughing planer. In some cases
lumber of one category may actually be laid back for subsequent cutt­
ing on a later order having abnormally difficult or perhaps low grade
specifications. In this connection, long range planning of sequential
cuttings over a period of time involving a succession of orders is
essential. The planner must have in mind up-coming orders which can
be advantageously served by best sorting of materials being currently
processed.

Rough planing of lumber ahead of the saws has the further ad­
advantage that it permits segregation for thickness. Frequently it
is possible to secure from plump four-quarter lumber items which
normally would call for five-quarter. It is well worthwhile in the
saving of lumber to pull these boards and, in effect, get something
for nothing.

Sorting out of the roughing planer for thickness in surfacing
hit or miss is a routine practice in preparing stock for edge-glued
panels. The chance of failure to get full final thickness in the
finish planer panel is greatly reduced if the thick is glued to
thick and thin to thin, rather than having a thin strip incorporated
in an otherwise uniform panel. Panel matching is expedited and re­
works are reduced with consequent improvement in utility.

It should be mentioned also that pre-surfacing enables the
cut-off sawyer to better see and identify defects and reduce trim
waste.

It may appear that the handling and re-handling entailed in
preliminary rough planing and varied sorting is unduly costly as
compared with the very common practice of cutoff - surface and rip.
It is quite possible that this is true where the product is simple,
repetitive and not highly exacting in its specification. In pro­
ducing technical wood products, however, and where the more costly
cabinet woods are used to produce quality furniture, refined sorting
ahead of the saws should be seriously considered as a technique for
improving yield and upgrading the product. I would emphasize again
that wood far outweighs labor as a cost element.

It is more or less conventional practice in the industry to
perform cross-cutting as a first operation. This fits well with
mechanization of the rough mill. With some types of products and
grades of lumber, this is unquestionably a sound procedure. In the
interest of maximizing utility, however, especially where longer lengths are required. Many boards should be ripped before they are crosscut. There are circumstances where real gains can be made by the pre-rip method and a rough mill will do well to have a facility for accomplishing this.

One gimmick aims at improved yield is what is commonly referred to as strip construction which is employed for making thin panels. To produce half-inch thick panels, for example, four-quarter lumber can be ripped to strips 1-1/2 inches wide, surfaced to 7/8" thick, turned on edge for gluing. By resawing, the half-inch panels can be made with considerably less gross lumber than if they are surfaced down from four-quarter. This technique is especially useful for certain types of corestock.

In the actual processing of lumber through the saws there are, of course, several more or less self-evident practices which make for best yield.

At the cut-off saw it is good practice for the cutting lengths to be marked on the infeed side of the saw to match the stops on the saw table. This enables the sawyer to judge whether it is better to cross-cut a defect or take a longer cut with a re-trim. This judgment is the key to a cut-off sawyer's skill.

It is important at this point, also, that the sawyer have a choice of cuttings - up to 5 or 6 - both in length of cutting and in grade of currying.

End-trim should be no more than necessary to clear end defects and crosscut close to knots. Excessive crosscuts should be avoided in the interest of long cuttings where retrims can be salvaged. Rip saws should stay on the defect side of the cutting. Edging trim should be paper thin. Rip saws should be minimum gauge - say 9/64" for a glue joint.

If a glue jointer is used, the cut should be minimum. In practice this is a common cause of unnecessary waste. If the jointer is set to cut clear on 100 percent of the sawmill edges, it is set too deep since it will be taking much more than would be required to clear the vast majority of pieces.

Allowances for the molder and for equalizing are frequently greater than necessary if the milling equipment is in prime operation condition. An allowance of 1/8 inch is adequate for much molder work.
The practice of molding in multiples of width, using a fifth head on the molder, will obviously save much sawkerf, knife allowance and labor.

It should be recognized that wastage in sawkerf, trim allowances, machining allowances, etc. can be of considerable magnitude. This wastage is of clear materials. One-eighth inch in width of a 2-inch strip is equal to 6 percent of the net yield. Over a period of time this means big money. I would emphasize that these wastes, although small when considered alone, are very substantial in the aggregate. They are "built-in" waste predetermined by the equipment used and by the machining allowances established in scheduling the rough cuttings. They can amount to 25 percent of the rough lumber with good practice and considerably more with sloppy practices. Here is a good place to look for a quick, readily recognizable, and substantial opportunity for improvement in yield.

There is one more small point I would like to make - or perhaps it is a question to ask. In my experience with other woodworkers, researchers and customers there appears to be no uniform definition of exactly what is meant by yield or waste. Some think in terms of footage of the final product in relation to rough lumber. Others consider yield as the product of the rough mill before molding or further machining. I believe it is critically important that these terms be clearly defined, especially in relation to any statistical yield data which may be published. Yield estimates are frequently used in establishing selling prices in advance of production. It is important that machining allowances and sawkerf be included properly in those costs. I would like to suggest to those who may make yield studies that this consideration be clearly defined.

One more statement - which I hope the participants in this seminar will be able to refute - there is danger that sacrifices of yield to the gods of automation may be a false religion. Not only that, it can be poor business.

Once again I want to congratulate North Carolina State University for its interest in promoting rough mill studies. I am sure you will have a productive seminar during the next two days.
"LEAST COST YIELD OF DIMENSION STOCK

by

Nicholas C. Weidhaas

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LEAST-COST YIELD OF DIMENSION STOCK

Tremendous savings are possible through improvement of rough mill operations and yield. This is immediately apparent when it is considered that the cost of lumber is in the order of 25-35 percent of the total cost of producing furniture.

Even slight improvements can lead to substantial savings. A 2 percent improvement in yield, for instance, for a furniture plant processing five million board feet annually could easily reflect a $15,000 to $20,000 yearly savings. If the effort is devoted, how many things can not be improved by at least 2 percent?

Management's Attitude

Institution of a well organized, formalized program of cost reduction in the rough mill can be the first step towards the achievement of "least-cost" yield. A brief series of calculations of the value of the lumber annually processed should stimulate any progressive manager to formulate such a program.

For the program to be of maximum effectiveness, strong backing by management is required. Unfortunately, especially with respect to yield programs, many individuals ignore the 99 percent that's right with an idea and concentrate on the 1 percent that's wrong. The 1 percent cannot be ignored, but neither should the 99 percent.

In a sense, the program must be made to work by management.

Better practices, or improved procedures will be successful only if administered intelligently. Since the ultimate administrator is the machine operator, he should be intelligent and well instructed in the improved practices. Too often, rough mill operators are chosen for their brawn and not their brains. Involvement may be the key word. The yield program will have a greater chance for success if the operators, foremen, superintendents and interested engineers all participate in the planning, and execution of the program.

Concept of Least-Cost Yield

Materials Cost

Reference to yield figures such as 40, 50, or 80 percent mean very little unless they are associated with specific grades of lumber, cutting sizes, and quantity requirements. A furniture plant might be enjoying 75 percent yield from FAS lumber and consider itself fortunate.
If the plant is paying $200.00 per MBF for the FAS, and 1000 Bd. Ft. are required to fill a cutting order of 750 Bd. Ft., the real materials cost for the order would be:

\[
\frac{750 \text{ Bd. Ft.} \times \$200/\text{MBF}}{.75} = \$200.00
\]

If, on the other hand, the plant chose to purchase 2 common lumber rather than the FAS, the yield which would result would obviously be lower -- perhaps only 50 percent. If the cost of the 2 common lumber is only $100 per MBF, the materials cost of filling the order of 750 Bd. Ft. would be:

\[
\frac{750 \text{ Bd. Ft.} \times \$100/\text{MBF}}{.50} = \$150.00
\]

It is the cost of yielding the 750 Bd. Ft. cutting order which is the pertinent factor. In this case, the materials cost would be $50.00 less if the company used the 2 common, rather than the FAS.

**Processing Cost**

The cost of processing must also be considered when alternative grades of lumber are compared. In the previous example, a lumber input of 1000 bd. ft. of FAS would be required to fill the cutting order. An input of 1500 bd. ft. or 500 bd. ft. additional, would be required if 2 common were used. The processing cost of this 500 bd. ft. must be added to the materials cost of the 2 common. The total cost of using the 2 common would then be compared with the total cost of using the FAS, and the most economical grade would be chosen.

**Yield Studies**

There is an optimum of least-cost grade-mix of lumber from which to produce any cutting order. Most furniture products try to use a better grade of lumber from which to produce long cuttings, and a lower grade from which to generate shorter cuttings. However, prior to the development of the series of yield tables \(^1\) by North Carolina State University, it was practically impossible to determine the least-cost grade-mix to use. Questions such as the following can now be answered through simple manipulated of yield tables.

What quantity of 46-inch cuttings lengths can be obtained from 1000 bd. ft. of FAS Select 1 common, or 2 common lumber?

\(^1\) Thomas, R. J., The Yield of Dimension Stock From Hardwood Lumber, MSC. Extension Publication No. 16, North Carolina Agricultural Extension Service, North Carolina State University, Raleigh, N.C.
What quantities of 13, 16, 19, 35, 47, etc., inch secondary cuttings would be generated, even though the operator was cutting primarily for 50 inch lengths?

The information in the yield tables, when related to price information and processing costs allow grades of lumber to be matched with cutting orders and the relationships to be optimized with resulting least-cost yield.

Other Factors

Other factors could influence the decision of what grades of lumber to use. Certain non-permissable defects may be more prevalent in the lower grades. The loss in yield resulting from these defects must be subtracted from any yield data which has been gathered solely on the basis of the standard grading rules.

A particular factory may not have the additional productive capacity to process a lower grade, even though it is more economical. The alternative of adding more machinery should then be considered.

Primary Manufacture and Seasoning Degrade

Logs & Lumber

Woods and sawmill practices have a pronounced effect on the subsequent yield of dimension stock from lumber at the furniture plant. Logs which are allowed to stain while in the woods may not yield lumber which will yield maximum usable dimension stock.

The generation of mis-cut lumber, whether thick, thin, or wedge shaped, will prohibit adequate drying in the lumber pile and lead to excessive degrade. Mis-cut lumber cannot be piled in a manner which allows adequate hold-down of the lumber during drying. For instance, two thick pieces of lumber, which are on either side of a board of proper dimensions, will allow the central board to cup, and twist. This degrade is ultimately reflected in a reduction in yield. A supplier rating program may allow the firm to reduce the quantities of mis-manufactured lumber which it purchases.

Air & Kiln Drying

Analysis of air and kiln drying practices should be an integral part of any yield program. Research by the U. S. Forest Service

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indicates that in certain sections of the Appalachian regions, the average loss in dollar value during air drying Red Oak is about $14 per MBF. Their research also indicates that through the institution of better drying practices, this loss can be reduced to only $1 or $2 per MBF. Although these figures reflect a reduction in the value of the lumber, it is also quite apparent that better drying practices should also reduce losses in yield which result from drying degrade.

Thousands of dollars can be saved through the institution of "well known" recommended procedures for drying lumber. The advisability of covering piles, proper placement of stickers, uniformity of stickers, adequate spacing of piles, yard sanitation, etc., have certainly been well documented in the literature.

The Cost of Cross-Cutting

End Trim

Tremendous quantities of lumber are wasted at the swing saw. One type of loss occurs at the ends of the boards when the operator automatically takes a three to four inch end trim to eliminate end checks which may only penetrate the board an inch or so. An automatic end trim of three inches on twelve foot boards is an automatic sacrifice of about 2% in yield. A loss of 2% could easily be a loss of $15,000 to $20,000 for the plant processing five million bd. ft.

It is often desirable to take the end trim with more than one cut. If the first cut does not remove all the end checks, another cut can be taken. To always cut a safe amount from the ends of boards is to allow waste material. A mirror mounted in such a way that it allows the operator to view the end of the board without undue effort, will allow the operator to know at a glance whether the end trim has been sufficient to remove all the end checks. This mirror could be mounted as in Figure 2.

The Backgauge

Another type of loss occurs when the operator "runs out of wood" on the following end of the board. For instance, assume an operator is cutting for three cutting sizes, 17, 22, and 32 inch lengths with primary target lengths of 22 and 32 inches, he might have cut a twelve foot board as in Figure 3.

Note that because of the combination of lengths cut, there would have been a 14 inch piece left over on the following end of the board.
If the operator has cut the board as in Figure 4, the waste would have been reduced to only two inches.

An average loss at the end of the board of six inches is not uncommon at the furniture plant. This loss could reflect a reduction in yield of over 4%. Providing the operator with a decision making aid, and some pre-planning can reduce the size of the end trim and the size of pieces wasted because of faulty cutting procedures around defects.

A simple backgauge has been proven effective in reducing the size of this "leftover" piece at the end of the board, and reducing waste around defects. In essence, the backgauge reduces the mental gymnastics which the operator would have to go through in choosing the combination of cuttings which would utilize the entire board. The backgauge indicates the combination of cuttings which should be taken, once the operator decides what defects he wants to remove, and where his last cut should be made.

Recall the cutting order which calls for 17, 22 and 32 inch lengths. The various combinations of these lengths are indicated in Table 1. These length combinations are marked off at their respective distances from the sawline along the cross cut sawtable as indicated in Figure 5. The 64 inch indicating line, for instance, represents a distance equivalent to two 32 inch cuttings. Similarly the 49 inch indicating line represents a distance equivalent to one 32 inch cutting plus one 17 inch cutting.

A color coding system helps the operators associate indicating lines with cutting lengths which should be taken. The color coding system is depicted in Figure 6. Each cutting length is assigned a color. Tapes in the various colors are then attached to the respective stops and put at the respective indicating lines on the other side of the saw.

Use of the gauge is very simple. Figure 7 depicts a board on the saw table. Assume a cut has just been made as indicated by the dotted line. In deciding what combination cutting lengths should utilize the remaining length of the board, the operator notes that the end of the board falls right at two blue tapes (representing the 44 inch indicating line or two twenty-two inch lengths). The operator then proceeds to cut two blue (22 inches) lengths, and minimum material is wasted. Actually, for fitting cutting lengths to the remaining length of the board, the gauge is only used to indicate the last two cuttings.
The backgauge may be used also for cutting up to, or around defects with minimum loss. In the case represented by Figure 8 (in which case the large defect should be removed by the cross cutting operation) by observing the position of the board relative the backgauge, the operation would see that by taking a 22 and 32 inch cutting (blue and 'rec:;) he could cut out the defect with minimum waste. The shorter cut is usually made first and the longer second. If the longer cutting is made too close to the defect and contains some of the defect, the cutting can be cut-back to the shorter length.

The construction of the backgauge can be very inexpensive. Even a length of cardboard marked off at various points with different colored crayons, could be used for trial purposes. If the technique were found suitable, an aluminum or steel backgauge could then be constructed.

Longest Length Cutting

The fact that cutting lengths are usually required in specific quantities prohibits the operator from cutting for maximum yield only. Usual practice is for the operator to cut primarily for a specific target length which is usually the longest length in the cutting order. Once the quantity requirements of the length have been satisfied, the operator then drops his target cutting length to the next longest length which is required, etc.

To prevent excessive accumulation of shorter lengths, the cut-off saw operator cuts as many of the long target lengths as possible even at the sacrifice of some yield. His long-length cutting policy, however, should be modified at the ends of the board, and when it is very obvious that excessive losses would result if a few shorter lengths were not taken. If it becomes apparent that too many short lengths are accumulating, the operator can then reduce the number of short lengths which he is cutting.

Number of Cuttings

The question of how many cutting lengths should be taken on any one saw has never been adequately answered. The number should be sufficient however, to allow the operator to have some flexibility in choosing his cuttings to maximize yield. It is generally believed that cutting five to nine lengths can be an adequate system. The key factor is whether or not the various combinations of the 5 or 9 cutting lengths which are chosen adequately cover all points on the backgauge without any excessive voids. The greater the number of cuttings, the closer will be the indicating lines on the backgauge. The closer
these lines are together, the better will be the selection of cutting-length combinations and consequent yield. The general rule then should be to cut for as many different sizes as the production system will allow.

**Optimum Board Length**

There is an optimum length of lumber from which to generate specific combinations of cutting lengths. This consideration is especially important when the better grades of lumber are cut and the cross cutting is more of a "cutting to length" operations than a defecting operation. In this case very few defects would be removed at the cross-cut saw, most being removed at the rip, and salvage saws.

One plant in Eastern North Carolina use 8' lumber from which to generate its primary cutting lengths 29½" and 34" pieces. From practically every 8' board it cuts two 29½" lengths and one 34" piece. Thus utilizing 93 inches of boards 96-inch length.

The longer the lumber, the lower the ratio of end trim to board length. Thus, less yield may be lost in end trim if long lumber is used. This situation must be studied carefully, however, since the grade of a board may be reduced simply because it is too short or narrow to meet the length and cutting restrictions of the higher grade. Furniture plants may in some cases get more for their money by capitalizing on these grading rules and purchasing short, narrow lumber, even though on a percentage basis more yield is apparently lost from end and edge trim.

**Optimum Allocation of Cuttings**

Conversely, there should be an optimum allocation of apportioning of the various lengths to the different cross-cut saws. The planned combination of cutting lengths and their allocation to the cross-cut saws result in a greater yield than a haphazard apportionment of the lengths to the available saws.

From the cutting order groups or combinations of cutting lengths must be selected and assigned to the various saws. Although a specific technique has not yet been developed for selecting the best combinations of lengths to assign to specific saws, the following procedure and considerations seem generally applicable.

1. Cutting lengths should be grouped or combined in such a way to utilize the entire length of one of the possible board lengths. Some combinations would be more appropriate than others as they might better "fit" one of the available lengths of lumber.
2. The cutting lengths must also be combined in such a way as to satisfy the quantity requirements of the cutting order.

3. The groups of cuttings should also be selected so combinations of the individual cuttings are sufficient in number to allow the lines on the backgauge to be fairly close together.

4. Combinations of 5-9 cutting lengths are then assigned to the various saws, and the best length and grade of lumber is utilized.

Other techniques and procedures have been effective in improving efficiency of the cross cutting operation, and improving the subsequent yield of dimension stock.

**Cutting Lengths**

The rough cutting lengths should be as close as possible to the finished dimension of the part. If the average cutting length is 40" and the lengths are two inches oversize, with respect to the final length of the part which is to be made from the cutting, then at least 5% in yield is automatically wasted. This yield figure is different however, than the yield figures mentioned previously, in that this 5% yield figure is 5% of the material which would be produced at the swing saw, and not 5% of the lumber input to the swing saw. In actuality, it would probably take about 7% more lumber from the kilns to replace the 5% which was lost because of cutting parts 5% oversize.

**Productivity**

Another improvement in the efficiency of the cut-off saws might be the installation air cylinders. These cylinders are activated by foot pedals, and can relieve the hands of the operators for more productive work, and reduce fatigue.

Cross-cut saw operations should not be required to engage in activities, other than deciding where a board should be cut, and making the appropriate cuts. They should not be required to haul into their cutting stations loads of lumber. Rather, to permit the operators and their machines to remain productive the operator should be supplied continuously with sufficient lumber. One operation visited did require the operators to pull to the cutting station their loads of lumber. This took an average of one hour and 20 minutes per day. The operators were then required to work overtime, at a premium rate, to meet the cut-stock demands of the plant.
Records of lumber yield should be kept by cutting order in order to adequately control any yield program. Quality control personnel should keep a constant check on, and record of the size of end trim losses, and other losses due to faulty cutting procedures. Lumber input and dimension stock output can be physically measured and analyzed. Or, all inputs, outputs, and wastes can be weighed.

Jointing and Ripping

Number of Cuts

More lumber is wasted because of excessive kerf and edging losses than for any other reason. Basically, the number of cuts which are taken at the rip saw, or the jointer, should be reduced to the very minimum. Every time a rip cut is made at least a 1/8 inch, and most likely a 1/3 inch, strip of material is wasted in kerf. Figure 10 shows that if 2 one-quarter inch edging strips are cut from the edge of a piece, and two 1/4" kerf, defect removing cuts are made on the same piece, a total kerf loss of 1 inch, plus the total edging strip loss of 1/2 inch would total 1 1/2 inches of wasted material. On an average board of 8" width, this reflects an immediate loss in yield of almost 19% of the stock going to the ripsaw. In terms of dollars and cents, this loss could easily be $150,000 to the plant processing 5 million Bd. Ft./yr.

Thin Gauge Saws

The quantity of material removed by each cut, should also be reduced. The thinnest saw blade should be used that will permit development of a surface which is consistent with specification requirements. Saw manufacturers can often offer recommendations as to which thin-gauge saws are best suited for various uses.

The importance of reducing the width of kerf is apparent even from the difference between the loss which results when a 1/8 inch saw is used versus the loss which results from using a 1/4" kerf saw. If an average of three rip cuts are made on each cutting length from the cross cut saw, and the board widths average only 8 inches, reducing the kerf from 1/4 to 1/8 inch would reduce the loss of yield due to kerf from 9.4% to 4.7%. In terms of dollars and cents, this reduction in waste could easily save $40,000 per year for the plant processing 5 million board feet.

Accurate Rip Cuts

Small improvements can also effect considerable savings. When ripping out defects, for instance, the saw line or kerf should remove part of the defect. Making the ripping cut a safe distance from the edge of the defect wastes lumber. A shadow line or a movable gauge can assist the operator to quickly locate his line of cut, and helps him reduce the waste which results from not cutting close enough to any defect. The shadow line or gauge can also help the operator to reduce this size of edging strips.

Bury The Saw?

Many companies have the theory that at least a 1/32 inch edging strip must also be removed to generate an adequate glue joint. In other words, the saw must be buried for a suitable glue joint to be developed. Other companies are generating acceptable glue joints without burying the saw.

An attempt should be made to generate the glue joint without burying the saws. If this practice is found unsatisfactory, it can then be discontinued. But, the potential for savings indicate that an attempt should be made to eliminate edging strips whenever possible.

Specified Width Vs. Random Width Ripping

Most companies require some pieces of specified widths. The decision must then be reached as to whether or not to cut only for the specified widths when they are required, or to cut for random widths only, gluing these into panels and re-ripping to specified widths, or to cut a combination of specified widths and random widths at the rip saw. Cutting random width, and gluing up the random widths usually results in the best yield if the panels do not have to be re-ripped to specified widths. Panels for chairs for instance, would be made from random width pieces. The panel would not be re-ripped.

It is often desirable to cut random widths at the rip saw, glue up the random width pieces, mark a series of patterns or parts on the panel, and then band saw these parts from the panel. In this way, parts can be nested on the panel with a resulting reduction of waste.

If fairly rectangular shaped pieces are to be cut from the panel, then the process of gluing up the random widths and then re-ripping to the fixed widths is probably inefficient. Every time a panel is re-ripped to specified widths, kerf losses result. At this state of manufacture these kerf losses are losses of material which should be 100 percent usable.
A more efficient way of producing specified widths could be to cut specified widths at the rip saw as much as possible, and to glue the edge and other random width pieces which result, into panels which are then re-ripped to the specified widths. If only specified widths were cut the board edge would often be wasted, as multiples of specified widths do not always exactly equal the width of the board. By gluing these extra pieces into panels, they can then be re-ripped to the desired specified widths with minimum waste.

The potential for saving at the rip saw is tremendous. For this reason quality control personnel should keep a constant record of the sizes of the edging strips generated, and of other waste which is produced. But just keeping records is not sufficient. The information derived from the record keeping must be acted upon.

Automatic Edging

The edges of boards could be jointed automatically or manually on either a jointer or a rip saw. Automatic jointing or ripping of the board edges relieves the rip saw operators of the task, and allows them to concentrate their efforts on removing defects in the best way. Care should be taken to see that the automatic jointer or rip saw is not taking an excessively thick edging cut.

The amount of wane in boards which are being processed is another consideration. Some boards can be more economically edged manually. In the case depicted by Figure 12, the automatic edging operation did not adequately remove all of the defect which was present on the edge. The remaining portion of this defect is then removed manually. But, because removal of wane was a two stage operation and the saw was buried in the manual second step, more material was wasted than would have been wasted if the board were originally edged manually. This loss is indicated by the dotted area.

For an automatic edging system to be 100% effective requires that an excessively heavy cut be made to assure complete removal of any defects. The system then should not be made to be 100% effective, since re-edging some of the boards will be cheaper than wasting extra material on the edges of all boards. Experience has indicated that up to 25% of the boards which are automatically edged must be re-edged manually. The fact should be considered when automatic edging systems are weighed against manual edging systems.
The Salvage Operation

The cross-cut saw operator, and the rip saw operators should cut with the salvage saw side in mind. Figure 13 indicates how material can be saved if the salvage saw is employed. Without this saw, the defects indicated would probably have been removed as shown in case A. With the salvage saw employed in the system, it would be possible to remove the defects as indicated in case B, thus saving the indicated portion of the piece.

The Matching Saw

To waste material at the matching saw, is to waste material which is already free from defects. Any waste, therefore, at this stage of manufacturing is especially costly. Excessive waste at the matching saw is primarily the result of avoidable kerf losses, and wasted edge strips, which would not have been generated if the system had been properly planned. Figure 14 illustrates a situation where an edge strip is wasted because of human inability to rapidly put together a number of random width pieces and have the resulting size be exactly the desired width. The overage in width is wasted if a matching saw is not employed.

The procedure for laying up panels when the matching saw is employed can be as in Figure 15. The overage is used as the first piece in the next panel which is laid up. Care should be taken to make sure that the last piece laid down in the panel is large enough to allow the panel to be trimmed to width, while still producing an extra piece of sufficient size to allow it to be used in the next panel.

Although it may seem rather insignificant, an effort should also be made to reduce the kerf loss at the matching saw. Even though a panel may only comprise two board feet, the overall yield from the lumber may be only 50%. Therefore, to make a panel of two board feet requires four board feet from the lumber yard. Therefore, any 1/4 inch saving at the matching operation is in reality a saving of 1/2 inch in material. For example, by reducing the matching saw kerf from 1/4 inch to 1/8 inch, assuming 20 inch panels were produced, a savings of over 1% in yield could be affected.
FIGURE 1. LOSS IN END TRIM

12' Board

2% Loss In Yield = $20,000

FIGURE 2. USE OF A MIRROR

Saw  Mirror  Stops  Operator

FIGURE 3. CUTTING BOARD WITH END WASTE

12' Board

14 Inch Waste

FIGURE 4. CUTTING BOARD WITHOUT END WASTE
FIGURE 5. CONSTRUCTION OF A BACK GAUGE

FIGURE 6. COLOR CODING THE BACK GAUGE

FIGURE 7. USE OF BACK GAUGE IN CUTTING TO BOARD END
FIGURE 8. USE OF BACK GAUGE IN DEFECTING

FIGURE 9. OPTIMUM BOARD LENGTH

8' Board

- 34" - 29 1/2" - 29 1/2"
FIGURE 10. RIP SAW LOSSES

1/4" Edging
1/4" Kerf

1/4" Kerf

1/4" Kerf

1/4" Kerf
1/4" Edging

1-1/2 Loss (Total) = 19% Yield Loss = $150,000
FIGURE 11. CUTTING BOTH SPECIFIC AND RANDOM WIDTH

3" Specified Width

3" Specified Width

1-1/2" Random Width To Be Glued Into Panel

FIGURE 12. LOSSES FROM AUTOMATIC EDGING

Defect

Additional Loss
FIGURE 13. A CUTTING BOARD WITHOUT SALVAGE

Cross Cut

Rip

FIGURE 13. B CUTTING BOARD WITH SALVAGE

Cross Cut

Rip

Salvage

Waste Indicated By

FIGURE 14. WASTE IN PANEL LAY-UP

Random Width Pieces Made Into Panel

Required Width

Overage Wasted
FIGURE 15. USE OF THE MATCHING SAW

Panel 1

Saw Cut

Use Edge Pieces First Piece In Next Panel

Panel 2

Etc.
"MANAGEMENT'S ROLE IN A PROGRAM FOR YIELD OPTIMIZATION"

by

Vincent R. Ross
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Yield Optimization

Definition
A technique used in lumber conversion that will produce the best or most favorable degree of utilization.

BASIC STEPS IN INSTALLING A YIELD OPTIMIZATION PROGRAM

I. Planning The Program

A. Obtaining Management Decision

1. Presentation or "Selling" of Program
   a. What Yield Optimization is
   b. Major Objectives of the program
   c. Reasons why company needs such a program
   d. Ways in which program will meet those needs
   e. Experience of other companies
   f. Limitations of such program
   g. Effect on costs -
      Cost of installation
      Cost of operation
      Cost of maintenance
B. Determining Who Will Do the Job

1. Management Consultants
   a. Advantages
   b. Disadvantages

2. Company Employees
   a. Advantages
   b. Disadvantages

3. Consultants and Employees Working Together
   a. Advantages
   b. Disadvantages

II. Preparing For The Program

A. Determining How Job is to Be Done - Formulating Basic Management Policies.

1. What departments are to be studied

2. Coverage - how many jobs in the chosen departments will be included.

3. Extent and nature of supervisory and employee participation

4. Administrative organization and procedures for operating, maintaining, and controlling program.

III. Publicizing The Program: "Selling" Supervisors and Workers

1. Methods
   a. Letter from a top line executive of the organization
   b. Pamphlets and brochures
   c. Sound Films and Slides
d. Bulletin, charts, posters

e. Staff or group meetings

f. Separate departmental meetings

g. Individual interviews

h. Employee magazines and newspapers

i. Others

2. Types of Information to be Disseminated

a. Effects of Program to supervisors and employees

b. Advantages of installing the program

c. Limitations of the program

d. Procedures to be carried out

e. Scope of program

3. Management - Union or Employee Participation

4. Special Techniques

5. Timing of the Announcement

IV. Organization for Yield Optimization

1. Assignment of Responsibility for Installing the Program

2. Organization of the Yield Optimization staff

   a. Place in the over-all organization structure

   b. Internal organization of the staff

3. Qualifications of the Members of Yield Optimization Staff

4. Selection and Training of the Staff
V. Establishing Procedures - Tools in Yield Optimization

1. North Carolina State University Yield Tables
2. Individual Machine Procedures
3. Cutting - bill forms
4. Recording Forms
5. Control Procedures
Selling Yield Optimization

Department Heads and Supervisors

I. Answers to First Objection -- That The Plan May Not Be All That Is Claimed.

A. Citations from successful achievements elsewhere or better yet the exposure of haphazard procedures within their own departments.

B. If the company has not yet developed good record keeping, of course the selling must include this step.

II. Answers to Second Objection -- Loss of Freedom In Supervising Department.

A. The supervisors can be shown that they will participate in the new procedures and that their recommendations will always have consideration; that only the guessing and ill-considered requests will be out. Probably they know full well that much of the success of the program depends on them. Acknowledge this and use it as a means of clinching their full cooperation.

B. Explain the operating procedures so they may see that they will no longer be liable to suspicions regarding lumber waste beyond their control; such things as poor drying practices, poor purchasing practices and poor yarding practices will be pinpointed and the responsibility fixed.

III. Answers to Third Objection -- That of Union Misunderstanding.

Can best be answered by the management inviting the union to
send a selected representative to sit as a member of the plant committee.

SELLING YIELD OPTIMIZATION TO EMPLOYEES

If Employees Are To Be Sold On Yield Optimization

1. They must be sold on basic principles.

2. They must be convinced of the competency of the group who are installing the program.

3. They must be informed that a Yield Optimization program is not a remedy for all lumber ills.

4. They must be convinced they will have a part to play in the program.

5. They must know that those in charge will keep them informed on the progress of the program.

6. They must be assured that they are not merely the subject of an experiment.

7. They must be assured that no individual will suffer loss of salary or wage as a result of the program.

8. Employees must be assured of a reasonable completion data for the program. However, they must also recognize the Yield Optimization is a moving, living thing; jobs change, techniques change, methods are created and research continues. All of these, must be provided for by the machinery that administers and keeps Yield Optimization up-to-date.
Pages 35 & 36 Are Missing

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2. If the cup is less than 1/16 and is not split, it should be turned downward when fed into a facing-type planer. A facing-type planer is recommended before a conventional planer because of the jointing action on the face of the board. A conventional planer tends to take a "hogging" cut if the cupped board has not been ripped and faced.

3. An operator can do a more accurate job at the Busting Saw if the saw is equipped with a guide-line light. This kind of light projects the path of the saw the entire length of the board and enables the operator to rip through a defect, if possible, when "busting" a board. If the defect is not too large, much of it will be removed by the kerf of the saw. The remainder of the defect will then be removed at the chain jointer and/or the straight line ripsaw. This method will save at least 1/8 inch of lumber and usually more. In addition, maximum, usable, board width is maintained. In ripping "solid" widths, maintaining maximum width can be an important economic factor.

4. In any ripping process, it is advisable to use the thinnest saw possible. The argument against thin saws is that they quickly overheat and begin to wobble in the cut. This can be avoided if the largest, possible stiffening collar is used. With large collars, most saws can be reduced from 3/16 to 1/8 inch. On a 6 inch board, this amounts to almost one percent per rip cut.

5. The Busting Saw can also be used as a straight line ripsaw if the cutting requires solid widths (not to be glued). At this point in the Rough Mill process, the board of course has not been surfaced, so it is impossible to rip for a glue joint with a degree of consistency. However, it is possible to rip solid widths, and this can be readily accomplished in this operation. By utilizing the saw 100 percent of the time, the problem of what to do with the operator when he is not ripping cupped boards is solved. If a glue jointer is used in the line, additional waste is avoided by keeping the "solid" boards out of the Jointer. The Busting Saw operator merely lays to one side all of the "solid" stock developed at his saw.

Glue or Chain Jointer

If a glue jointer is used in the line, it is advisable to keep close control on the depth of cut on each head. The heads should be set about 1/8 inch and 1/16 inch respectively. The rough edge of the
board is jointed on the 1/8 side and the smoother edge on the 1/16 side. It is not good practice to run long boards (over 40 inches) through the Jointer. Because of crook or warp, they seldom clean-up in one or two passes. If the heads are set to do an adequate clean-up job on long stock, the shorter lengths suffer excessive yield losses. This condition coupled with the facts that:

1. A glue jointer is somewhat difficult to keep in precise adjustment and,

2. Ripsaw operators will invariably rip a surface that has already been jointed, and make it problematical as to whether a glue jointer is worthwhile in most rough end operations.

Ripsaws

Usually the most dramatic changes in lumber utility occur at the ripsaw. Straight-line ripping is a must in any program to reduce waste. To properly accomplish straight-line ripping, tapers must be eliminated, edging losses minimized and defects handled in the manner described under "Busting or Grading Saw." To assist in accomplishing this end, guideboards or guide-line lights and pointers should be installed on each ripsaw. If the Rough End layout is such that certain ripsaws rip only short lengths, guideboards or guide-line lights are unnecessary. The purpose of a guideboard or guide-line light is to allow an operator to edge or defect long boards with little or no lumber loss except saw kerf. With a guideboard, the edge is aligned with the saw blade and extended beyond the ripsaw table and anchored to the floor. The guide-line light is mounted above the saw and in-line with the saw blade. The light casts a shadow the length of the board indicating the path of the saw. It is good practice to keep the lights clean so that the shadow cast on the board does not appear over-sized due to an accumulation of dust. It is usually good policy to have some inspection method set-up to check ripsaw edging waste. This can be accomplished by putting waste in scrap trucks or letting it all go to the scrap sawyer to be sorted and utilized. There are dangers in the latter method, however, in that a salvage sawyer will not inspect the stock adequately if his work station becomes inundated with all kinds of material.
"SALVAGE AND MATCHING"

by

Rudolph Willard

North Carolina State University
SALVAGE & MATCHING

by

Rudolph Willard
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Two unrelated subjects are involved so let's take them one at a time, salvage first, matching second.

SALVAGE

(a) Typical rough mill sequence of operations is as follows:

Cut-off saw
Facer
Rough planer
Straight line rip saw

For best yield the cut off operation should not try to cut out all defects but should depend on the ripping operation to remove some defects whenever the removal of the defect can be done at the rip saw with less waste than at the cut-off saw.

Stock leaving the rip saw should be free from all defects which would be objectionable in the finished product. This is not true of the cut-off saw. A board might have a slight bark edge (wane) Figure 1. A ripsaw cut along line A-A might involve less waste than cut-off saw cuts along lines B-B.
Or a board might have an end check or split nearly parallel to the edge of the board, Figure II, so that two ripsaw cuts along lines C-C would involve less waste than a cut off saw cut along line D-D.

Figure II.

A similar situation would be two or more knots somewhere nearly in line, Figure III. Ripsaw cuts along lines E-E would permit getting some long stock whereas cut-off saw cuts along lines F-F might produce stock too short in length for any of the parts required.

Figure III.
Frequently a situation arises, Figure IV, where a long cutting can be produced from stock with a defect near one edge or end by ripping along line G-G but the edging is too good to throw away in spite of the fact that no more full length stock can be made from it. If this edging were cut back on a cut-off saw to a shorter length which is also needed, the good material in the edging can be partially salvaged. This is the purpose of the salvage saws. Stock from the ripsaws to be re-cut goes to the salvage cut-off saw and subsequently to the salvage ripsaw. Many shops depend on these salvage saws to get what short length parts are needed from material laid out at the main rip saws for re-cutting. At the main cut-off saws they do not cut fresh lumber for short parts unless salvage saws fail to produce enough from ripsaw discards. Sometimes this procedure will result in excess waste at the cut-off saws in the form of short ends. Possibly a compromise is best, cutting shorts at the cut-off saw only when necessary to avoid waste, and using salvage saws for all short stock which can be produced from ripsaw discards. Because shops and products differ, no arbitrary statement can be made as to the one best way. But it is still true that preventable lumber waste is a big cost item in most rough mills and it should be analyzed and watched continually because it pays in cost reduction to do so.

(b) When properly operated, there are four categories of material leaving the ripsaw.

Usable stock
Narrow or defective edgings
Stock to be re-cut and salvaged
Sawdust (up the blow pipe)
(c) In a non-conveyorized rough mill the stock coming to the cut-off saw is usually on a lumber lift and stock leaving the cut-off saw is usually stacked on pallets or shop trucks. Floor space is usually available so that stock coming to the cut-off saw could be stock for salvage which is stacked on a pallet.

Stock coming to the ripsaw is on pallets and stock leaving the ripsaw is on pallets. One pallet will have usable stock, another pallet will have stock for re-cutting and salvage. Trash edgings will go into a scrap truck or a conveyor for removal to the boiler room (with or without a wood hog).

In this sort of non-conveyorized rough mill, one of the main cut-off saws can be used to re-cut stock for salvage and one of the main ripsaws can be used to rip it. As an alternative, there can be a cut-off saw and a ripsaw which are apart from the main machines and which are used for the salvage operations.

(d) In a conveyorized rough mill it usually pays to have a cut-off and a ripsaw apart from the production line and let these machines handle the salvage operation without interfering with the main production line. Two men would probably be assigned to these salvage machines.

The exact arrangement and machines to be used for the salvage operation depend on the individual shop, its available space, its man power balance, and the amount of material to be salvaged. The fundamentally important basic thing is this: be sure to include salvage operations in your rough mill procedure. If you don’t, you will be missing some important savings in lumber waste. Usually the cut-off sawyers do not try hard enough to get the required long cuttings first. They would cut on line H-H Figure IV instead of letting the ripsaw rip on line G-G and then salvage the wide edging. One result is that the shop usually accumulates more short cuttings than it needs. These eventually get thrown away when the boss isn’t looking. Cut-off sawyers usually like to cut out all defects and it will take some doing to re-train them; but the effort will pay off in reduced lumber waste. If you’re cutting 15M ft. of lumber a day worth $150 per M at the cut-off saw, one lousy percent is $22.50 per day or $5,600 per year. It would pay the wages of one and three quarters men. It is not negligible; it is important.

MATCHING

Matching applies to stock to be used for edge gluing, it does not apply to one piece solid stock ready for the moulder. Stock for
edge gluing is usually ripped random width. After edge gluing the
panel needs to be some specific width. As I shall use the word
"matching", it refers to an operation in which the random width strips
for edge gluing are placed on a saw table with edges tight up against
each other and a ripsaw cut is made to the exact rough width required
by the panel which is to be edge glued. These "matched" strips are
kept together until edge glued into the panel.

The advantages and disadvantages of matching depend on the gluing
method which is to be used and on the specifications of the panel to
be glued. We'll discuss various gluing methods separately.

GLUING ON TAYLOR PANEL-FLO MACHINE

(a) If you do edge gluing on a Taylor Panel-Flo machine which
has a flying ripsaw attachment, a matching operation ahead of the
dge gluing would be a waste of labor cost of the matching operation
with no offsetting advantage in lumber waste.

(b) With other methods of edge gluing certain special require-
ments for stock selection can be accomplished with a matching operation
which can be accomplished on the Panel-Flo by training the operators
who feed the gluing machine. These are briefly:

1. Color selection. Panel must have one face all sapwood or
all heart wood. Train operators to discard any individual strip which
does not meet the specification instead of feeding it through the
machine. Better to discard a 3" strip than glue it into a 20" panel
and then discard the panel afterwards.

2. Skip dressing. Many shops rough plane stock in the rough
mill too thick, for instance 14/16" for 4/4 lumber. If the glued
panels are to finish 13/16", it would be better to rough plane 7/8"
and instruct operators to put no individual strip into a glued panel
if the strip skip dressed. As it is, many skip dressed strips are
thick enough but many are not. This introduces an element of guess
work on the part of the operator which causes preventable waste. The
way suggested eliminates guess work.

(c) One special situation might justify matching ahead of the
Panel-Flo machine. On a part such as the core for a veneered top for
a chest, it is common practice to permit small tight knots where the
veneer will cover them but to require the core to be clear for about
2" at both ends and the front edge. The purpose of the clear speci-
fication is to make sure that when the edges of veneered panel are
shaped and finished no defects will show in the shaped edges.
In feeding the Panel-Flo the operator can watch each individual strip and discard any strip which has a defect within 2" of either end. But he cannot tell where the front edge will come because the flying ripsaw controls the location of the cut for the front edge. Even ripping at random on the flying ripsaw many panels will come out with at least one edge clear for 2". But if experience shows that an excessive number of panels are rejected for failure to have a clear edge, it might pay to match up ahead of time and disconnect the flying ripsaw when edge gluing the stock. In the matching operation the operator can tell for sure where the front edge will be and can assure that it is clear.

GLUING ON ELECTRONIC BATCH PRESS

These machines are designed so that the rams for edge pressure are adjusted for each different width of panel to be glued. Most of them will operate if the width varies from the specified width by plus or minus an inch or two. The operator has to handle the strips in order to place them on the layout table from which the press is fed so that the operator can inspect and reject any individual strip which is defective. He can do this without any extra handling of the stock and with very little delay, if any. If the stock has not gone through a matching operation the operator of the batch press must be careful to lay out enough stock to make the required width of the panel being glued. In practice, this means that every panel is glued up somewhat wider than the required width and must be ripped to the required width. This re-ripping operation is faster than a matching operation but it does involve some lumber waste in edgings at re-ripping. This waste can be avoided if the stock is matched to width before gluing instead of re-ripping after gluing.

The loss from edgings at re-ripping varies greatly from one shop to another according to how fussy the batch press operator is about laying up only a little more than the required width but still be sure to get enough to make the required width. Even with care, the edgings at re-ripping will usually average 1" wide or more. If the panels being glued are an average width of 20", a 1" loss in 20" of usable width is 5% of the usable material. If your rough mill is cutting 15M ft. of lumber per day and the lumber is worth $150. per M at the cut-off saw you are cutting $2,250 per day value of lumber. If half of this edge glued, and if you are losing 5% of the edge glued footage in edgings at re-ripping, you are losing:

\[
\frac{2,250}{2} \times 0.05 = $56.00 \text{ per day}
\]
One good man on a matching saw could probably handle your production but it would surely not take more than two. Two men would cost about $30.00 per day for labor so there would be a net saving of $26.00 per day or $6,500 per year. The saving would be increased by whatever the labor cost is for a re-ripping operation. Re-ripping would not be needed if the stock is matched to width before gluing. So the total saving would probably be closer to $10,000 per year than $6,500 per year.

GLUING ON GLUE REEL

The discussion on electronic batch press also applies to the glue reel process.

THE MATCHING OPERATION

Matching to width (including inspection) is usually done on a table saw. Any variety saw will do but it is more convenient and faster on a table saw built for the purpose. Wood table is satisfactory. Both the infeed and outfeed ends of the table should be as long as the longest stock to be handled. Tilting arbor is not needed. A ripping fence is required. The saw blade should be guarded and the guard should include a splitter back of the saw blade to reduce kick backs. The table should be wide enough to permit setting the ripping fence for the widest panel to be matched. It is convenient to have a narrow table (about 6") on the side of the saw blade opposite to the ripping fence. This permits the operator to work along the side of the table instead of the position usually used on a variety saw.

Stock coming to the matching saw has had defects ripped out, two edges machined for glue joint and is random width. The matching saw operator sets his ripping fence for the width of panel desired and lays up stock on the infeed table and against the ripping fence, inspecting the stock as he lays it up. When he gets nearly enough width for the panel he selects and lays up a strip of stock which is too wide so that the edging from this strip (when the saw rips it off) will be wide enough for the first strip of the next panel. The whole batch of strips is then pushed past the saw and the matched stock for one panel is placed from the outfeed table onto a pallet to form one layer of a load. The edging strip is placed against the ripping fence and stock for the next panel is laid up against this edging strip. This procedure produces no waste edging strips at all; the only waste is one saw kerf per panel. It is important not to tip over a load or otherwise mix up stock which has been matched for width. If it is mixed it is necessary to match all over again and the edges which have been ripped on the matching saw are not usable for a glue joint.
As a machine, the matching saw is cheap. It requires only:

1. Home made wooden table
2. Home made ripping fence
3. Saw mandrel with collars
4. Ball bearing pillow blocks for mandrel
5. Motor
6. Pulleys with belt
7. Guard with splitter.

No adjustments are needed for tilting the saw nor table or for height of the saw. The whole machine should cost less than $300.00.

While the moulder is not usually considered part of the rough mill, it is a spot where controls coupled with corrective action can contribute to reduced lumber waste. It is not uncommon to have up to five percent of the stock coming out of the moulder turn out to be rejects for one reason or another. If rejects develop anywhere they contribute to lumber waste.

We would suggest a four step procedure behind the moulder.

1. Off-bearer inspect all stock coming out of the moulder. Pile good stock on one truck and rejects on a different truck.

2. At end of the run and before set-up is changed, count the good stock and make record of actual count of good stock. If not enough for the job, immediately notify machine foreman who can decide whether to rush extra stock to the moulder or whether to change set-up and run the shortage later with another set-up.

3. Once a day have the machine foreman (or someone appointed by him) go over all the rejects one by one and make a record of what was wrong with each piece.

4. Have the machine foreman review the daily reports on these rejects at least once a week, make a shrewd guess at the cause of each different kind of reject, and take action to correct the causes.

Step 1

Most off-bearers think their job is simply to pile stock on a truck for the next operation. If the off-bearer is trained to inspect you can get inspection at this point at no extra cost. (This may not be possible when moulders are run at extra fast feed rates.)
Rejects from different runs of stock can all be piled onto one truck of rejects until the truck is full. The purpose of separating rejects from good stock is to make it easy for someone with judgment to look over and make a record of the rejects.

Step 2

One purpose of the record of actual count is to control overruns. Many shops waste an average of four percent or more in overruns which are unnecessarily large. But the record of count is of no value unless someone looks at it regularly and takes action if overrun gets out of line (either high or low). High overrun wastes lumber. Too low overrun means too many shortages with time waste of extra set-ups for shortages.

Some shops keep a stock of long, wide, clear panels near the moulder. In case of shortages, the moulder man can rip and cut from these panels what extra stock he needs for the shortage and run it before he changes set-up. A cheap, second hand table saw is adequate and can be placed convenient to the moulder.

Step 3

It is a good idea to have a mimeograph or printed form for making record of rejects. A typical form is shown on the next page.
# REJECTS BEHIND MOULDER

<table>
<thead>
<tr>
<th>Lumber defect which rough mill missed</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skip dressed, top</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skip dressed, bottom</td>
<td>III</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skip dressed, outside edge</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skip dressed, inside edge</td>
<td>III</td>
<td>III</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Torn grain, top</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Torn grain, bottom</td>
<td>III</td>
<td>III</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Torn grain, outside edge</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Torn grain, inside edge</td>
<td>III</td>
<td>II</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knife burns</td>
<td>III</td>
<td>III</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bite outs at one end</td>
<td>II</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
From your own experience fill in headings for such other defects as frequently show up behind the moulder. Leave some blank lines for things you overlook in making up your form.

Step 4

The reports in step 3 are wasted time unless someone with judgment and authority looks them over regularly and takes action. The machine foreman is probably the most logical man to do this. He can usually tell from the nature of the defect what is the probably cause. Torn grain might be too fast a feed rate, or it might be wrong cutting angle on knives of the moulder. It can sometimes be torn grain at the rough planer which goes into the stock so deep that the moulder will not dress it out. Skeip dressing on outside head might be caused by ends of the stock being cut badly off square. This is especially likely on short, wide stock like drawer sides. When rejects run too high, the report will show it. But the report will not correct the causes. It requires a man taking action. But the reports will give him a good idea where to look.

FINISH PLANER

The previous discussion of the moulder also applies to the finish planer. Planers very seldom feed too fast for the off-bearer to inspect. But he won't inspect unless you train him to.

It is downright disgusting (and expensive) to reject a panel 20 inches wide because one little 1 1/2 inch strip skip dressed. If the strip was too thin it should not have been glued into the panel. If it was thick enough but was not flushed in edge gluing something should be done about edge gluing procedure.
NOTES
ON THE USE OF NORTH CAROLINA STATE UNIVERSITY'S
LUMBER YIELD TABLES

by

Nicholas C. Weidhaas

Extension Wood Product Specialist
Extension Forestry Department
North Carolina State University
The competitive nature of today's industrial society compels every firm to maximize the value of its output in relation to the cost of its input of raw materials. The furniture industry is not an exception to the above principle of operation.

Lumber, the main raw material of the furniture industry, currently is in scarce supply, and prices reflect this scarcity. Producers must employ practices that will yield the maximum quantity of dimension stock from their lumber, at the least possible cost.

Just as there is a "best" finishing material to purchase for a particular requirement, there is an optimum or least-cost grade or grade-mix of lumber from which to generate required cutting orders in the rough-end of the plant.

Most companies currently exercise some judgment in deciding what grades should be cut into certain cutting lengths. Usually the better grades of lumber are used when long lengths are needed, and the lower grades are used for shorter cuttings.

But the decision rules are "at best" rules of thumb.

The purpose of this writing is to discuss the use of the yield tables developed at North Carolina State University. Interpretation of the tables will allow the manufacturers of furniture or dimension stock to determine the following:

(1) The least-cost grade or grade-mix of lumber to use for any combination of required cutting lengths.
(2) A basis for evaluating the adequacy of current lumber yields.
(3) A standard of production and a goal for machine operators.

Only the first of these determinations will be discussed in this writing. The explanation of the use of the tables will be divided into the following sections:

(1) General Description of yield tables.
(2) Basic techniques of using tables.
(3) Application of tables to industrial problems.
II. GENERAL DESCRIPTION

A. Data Collection + Computer Programming

The tables are based on data gathered by the examination of 12,569 bd. ft. of lumber. The data pertaining to the defect positions, sizes, and lumber sizes were manually measured, and punched on electronic data processing cards. A computer then examined the cards and considered the defect positions and sizes in relation to various cutting length requirements. The computer indicated the yields of lumber which were possible from the various grades of lumber in relation to the cutting length combinations.

The computer was programmed in two ways. By one method, the longest length in the cutting order was given preference and quantity requirements were, in a sense, considered. In the second cutting method, the computer was instructed to indicate only maximum yield.

Only the "longest length" information is included in this writing, since it is the information which is applicable in the conventional cutting situation, when quantity requirements are attached to the cutting lengths.

The maximum yield figures, which are not included, indicate the yields which would result if lumber were cut for maximum yield only and not as in industry today, for maximum yield of certain quantities of lengths.

B. Applicability of Tables

The information in the tables is applicable only to lumber which has been graded in compliance with the Standard National Hardwood Lumber Association Grading Rules. The tables apply, for instance, to such woods as Beech, Birch, and Hard Maple, etc.

The tables cannot be applied to such woods as Walnut and Cherry, which are graded by a special grading procedure, unless these species are regraded according to the standard rules.

All figures in the tables pertain to 4/4 lumber, and clear two_sides cutting requirements. The tables also can be used for 3/4 lumber, but additional data adjustments are required for 6/4, and 8/4 lumber, and for clear one_side cutting requirements.

The figures in the tables represent yields from graded and scaled kiln-dried lumber. Most yield figures available to the dimension
stock producer pertain to green or air-dried volumes and grades. The table data must be adjusted to account for this difference in input data.

Additional modifications, which often are necessary, will be pointed out later in this writing. At this point it may seem that the required adjustments are numerous. These adjustments, however, can be rather easily made.

Industrial experience has indicated that by using the tables, the furniture manufacturer can predict his yield in rough dimension stock from the various grades of lumber, when cutting lengths and quantities are specified, with an accuracy of plus or minus five percent.

III. BASIC TECHNIQUES IN USING TABLES

The yield tables consist of four pages. Each page represents a grade of lumber. Page 1, of the tables, for instance, pertains to the yield in number of cuttings which will be produced from 1000 Bd. Ft. of FAS lumber.* The far right-hand column of percent yields indicates the yields which would result if lumber of the indicated grade were cut into various lengths.

Example 1

**Question:** What percent yield would result if 1000 Bd. Ft. of FAS lumber were cut into only 5' lengths (random width)?

**Procedure:** Find 5' target length in left-hand column of page 1 of tables, and read across to corresponding percent yield.

**Answer:** 76.7%

Pages 2, 3, and 4 of the tables pertain to select, 1 common and 2 common grades respectively.

Example 2

**Question:** What percent yield would result if 1000 Bd. Ft. of (a) Select lumber were cut into 4' lengths? (b) common lumber? (c) 2 common lumber?

* For industrial use, these tables must be adjusted, as will be pointed out later. The general concepts and techniques discussed under the "Basic Techniques" heading will still apply.
Procedure: (a) Turn to page 2, locate 4' target length on left-hand side of page and read across to corresponding percent yield figure. (b) Turn to page 3 and do the same. (c) Turn to page 4 and do the same.

Answer: Yield in 4' lengths (random width) from Selects = 76.6%
Yield in 4' lengths (random width 1 common = 62.8%
Yield in 4' lengths (random width 2 common = 46.1%

Note that the figures so far obtained were read from the "Inclusive rows." Inclusive refers to random width. The figures in the body of the tables to the left of the percent yield figure and in the inclusive row, indicate the distribution of widths, in numbers of pieces, which will result when 1000 Bd. Ft. of the associated grades are cut into the indicated target lengths.

For instance, if 1000 Bd. Ft. of FAS lumber were cut into 1' lengths after ripping and salvage, 76-1" widths would be produced, plus 77-2" widths, plus 70-3" widths, etc.

Exclusive refers to fixed or specified width cutting. For instance, the FAS grade indicates that if only 3" widths by 2' lengths were cut, 1487 pieces 2' x 3" would be yielded.

Example 3

Question: How many pieces 5' x 4" would be yielded from 1000 Bd. Ft. of (a) FAS lumber? (b) 1 common lumber? (c) 2 common lumber?

Procedure: Follow 5' target length "row" across until it intersects 4" width column for each grade.

Answer: (a) Yield in 5' x 4" pieces from FAS = 343 pieces
(b) Yield in 5' x 4" pieces from 1 common = 192 pieces
(c) Yield in 5' x 4" pieces from 2 common = 62 pieces

One important note -- The piece numbers in the "exclusive" rows are not additive. If 5' x 4" cuttings are cut from FAS, ONLY 343 pieces will result. IT is incorrect to say that 242 - 5' x 5" pieces, etc., will also be yielded. The piece numbers in the exclusive rows are not additive.

Remember, exclusive refers to fixed or specified widths. Inclusive refers to random width yield. The exclusive yields are not additive across the row, but the inclusive widths are additive across the row.
Example 4

**Question:** (a) If 1000 Bd. Ft. of FAS lumber were cut into 3' lengths of random width, how many of those random width cuttings would be 6" wide?

(b) If 1000 Bd. Ft. of FAS lumber were cut into 3' x 6" pieces, how many pieces of that size would be yielded?

**Procedure:**
(a) Read inclusive row on FAS table
(b) Read exclusive row on FAS table

**Answer:**
(a) Inclusively yield in 3' x 6" pieces from FAS = 78 pieces*
(b) Exclusively yield in 3' x 6" pieces from FAS = 369 pieces.

Example 5

**Question:** How many board feet of FAS lumber would be required to fill a cutting order calling for 700 Bd. Ft. of random width cuttings 6' long?

**Procedure:**
(a) Obtain yield value from table: Table yield = 73.5%
(b) Divide required yield by predicted table yield per thousand.

**Answer:** FAS 700 = 948 Bd. Ft. .738

Example 6

**Question:** How many board feet of lumber would be required to fill the above order if (a) select, (b) 1 common, (c) 2 common were used?

**Procedure:** Use same procedure as in Example 5, for each grade.

**Answer:**
(a) Select 700 = 1051 Bd. Ft. .666
(b) 1 common 700 = 1423 Bd. Ft. .492
(c) 2 common 700 = 2154 Bd. Ft. .325

* Pieces in all other widths up to 12" would also be yielded.
Example 7

Question: Which would be the "least cost" grade of lumber to use for the previous example, assuming the following price schedule:

<table>
<thead>
<tr>
<th>Grade</th>
<th>$/MBF</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAS</td>
<td>245</td>
</tr>
<tr>
<td>Select</td>
<td>195</td>
</tr>
<tr>
<td>1 common</td>
<td>157</td>
</tr>
<tr>
<td>2 common</td>
<td>70</td>
</tr>
</tbody>
</table>

Procedure: Multiply lumber prices by quantity requirements for each grade.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Necessary Inputs to Fill Order of 700 Bd. Ft.</th>
<th>Lumber Price</th>
<th>Lumber Cost for Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAS</td>
<td>948 Bd. Ft.</td>
<td>x $245/MBF</td>
<td>$232.26</td>
</tr>
<tr>
<td>Select</td>
<td>1051 &quot; &quot;</td>
<td>x $195/MBF</td>
<td>$204.95</td>
</tr>
<tr>
<td>1 common</td>
<td>1423 &quot; &quot;</td>
<td>x $157/MBF</td>
<td>$223.41</td>
</tr>
<tr>
<td>2 common</td>
<td>2154 &quot; &quot;</td>
<td>x $ 70/MBF</td>
<td>$150.78</td>
</tr>
</tbody>
</table>

IV. APPLICATION OF TABLES TO INDUSTRIAL PROBLEMS

For industrial applications, dealing with five or more cutting lengths, the ideal would be to have a computer perform the required calculations. Over one thousand calculations would have to be made if all the possible combinations of grade inputs were examined in an attempt to determine the optimum grade mix of lumber to use for a cutting order involving five lengths. Certainly, only a computer could feasibly handle the task.

North Carolina State is considering the development of a computer program which would allow plants to feed into the computer their cutting length requirements, current lumber prices, etc. The required calculations would be made automatically, and the computer would indicate the least-cost grade mix of lumber to use to satisfy the cut-stock requirements.

An abbreviated, but successful, procedure for using the tables has been developed by Mr. Sterling Durst, ** and Mr. Vincent Ross.*** The procedure involves four basic steps.

* Least cost grade.
** Director of Manufacturing, Owen's Yacht Company, Division of the Brunswick Corporation, Baltimore, Maryland.
(1) Adjustment of yield tables.
(2) Graphing adjusted yield information, and developing a yield curve for each grade.
(3) Reducing cutting orders to a manageable number for calculation purposes, by combining cutting lengths.
(4) Extracting yield information from curves and performing abbreviated calculations which will indicate the approximate least-cost grade to use for the order. Through trial and error, and experience the least-cost grade mix can then be approximated.

A. Adjustment of Yield Tables

It was pointed out previously that the table yield values must be adjusted, if lumber and cutting size requirements in the production situation are different from the lumber and cutting size requirements on which the yield tables were based. Recall the tables were based on the following:

(1) 4/4 lumber
(2) Clear 2 sides cutting requirements
(3) Kiln-dried lumber volumes and grades
(4) Yields determined by a computer
(5) NHLA Standard Grading rules

The necessary adjustments can be represented by the following equation:

\[
\text{Yield from table} \times \text{Adjustment factor for narrow widths} \times \text{Standard adjustment factor for occurrence of prohibitive defects} \times \text{Adjustment factor for error, kiln degrade, and shrinkage} = \text{Predicted yield}
\]

1. Adjustment for Narrow Stock

Some plants will not use stock narrower than 3" in width. But the 1" and 2" wide stock has been included in the inclusive yield volumes indicated in the tables. If these narrow widths are not useful yield, their volume must be subtracted from the total volume, and the percent yield values correspondingly reduced.
For instance, assume widths narrower than 3" are not useful to a particular company. The following is an example of the procedure for reducing the table yields of 1' lengths, from FAS lumber, to account for the narrow widths. All table yields would similarly be adjusted.

1. Yield in 1' x 2" = 76 pieces = 76 units
   Yield in 1' x 2" = 77 pieces = 154 units
   Total yield in narrow widths = 230 units

A unit is equal to the equivalent of a one-inch wide strip. A piece 1' x 2", for instance, would contain two units, etc.

2. Divide the number of units of narrow widths by the total possible yield, as indicated in this case, by the number of pieces in the 1' x 1" exclusive category.

   230 units  = .020 yield in narrow widths
             11295 units

3. Subtract percent yield in narrow widths from 1.000.

   1.000 - .020 = .98 narrow width factor

4. Multiply the adjustment factor determined in step 3, by the table yields to determine the yield in useful widths.

   Table Yield x Narrow Width Factor = Useful Yield

   \[ 94.1 \times .98 = 92.2 \]

2. **Standard Adjustment Factor**

   The standard adjustment factor will usually be about .90. This adjustment is necessary to account for the fact that the yields in the table were determined by an electronic computer. An operator's ability will not match the ability of the computer to maximize yields.

   Also, as mentioned previously, the yields in the table are based on kiln-dried volumes and grades. Account must be taken of the fact that lumber volume and grade figures available to the furniture producer are relative to green lumber.
The standard adjustment factor is based upon the following estimates:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss in yield due to operator error</td>
<td>0.05</td>
</tr>
<tr>
<td>Loss in yield due to kiln shrinkage</td>
<td>0.03</td>
</tr>
<tr>
<td>Loss in yield due to kiln degrade</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>0.10</td>
</tr>
</tbody>
</table>

\[1.00 - 0.10 = \text{standard adjustment factor} = 0.90\]

If clear one-side cuttings are permitted, the adjustment factor can be increased by about 0.02, resulting in a 0.92 standard adjustment factor.

If 6/4" or 8/4" stock is cut, rather than 4/4" or 5/4" lumber, the factor should be reduced by about 0.03, resulting in a 0.87 standard factor.

3. **Adjustment Factor for Prohibitive Defects**

When a company finds that it loses yield because of defects which are present in the lumber, which were not recognized as defects by NHLA grading rules, the predicted yields of the tables must be correspondingly reduced.

For instance, if yield is reduced by six percent because of prohibitive mineral streak, the values in the tables must be adjusted by multiplication by a 0.94 factor.

\[(1.00 - 0.06 = 0.94)\]

**Example 8**

Assume XYZ furniture company desires to prepare a series of curves indicating what yields in useful stock they could expect from the various grades of 4/4" lumber. The company will not accept widths less than three inches, but it will accept clear one-side cuttings. The company has found from experience that it loses five percent yield of dimension stock because of defects which were not reflected by NHLA grades.

What would be the adjusted percent yield value which they would plot for the two common lumber and the three-foot target length?

**Procedure:**

1. From curves, determine predicted yield (not adjusted).

   Predicted yield = 54.3%
2. Calculate adjustment factor for narrow widths. (2 common, 3' lengths)

(a) Yield in 3' x 1" = 173 pieces = 173 units
Yield in 3' x 2" = 173 pieces = 346 units
Total yield in narrow widths = 519 units

(b) Divide units of narrow widths by the exclusive yield of 3' x 1" pieces

\[
\frac{519 \text{ units}}{2179 \text{ units}} = .238 \text{ yield in narrow widths}
\]

(c) Subtract percent yield determined in step 3, from 1.00

\[
1.000 - .238 = .762 \text{ narrow width factor}
\]

3. Calculate standard adjustment factor.

(a) Standard factor for operator error, shrinkage and degrade = .90

(b) Add .02 since clear one side admitted + .02

Total standard adjustment factor = .92

4. Calculate adjustment factor for prohibitive defects.

(a) From statement of problem, five percent yield loss results.

(b) \[1.00 - .05 = .95 \text{ Adjustment factor for prohibitive defects.}\]

5. Multiply all adjustment factors times table yield.

Table x Adjustment factor for narrow widths x Standard adjustment factor x Prohibitive defect adjustment factor = Predicted yield factor

\[
54.3 \times .762 \times .92 \times .95 = 36.2\%
\]

The value of 36.2% yield would then be graphed as the predicted yield from 2 common lumber of three-foot lengths.
B. Graphing of Adjusted Yield Values

All yield values are graphed to facilitate the determination of expected yields of cuttings which are not of even one-foot lengths. If only the modified yield tables were used, interpolation would be required for cutting sizes such as 22", 17", etc.

The curves on page 12 were developed by an industrial concern to suit their particular situation. Every company should develop their own sets of curves.

Example 9

Question: From the graph, what yield would be expected in 52" cuttings from (a) 1 common lumber? (b) FAS lumber?

Procedure: Find point on grade curves where horizontal line from 52" point on Y-axis intersects grade curve. Follow vertical line to the X-axis and read expected yields.

Answer: (a) 1 common - 49% yield
(b) FAS - 72% yield

C. Combining Lengths in Cutting Order

It is usually best to reduce the number of curring lengths to not more than five, for ease of calculation. This is accomplished by grouping similar cutting lengths into one category as indicated below.

<table>
<thead>
<tr>
<th>Original Order</th>
<th>Combined-Length Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>Board Feet</td>
</tr>
<tr>
<td>84&quot;</td>
<td>1000</td>
</tr>
<tr>
<td>61&quot;</td>
<td>300</td>
</tr>
<tr>
<td>60&quot;</td>
<td>200</td>
</tr>
<tr>
<td>59&quot;</td>
<td>100</td>
</tr>
<tr>
<td>33&quot;</td>
<td>700</td>
</tr>
<tr>
<td>32&quot;</td>
<td>700</td>
</tr>
<tr>
<td>31&quot;</td>
<td>600</td>
</tr>
<tr>
<td>24&quot;</td>
<td>2000</td>
</tr>
<tr>
<td>23&quot;</td>
<td>1000</td>
</tr>
<tr>
<td>16&quot;</td>
<td>3000</td>
</tr>
<tr>
<td>12&quot;</td>
<td>300</td>
</tr>
</tbody>
</table>
Note that the 59", 60", and 61" lengths and volumes are grouped into a 60" category. Similarly, the 31", 32" and 33" lengths were grouped, etc.
YIELD CURVES FOR POPLAR
D. Using Curves and Performing Calculations

Example 10

Question: How many board feet of 2 A-Common lumber would be required to satisfy the following cutting order?

<table>
<thead>
<tr>
<th>Length</th>
<th>Board Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>84&quot;</td>
<td>1000</td>
</tr>
<tr>
<td>60&quot;</td>
<td>600</td>
</tr>
<tr>
<td>32&quot;</td>
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</tr>
<tr>
<td>24&quot;</td>
<td>3000</td>
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<tr>
<td>16&quot;</td>
<td>3000</td>
</tr>
<tr>
<td>12&quot;</td>
<td>300</td>
</tr>
</tbody>
</table>

Procedure: Construct a table similar to the one on page 65.

- **Column (A)**
  Enter in Column (A) the cutting length requirements in order of decreasing length.

- **Column (B)**
  Enter corresponding volume requirements.

- **Column (C)**
  Enter grade(s) of lumber being considered.

- **Column (D)**
  Enter yields from curves. In this case, the curves on page 12 were assumed to be appropriate. In actual practice, each company would use its own curves.

- **Column (E)**
  Calculate values to be entered in this column by subtracting each value in Column (D) from the value below it. The value of .085, for instance, was calculated by subtracting 
  
  \[ .225 - .140 = .085 \]

  Similarly, the value of .100 was calculated by subtracting 
  
  \[ .570 - .470 = .100 \]

  Since the top value in Column (D), .140, does not have any value above it, it is simply entered in Column (E).

  An example will best explain what is meant by "yield distribution."
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) 84&quot; 1000</td>
<td>2A .140 .140 7142</td>
<td>1000 0 0 0</td>
<td>7142</td>
<td>(R) 84&quot; 1000</td>
<td>2A .140 .140 7142</td>
<td>1000 0 0 0</td>
<td>7142</td>
<td>(S) 60&quot; 600</td>
<td>2A .225 .085 607 0 0 0</td>
<td>607 0</td>
<td>0</td>
<td>532</td>
<td>(T) 32&quot; 2000</td>
<td>2A .470 .245 1750 250 532 250 0</td>
<td>532</td>
<td>(U) 24&quot; 3000</td>
<td>2A .570 .100 714 2286 53 2233 3917 2233 0</td>
</tr>
</tbody>
</table>
Assume 84" is the primary target length. The yield in that length which will result is .140. Also, however, additional shorter lengths will be yielded as secondary cuttings. An additional yield of .085 will result in 60" lengths, .245 in 32" lengths, etc.

Column (F)
Calculations are made by considering the cutting lengths in order of decreasing length. Once the output requirements for the longest length have been satisfied, the input requirements to satisfy the next longest length are calculated.

The first input requirement is determined by dividing the required output in 84" lengths by the associated yield in Column (D).

\[
\frac{\text{Output required}}{\text{Yield from curves}} = \frac{1000 \text{ Bd. Ft.}}{.140} = 7142 \text{ Input Required}
\]

Column (G)
The required output in 84" lengths of 1000 Bd. Ft. is yielded from the first lumber input.

The additional output is secondary lengths is calculated by multiplying the input of 7142 Bd. Ft. by the corresponding yield distribution factors.

<table>
<thead>
<tr>
<th>Yield Distribution Factor</th>
<th>Required Input</th>
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</thead>
<tbody>
<tr>
<td>.085</td>
<td>7142 x</td>
</tr>
<tr>
<td>.245</td>
<td>7142 x</td>
</tr>
<tr>
<td>.100</td>
<td>7142 x</td>
</tr>
</tbody>
</table>

Column (H)
The output requirements (indicated in Column (B) of the 84", 60", and 12" lengths were satisfied by the first lumber input. Therefore, there are no "deficits" in those lengths.

However, an additional 250 Bd. Ft. of 32" lengths, 2286 Bd. Ft. of 24" lengths, and 2322 Bd. Ft. of 16" lengths are still required.
**Column (I)**

What should be the second input of lumber if the additional requirement of 250 Bd. Ft. of 32" lengths is to be satisfied?

\[
\text{Deficit} = 250 = 532 \text{ Bd. Ft.} \quad \text{Input required.}
\]

\[
\text{Yield from curves} = .470
\]

**Column (J)**

The requirement for 32" lengths is satisfied. Fifty-three board feet of 24" lengths (532 x .100), and 50 Bd. Ft. of 16" lengths (532 x .095) are also produced.

**Columns (K) - (P)**

Follow same procedure as described in Columns (A) - (J).

**Columns (Q)**

Transfer all input requirements and sum.

**Answer:** Approximately 14,500 Bd. Ft. of 2 A-common lumber would be required to satisfy the cutting order.

The necessary quantities of lumber to satisfy the cutting order also can be calculated for the other grades. With knowledge of the price of each grade, the cost of using each grade can be calculated, and the least-cost grade can be selected.

It usually will be found that the least-cost method of satisfying a cutting order will involve the use of more than one input grade of lumber.

For instance, the possibility of using FAS for the 84" and 60" lengths, 1 common for the 32" lengths, and 2-A common for the other requirements should be considered.

In essence, the procedure for estimating the least-cost grade mix of lumber to use will require a decision to be made for each of the cutting lengths, relative to which grade should be used to satisfy the cutting requirements.

These decisions can be made within the framework of the table on page 66.
### First and Seconds

Yield in number of longest length cuttings per thousand board feet. Clear two sides.

<table>
<thead>
<tr>
<th>Target Length (Feet)</th>
<th>Inclusive</th>
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</tr>
</thead>
<tbody>
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<td></td>
<td>Width of Cutting in Inches</td>
<td></td>
</tr>
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|                      | 800 | 357 | 208 | 138 | 97 | 73 | 53 | 29 | 12 | 7 | 6 | 2 |          |          |
## SELECT GRADE

**YIELD IN NUMBER OF LONGEST LENGTH CUTTINGS PER THOUSAND BOARD FEET CLEAR TWO SIDES**

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<th>Target Length (feet)</th>
<th>Cuttings</th>
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<th>Percent Yield</th>
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</table>
## NO. 1 COMMON GRADE

**Yield in number of longest length cuttings per thousand board feet, clear two sides**

<table>
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<tr>
<th>Target Length (feet)</th>
<th>Cuttings</th>
<th>Width of Cutting in Inches</th>
<th>Percent Yield</th>
</tr>
</thead>
<tbody>
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## NO. 2 COMMON GRADE

**YIELD IN NUMBER OF LONGEST LENGTH CUTTINGS PER THOUSAND BOARD FEET CLEAR TWO SIDES**

<table>
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<tr>
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<th>Cuttings</th>
<th>Width of Cutting in Inches</th>
<th>Width of Cutting in Inches</th>
<th>Width of Cutting in Inches</th>
<th>Width of Cutting in Inches</th>
<th>Width of Cutting in Inches</th>
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<th>Width of Cutting in Inches</th>
<th>Percent Yield</th>
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</thead>
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</tbody>
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Percent Yield
"ANATOMY OF A LUMBER UTILIZATION IMPROVEMENT PROGRAM"

BY VINCENT R. ROSS
ROSS ASSOCIATES
ASHEVILLE, NORTH CAROLINA

In the lumber yield workshops prior to this one, we concentrated our effort on methods, techniques, and processes for the improvement of lumber utilization. In this seminar, we will again attempt all of these things, and in addition, we will lead you through an actual case history of the installation of such a program.

The results in terms of increased lumber utility are of course the focal point in the case history. However, your reaction to the information may be one of surprise when you are presented with some of the very interesting and unsuspected side issues. These issues develop as one probes for the information and data necessary to the establishment of a solid program.

How and why does a company suddenly become interested in doing something about their lumber utility? The "how" part of the question can be answered by seminars of the type we are participating in today as well as association publications and contact with fellow manufacturer The "why" part of the question, although not more complex is somewhat more interesting. Four or five years ago in our work with the furniture industry we found it almost impossible to convince any of our clients that they should concentrate more of their attention on lumber utility. Most of their effort was directed toward cost savings via new and sophisticated equipment, and reduction in labor per unit of production. The fact that lumber is usually the single most costly item in the factory seemed to have little bearing on the thinking of that period. Fortunately the worm has since turned and management, for the most part, realizes the great potential for cost savings in lumber utility.

INITIAL INTEREST

A lumber utilization program is usually conceived by a member of a company's management team contacting a firm or individual who specializes in this work. If the member of management is convinced that the specialist's services may be helpful to his company, he will set up a meeting with other members of the management team. If the management group as a whole think the proposed program is sound, a contract is signed and a starting date established.
PREPARING THE PROPER CLIMATE

This is a phase of the program that cannot be emphasized too strongly. We all know that a poor system can be made workable given enthusiastic management support and employee participation. By the same token, a good system can be shot-down given uninterested management and antipathetic employees. The approach then is to use some means to "get the team up for the ball game".

One approach that is effective is a series of group meetings, first with supervisors, then with employees. If the plan is relatively small, one meeting for supervisors and one meeting for employees may suffice. In a large plant, the groups are usually broken down by departments with several meetings held. The meetings are more effective if the groups are not too large. The approach is to indoctrinate all concerned individuals, supervisors and employees, by members of top management. Management stresses the point that the program is sound and well-grounded in fact and experiences. Most important, they stress the fact that the program shall work. That is is not something experimental to be accepted or rejected, but a workable, viable approach to a problem that up to now has gone unsolved. This whole management approach and attitude is reinforced by the outside specialist with discussion, the presentation of slides, and information from successful operations elsewhere. When this phase has been completed, the program is ready for implementation in the factor. The study that follows is an example of the implementation and results of a lumber yield optimization program that was installed in a multi-plant operation. Excerpts from, or actual examples of, reports and other data are included in the presentation.

************XYZ FURNITURE COMPANY, ANYTOWN, VIRGINIA**********

ADJUSTMENT FACTORS - YIELD TABLES

<table>
<thead>
<tr>
<th>% - 4/4 Poplar - C2S</th>
<th>FAS</th>
<th>Selects</th>
<th>#1C</th>
<th>#2C</th>
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<tr>
<td>Kiln Shrinkage</td>
<td>4</td>
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<td>4</td>
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<tr>
<td>Kiln Degrade</td>
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<td>Scrap Saw</td>
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<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Glue Jointer</td>
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<td>2</td>
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<td>2</td>
</tr>
<tr>
<td>Cut-off Saw</td>
<td>7</td>
<td>7</td>
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<td>7</td>
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<table>
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</tr>
<tr>
<td>(8/4)</td>
<td>3</td>
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LUMBER USAGE - FIRST 6 MONTHS 1965

<table>
<thead>
<tr>
<th></th>
<th>BOARD FEET</th>
<th>% TOTAL</th>
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<tbody>
<tr>
<td>Poplar</td>
<td>4,632,901</td>
<td>46%</td>
</tr>
<tr>
<td>Hackberry</td>
<td>3,739,540</td>
<td>35%</td>
</tr>
<tr>
<td>Walnut</td>
<td>412,062</td>
<td>4%</td>
</tr>
<tr>
<td>Pecan</td>
<td>817,185</td>
<td>8%</td>
</tr>
<tr>
<td>Others</td>
<td>778,763</td>
<td>7%</td>
</tr>
<tr>
<td>Total</td>
<td>9,918,439</td>
<td>100%</td>
</tr>
</tbody>
</table>

XYZ FURNITURE COMPANY, ANYTOWN VIRGINIA

YIELD TABLE ADJUSTMENT INFORMATION

1. No select grade in Pecan or Hickory unless cabinet Grade is specified.
   a. Bird peck admitted in #2C.
   b. Cuttings are "Sound" and not clear in #2C.


3. Standard grades of maple and hackberry yield 5 percent less than poplar. While maple yields same as poplar.

4. Standard grades of pecan and hickory yield 8 percent less than poplar.

5. Standard grades of walnut yield 10 percent less than poplar.
LUMBER STUDY

INTRODUCTION

The following report is the result of a lumber utilization study initiated by the research facilities at N. C. State College and directed by Ross Associates of Asheville, N. C. Its purpose was to determine the feasibility of buying, separating and using lumber by grade in the manufacture of furniture parts. The original research at State College attempted to develop yield expectancy charts for dimension stock obtainable from random width graded lumber. Our program at adjusted these taking into consideration such factors as quality, tolerance, and buying practices.

PROCEDURES

Of necessity our studies were limited to a single species, i.e. Hackberry. The tests included 7,700 #FAS, 7,800' 4/4 #2 Com, 7,900 4/4 #1 Com, 7,070' 5/4 FAS, and 9,800' 8/4 #1 Com. The yield of each grade was closely calculated under plant conditions and charts were adjusted in accordance with these results and with accumulated records of past performance with the mixed grade presently being utilized.

A representative cutting was then determined and footage requirements were calculated by grade in accordance with the adjusted charts. The gross footage necessary to produce net requirements in the rough mill and the resultant waste percentage as compared to requirements and costs resulting from our present waste percentages are shown in the following analysis of the test cutting. See Appendix I.

FINDINGS

Price and yield studies clearly indicated that lengths in excess of 40" are more profitable cut from FAS lumber and those shorter than 40" from a #2 Com grade. Based on these findings it was determined that our projected requirements for the FAS grade were far in excess of the market availability. Similarly, it was found to be impossible to exclude the #1 Com Grade. It was, therefore, decided to separate for study purposes into two classifications, i.e. Com & Btr. and #2 Com. Com. & Btr. has been determined under present buying practices to be 8% FAS and 92% #1 Com. It should be noted that FAS lumber is still by far the most economical grade under the present market price structure.

An analysis of the representative cutting indicates an increase in total footage requirements but with an overall potential savings
in avg. cost per M. Complete analysis of these variance is given in Appendix III. The potential savings inherent in this program stem largely from greater utilization of the #2 Com grade. This became apparent in the comparison of grade costs: 4/4 #2 Com Hackberry cost approximately $95.00/M whereas #1 Com & Btr. costs approximately $191.00/M. An additional savings can be realized by increasing our percentage of FAS in the #1 Com & Btr. grade whenever possible. It should be noted, however, that grading of #2 Com must be in strict accordance with the National Hardwood Association rules, that is 50% clear. It was discovered during the course of these studies that stained lumber was being admitted by our graders as no defect in the clear cutting portion of the board. A clarification of the rules was obtained from the association to confirm the 50% clear requirement.

BUYING PRACTICES & RELATED COSTS

Although the quantities involved in the test cutting were calculated to be representative according to sales experience, it was evident that footage involved in many cases is not sufficient to draw conclusive decisions. It is apparent, however that a much larger percentage of #2 Com. can be effectively used. Our present buying practices and avg. cost per thousand compared with projected requirements based on this study is given in Appendix II.

RECOMMENDATIONS

Needless to say, certain dangers exist in handling and utilizing graded lumber. Any attempts to yield lengths in excess of 40" from #2 Com. lumber would result in excessive accumulations of short ends and a considerably lower yield percentage than is now being realized. The right grade would have to be available at the right time to attain the desired results. This study did not attempt to evaluate scheduling problems inherent in maintaining facilities at the yard or in the drying and storage by grade at the separate plant locations. Consideration of these factors deserves careful evaluation in terms of the practicality of the overall system.

As the program is designed, long lengths will be cut first using the C & B grade and producing only the minimum of shorter lengths necessary to efficiently utilize the material. This may necessitate more frequent transferring of kiln trucks in order not to over cut the more expensive lumber in the manufacture of short lengths.

A separate study of counting procedures at the four uptown plants clearly indicated the need for closer control. Spot checks of approximately 50 different bills showed variances from minus 17.4% to plus
51.8% on quantities ranging from 100 to 3,000 parts. Should this program be adopted, it is evident that greater emphasis must be placed in this area. Excessive over counts on parts produced from the higher priced lumber could seriously affect our cost picture.

It is recommended that one man in each rough mill department be designated to count stock for all saws as it is being ripped. He would likewise be responsible for overseeing the selection of lumber for use in producing specified stock. For maximum effectiveness this individual should not be under the direction of the rough mill foreman.

Such a procedure would entitle the classification of all parts according to expected loss rate in the plant and the inclusion of an allowable over count on each bill tag. The classification of parts can be accomplished at time of billing. Preliminary work on parts classification has begun and rough counts can be accomplished with a minimum of change in the present procedures.

CONCLUSIONS

The program is basically sound in that it is formulated from standard grading rules, and present retail lumber prices. In order to be successful in its entirety, greater emphasis must be placed on scheduling and inter-plant controls. The availability of specified grades in the quantities required and the costs of maintaining the program have not been fully investigated.
### APPENDIX I

**1260 GROUP LUMBER STUDY**

**5/18/66**

<table>
<thead>
<tr>
<th>Species</th>
<th>Grade</th>
<th>Gross Requirements</th>
<th>Net Footage</th>
<th>Waste %</th>
<th>Grade</th>
<th>Gross Requirements</th>
<th>Net Footage</th>
<th>Waste %</th>
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<tbody>
<tr>
<td>4/4 Hack-berry</td>
<td>C&amp;B</td>
<td>6581'</td>
<td></td>
<td></td>
<td>#2</td>
<td>Com. &amp; Btr.</td>
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<tr>
<td></td>
<td></td>
<td>#2C 7157'</td>
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<td><strong>TOTAL</strong></td>
<td></td>
<td>13,728'</td>
<td>7,516'</td>
<td>48%</td>
<td>12,928'</td>
<td>7,515'</td>
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<td></td>
<td></td>
<td>+ 6.2%</td>
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<tr>
<td>5/4 Hack</td>
<td>C&amp;B</td>
<td>1,754'</td>
<td></td>
<td></td>
<td>#2</td>
<td>Com. &amp; Btr.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>#2 4,632'</td>
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<td></td>
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</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>6,386</td>
<td>3,414'</td>
<td>47%</td>
<td>5,565'</td>
<td>3,414'</td>
<td>39%</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+14.7%</td>
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<tr>
<td>8/4 Hack</td>
<td>C&amp;B</td>
<td>2,069'</td>
<td></td>
<td></td>
<td>#2</td>
<td>Com. &amp; Btr.</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>#2C 5,558'</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>7,627'</td>
<td>4,126'</td>
<td>46%</td>
<td>6,643'</td>
<td>4,126'</td>
<td>38%</td>
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<td><strong>GRAND TOTAL</strong></td>
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<td>27,751'</td>
<td>15,056'</td>
<td>46%</td>
<td>25,136'</td>
<td>15,056'</td>
<td>40%</td>
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## APPENDIX II

### BUYING PRACTICES

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<tr>
<th>Grade Thickness</th>
<th>FAS</th>
<th>#1 Com.</th>
<th>#2 Com.</th>
<th>Avg. Cost/M</th>
<th>Com. &amp; Btr.</th>
<th>#2 Com.</th>
<th>Avg. Cost/M</th>
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</thead>
<tbody>
<tr>
<td>4/4</td>
<td>7%</td>
<td>83%</td>
<td>10%</td>
<td>$182.00</td>
<td>48%</td>
<td>52%</td>
<td>$141.00</td>
</tr>
<tr>
<td>5/4</td>
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<td>71%</td>
<td>16%</td>
<td>190.00</td>
<td>27%</td>
<td>73%</td>
<td>129.00</td>
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<tr>
<td>8/4</td>
<td>23%</td>
<td>62%</td>
<td>15%</td>
<td>230.00</td>
<td>27%</td>
<td>73%</td>
<td>151.00</td>
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## APPENDIX III

### ROUGH MILL COST COMPARISON TO PRODUCE 1000' NET FOOTAGE

<table>
<thead>
<tr>
<th>Species</th>
<th>Material Cost</th>
<th>Labor Cost</th>
<th>Total Cost</th>
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<th>Labor Cost</th>
<th>Total Cost</th>
<th>Savings</th>
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<tr>
<td>4/4</td>
<td>$269.00/M</td>
<td>$48.00</td>
<td>$317.00</td>
<td>$182.00</td>
<td>$43.00</td>
<td>$356.00</td>
<td>$39.00</td>
</tr>
<tr>
<td>5/4</td>
<td>242.00</td>
<td>47.00</td>
<td>289.00</td>
<td>310.00</td>
<td>41.00</td>
<td>351.00</td>
<td>62.00</td>
</tr>
<tr>
<td>8/4</td>
<td>279.00</td>
<td>46.00</td>
<td>325.00</td>
<td>371.00</td>
<td>40.00</td>
<td>411.00</td>
<td>86.00</td>
</tr>
</tbody>
</table>
Note: The accompanying article was written in January 1966 and published in the newspaper of the company represented in this case history. It is interesting to note that a 1% saving for this company represents $35,000 per year. At the time the article was written a 12% improvement had been made representing $420,000 per year savings.

What part of xxxxxx $3 1/2 million expenditure for lumber each year can be saved -- saved perhaps to help provide things like a pay raise for employees, or for a better dividend for the stockholders of the Company, or for new production equipment?

The answer is -- a whole lot. Thousands and thousands of dollars. This, at least, is what xxxxxxxxxx industrial engineers think. They are in the business now of finding out.

An experimental program to increase lumber yield was started at the Company in June last year. The project was formulated in 1964 at the University of North Carolina, Raleigh, by Dr. Richard Thomas. Since then only one other furniture manufacturer in the United States besides xxxxxx has put the program into use.

The xxxxxxxxxx project is directed by Vincent R. Ross, of Ross Associates. Getting the program in operation here are Larry Yost and Jimmy Spencer, of the Company Engineering Dept. They work with Mr. Ross under the supervision of R. L. Whitener, vice-president in charge of manufacturing.

So far results from the program are encouraging. Phase One of the experimental program already shows a 12 percent improvement for a four months period under study.

When the lumber yield program was started the four xxxxxx production
plants were using 7.45 percent MORE lumber than the Company was showing in its cost system. The Company cost system is used to determine the production cost of furniture here.

But at the end of Phase One of the lumber yield program the use of lumber during the four months period was down to 95.06 percent— or 4.4 percent LESS than the Company was calculating in the cost system.

Here is a breakdown by plants for a six months period in 1965.

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<th>Plant No.</th>
<th>END</th>
<th>BEGINNING</th>
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<tr>
<td>No. 1</td>
<td>101.3%</td>
<td>103.52%</td>
</tr>
<tr>
<td>No. 2</td>
<td>91.74</td>
<td>107.11</td>
</tr>
<tr>
<td>No. 4</td>
<td>96.68</td>
<td>110.13</td>
</tr>
<tr>
<td>No. 8</td>
<td>91.73</td>
<td>93.14</td>
</tr>
</tbody>
</table>

The overall comparative change for the plants was from 104.76% at the beginning of the six months period down to 95.06% at the end of the six months period in November, 1965.

What brought about the change? What affected the savings in lumber used?

Simply the constant checking to see that the men in the Rough End Dept.—at the cut off saws, at the joiners, and at the salvage saws—knew what to do and how to use the equipment. Better training, improved techniques in machinery operators, and constant checking accounted for the good results in Phase One of the experimental lumber program.

The attitude of production men in the factory working with the program has been splendid, xxxxxxx engineers say. There are always problems in introducing new ideas and different methods. But production men in the factory have tried their utmost to understand these problems and to co-operate effectively with the Engineering Department.
"Certainly without this fine co-operation of men in the factory, this lumber yield program wouldn't have a chance for the success it has had," says Jimmy Spencer, who is working with the program.

Phase Two of the program will get underway next month. In this phase of the program specific grades of lumber will be cut to get maximum yield.

This is a change from usual procedure where four or five different grades of lumber are fed at random to the Rough End Department in the "hope" that the best possible yield will be obtained.

In Phase Two of the Lumber Yield program only specific grades of lumber will be fed to the Rough End Dept. The maximum yield of various grades of lumber can be mathematically or scientifically determined. So it is expected that when the "right" grade of lumber is used for the "right" lengths wanted, maximum lumber yield will result.

All this is what studies at the University of North Carolina say will happen. They have figured it out with the help of giant computers and small field tests.

All indications so far at xxxxxxxx are that the N. C. State studies and computers are right. There is an opportunity for huge savings in handling lumber here.