Influence of Lumber Volume Maximization in Sawing Hardwood Sawlogs

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INTRODUCTION

The Best Opening Face (BOF) technology for volume maximization during sawing (1,4) has been rapidly adopted by softwood sawmills. Application of this technology in hardwood sawmills has been limited because of their emphasis on sawing for the highest possible grade of lumber. the reason for this emphasis is that there is a relatively large difference in price between the respective grades of hardwood lumber compared to the difference between the softwood lumber grades. Hardwood sawmillers have judged that an attempt to maximize volume would result in value loss to the degree that total value yield would be significantly reduced. While hardwood sawmillers may be correct there has been no data available supporting their expectation that maximizing for volume yield will reduce value yield.

The potential volume yield improvement from BOF decisions for sawing hardwood sawlogs is 6.3 percent which is only slightly less than for sawing softwood sawlogs (11,13). The BOF technology employs an iterative procedure that tests numerous initial opening face distances from log center for each given sawing pattern. These solutions begin at an opening face position at which the first board face sawn will be of the minimum acceptable dimension. The complete simulated sawing of the log is performed at this minimum opening face position. Subsequent opening face positions are tested by reducing the opening face distance from log center by arbitrarily selected increments. The distance over which opening-face position is tested has been the thickness of one piece of lumber plus kerf width (4).

Maximum-volume yield is attained at the initial minimum opening face position for only a small percentage of BOF solutions (12). For this reason maximum-volume yield is generally obtained for some opening face position somewhat closer to log center than that of the minimum opening face. In fact, Steele et al. showed that the highest yielding BOF position is generally obtained by centering the sawing pattern in the sawlog (12).

The most frequent of the defect types in sawlogs are knots. Knots are most numerous near log center. Therefore, the movement of sawlines slightly towards log center from a minimum opening face, required for BOF volume maximization, should increase the frequency of sawline intersection with knots. Increased frequency of sawline intersection should result in the yield of lower grade lumber that is of lower value.

Past research has examined hardwood log orientation to determine the influence of defect placement on total lumber value (2,7,8,9,15,16) with the most recent study showing a significant 10 percent increase in lumber value for best log orientation (15). All studies, however, opened the sawlog only at the minimum opening face for comparisons of log orientation. The iterative BOF procedure to locate the volume maximizing initial opening face was not performed at each rotation. Because volume yields were not maximized, it was not possible to determine if a conflict between volume and value maximization existed.

The objective of this study was to determine the influence of lumber volume maximization on value yield in sawing hardwood sawlogs.

PROCEDURES

The live sawing method was analyzed to simplify this initial examination of the value versus volume yield question. A computer simulation model of the live sawing method was available from a previous study and the assumptions underlying its performance are described in published reports (2,15). This existing live sawing simulation model opened the log at an initial minimum opening face. For this study, the model was modified to open additional opening face positions in the direction of log center, at the same rotational position, to determine the highest yielding BOF position at that face.

A database of 24 digitally-described red oak (Quercus Sp.) sawlogs was also available from a previous study (15). The 24 sawlogs were all 12 feet in length and had been selected to be approximately 16 inches in diameter. The sample logs were selected to be as round in cross section as possible. Eight logs in each of the U.S. Forest Service hardwood log grades (17) were selected.

The BOF concept of determining the distance from log center at which to open the sawlog for maximum volume by repetitively simulating the sawing of the sample logs was followed for this study. A minimum opening face distance was selected and the log was completely sawn by the simulated live sawing method. The opening face was moved toward log center by 1/4 inch and the log was again completely sawn by simulation. Lumber from each simulated sawing was edged and graded, and the board footage computed and a value assigned. One-quarter-inch incremental movements toward log center were chosen because the sawlogs were described by a 3-dimensional array consisting of 1/4 inch units. As Figure 1 shows, there were 4 incremental movements toward log center which resulted in 5 opening face positions tested. The lumber thickness sawn was 1.00 inch with a 0.250 inch kerf width.

The search for BOF position was carried out at the rotational angle for each log that gave the highest value lumber for the particular minimum opening face selected (15). Sawing procedures recommended by Malcolm to obtain highest value of lumber were applied (5). Two minimum opening face dimensions were tested in this study. The minimum opening position (MOP) face width tested was 3 inches wide by 8 feet long.

Past research on BOF position has concentrated on locating the maximum-volume or maximum-value position for each sawlog. For comparative purposes, value and volume for additionally defined positions were also investigated in this study at the initial MOP, at the position of minimum-volume yield and at the position of minimum-value yield. The mean volume and corresponding mean values obtained for all positions tested were computed.

The centered-solution method of volume maximization developed by Steele and Wengert (12,14) for ideal log forms was also tested for the real log shapes in this study. For this purpose, the centered-solution values and volumes were also determined. For comparative purposes, both maximum and minimum values and volumes were also determined.

Lumber sawn by the sawing simulation was graded according to NHLA rules (6) by hardwood lumber grading software developed by Klinkachorn et al (3). Prices from a previous study (15) were assigned to the lumber grades to allow comparison between the results of both studies.

All comparison-of-means tests were performed by the least significant difference method. Both analysis-of-variance and comparison-of-means tests were at the 0.05 level of significance. Fisher's protected t-test was utilized prior to performing comparison-of-means tests. By this procedure, means comparisons are not performed if the variables are not significant in the analysis of variance (10). Results of comparison-of-means tests are indicated in Figures 2 to 4 by letters on the right side of the graphs.

RESULTS

Figure 1 gives the respective volume yields for sawing positions of maximum value, centered solution, MOP, mean volume, maximum value, and minimum volume. The statistical results show that the maximum-volume board footage yield did not differ significantly from that of the centered-solution yield. The maximum-volume solution had significantly higher board footage yields than the

MOP volume yields. The mean-volume and maximum-value board footage yields were significantly lower than those for maximum-volume and centered-solution positions. The mean-volume and maximum-value board footage yields did not differ significantly between themselves. The minimum-volume yield was the significantly lowest yielding position of those tested.

The fact that the maximum-volume position volumes differed significantly from the volume at maximum-value positions provides evidence that the hypothesized conflict between volume and value yields is real. This result indicates that an attempt to maximize value will sacrifice an average of nearly 3 board feet per log yield. For each log sawn, simply opening the sawlog at the MOP would obtain significantly higher volume yield than that obtained by the maximum-value solution. A volume yield equivalent to that at the maximum-value position could be obtained by opening the log at random, as shown by the lack of significant difference between the mean-volume and maximum-value yields. The volume yield at maximum value is significantly higher than that of the minimum-volume yield, however.

Employing the centered-solution position to maximize volume yield may be practical as indicated by the lack of significant difference between the centered-solution and maximum-volume yields.

Figure 3 gives the results on relative value yields by sawing position. The centered-solution position values did not differ from those of the maximum-volume position. This indicates that the centered-solution could be a rapidly computed substitute to determine the volume maximizing BOF position without significant loss of lumber value. However, simply sawing to the MOP position is as effective as sawing at either the centered-solution or the maximum-volume position. The mean-value position did not differ significantly from centered-solution and maximum-volume yields. These results indicate that the log could be opened at random, within the l-inch range in which opening face positions were tested, to give value yields equivalent to those from opening the log at the computed centered-solution or maximum-volume positions. The value results of Figure 3 indicate that the minimum-value position had significantly the lowest value.

Figure 3 also substantiates the value versus volume maximization conflict. The maximum-value yield was significantly higher than the value at maximum-volume with a difference of 3.7 percent. The mean value difference was $1.79 per sawlog. Therefore, using BOF procedures to obtain maximum-volume in a hardwood sawmill could result in a significant lumber value loss.

Figure 4 gives the relative locations of the sawing positions in terms of mean distance from the MOP. The minimum-volume position was found at the significantly greatest distance from the MOP position. This result indicates that the l-inch range of distance towards log center within which initial opening face positions were tested was of sufficient depth into the log. Those positions closest to log center gave the lowest volume yield.

The minimum-volume position was significantly further from the MOP than the maximum-value yielding position. The minimum-value position was slightly further from the MOP than the minimum value position, but not significantly so. Therefore, a maximum-value solution distance from MOP for one log may easily be a minimum-value solution for another. This result appears to indicate that total value yield is strongly dependent on each particular log's defect depth and orientation. Determining the value maximizing distance from MOP for a specific log apparently requires a precise knowledge of defect location.

The maximum-volume and centered-solution positions are located at the farthest distance from MOP. The centered-solution position was significantly further from MOP than all other positions except the maximum-volume position. The 3-inch MOP maximum-volume position did not differ significantly from the minimum-value position.

The centered-solution and maximum-volume solutions did not differ significantly in distance from the MOP. This fact indicates, once more, the effectiveness of the centered-solution position as a proxy for locating the position at which maximum volume can be sawn.

SUMMARY

A conflict between value and volume yield was found to exist for the live sawing of hardwood sawlogs. Maximizing volume yield by employing the BOF method resulted in a loss of about $1.79 per sawlog which amounted to a 3.7 percent average yield loss. This loss occurred even though volume yield increased by 3 board feet. Simply opening each log at the MOP gave the same volume yield as obtained for the maximum-value position. Similarly, opening each log at random provided lumber value yields equivalent to those computed for the maximum-volume position.

The minimum-volume position was closest in distance to log center, which indicates that the l-inch distance across which the initial opening face positions were tested was adequate. The minimum-value and maximum-value positions did not differ significantly in distance from MOP. This result apparently indicates that total lumber value yield is dependent on each particular log’s defect depth and orientation. To obtain maximum-value yield a precise knowledge of internal defect location for each log is required. This finding implies that current research to develop scanning devices to detect internal log defects is required to truly maximize value yield from hardwood sawlogs.

The centered-solution position was found to be a good proxy for locating the maximum-volume position. The centered-solution was the same distance from the MOP as the maximum-volume position. In addition, the volume and value yields for the centered-solution position did not differ from those for the maximum-volume position.

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Table 1. Lumber prices by grade assigned to lumber produced by the sawing simulation. Source: Hardwood Market Report, January 14, 1989.

Grade	Price ($)
FAS	790
SEL	690
1C	510
2C	250
3A	195
3B	150

Figure 1. Sawlog cross section showing the minimum opening position (MOP) and the 4 incremental l/4-inch movements of initial opening position towards log center.

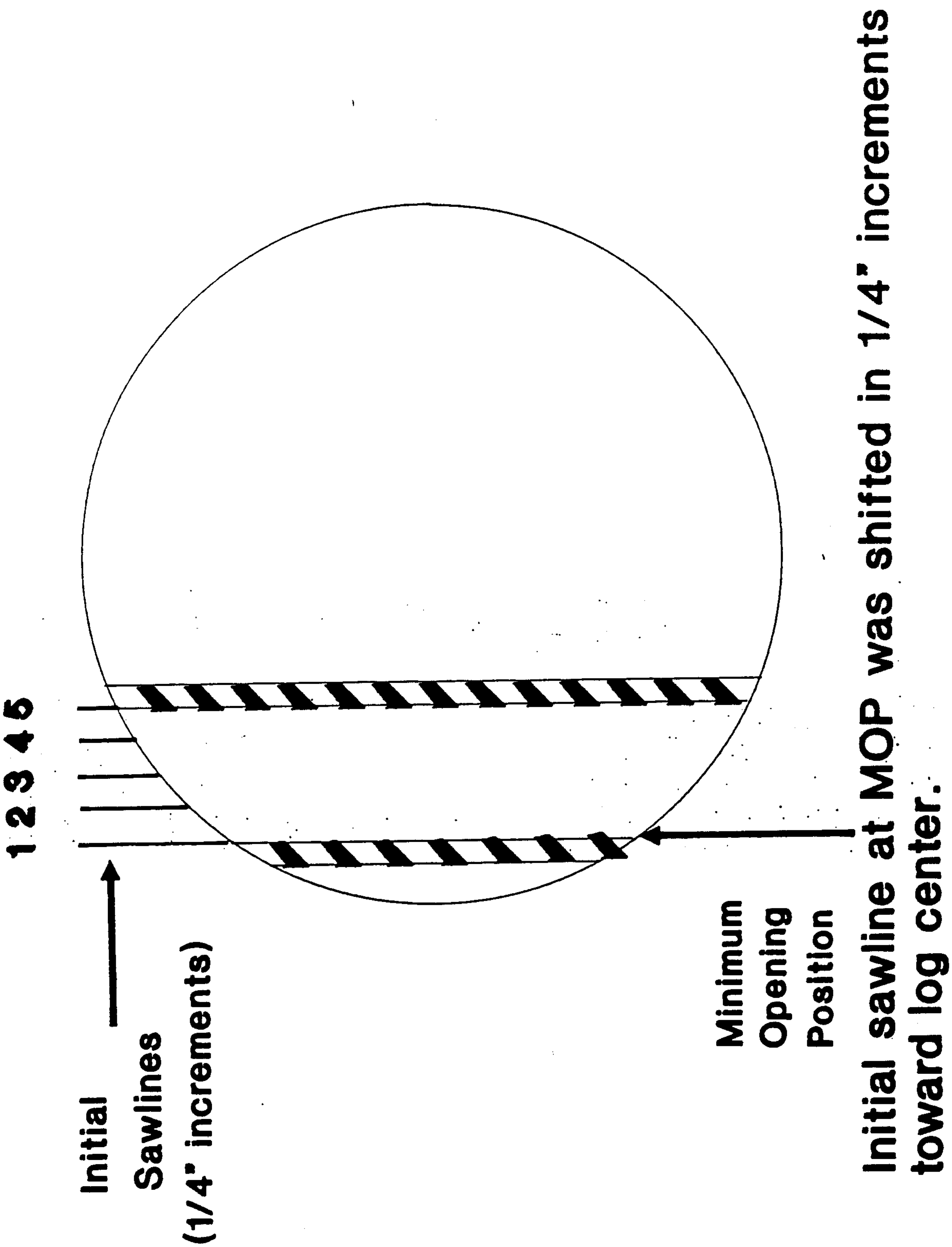

1 2 3 4 5
Initial
Sawlines
(1/4" increments)
Minimum
Opening
Position
Initial sawline at MOP was shifted in 1/4" increments toward log center.

Figure 2. Lumber volume yield by sawing position with results of comparison-of-means tests indicated by letters on the right side of the graph. Sawing position values with different letters differed significantly.

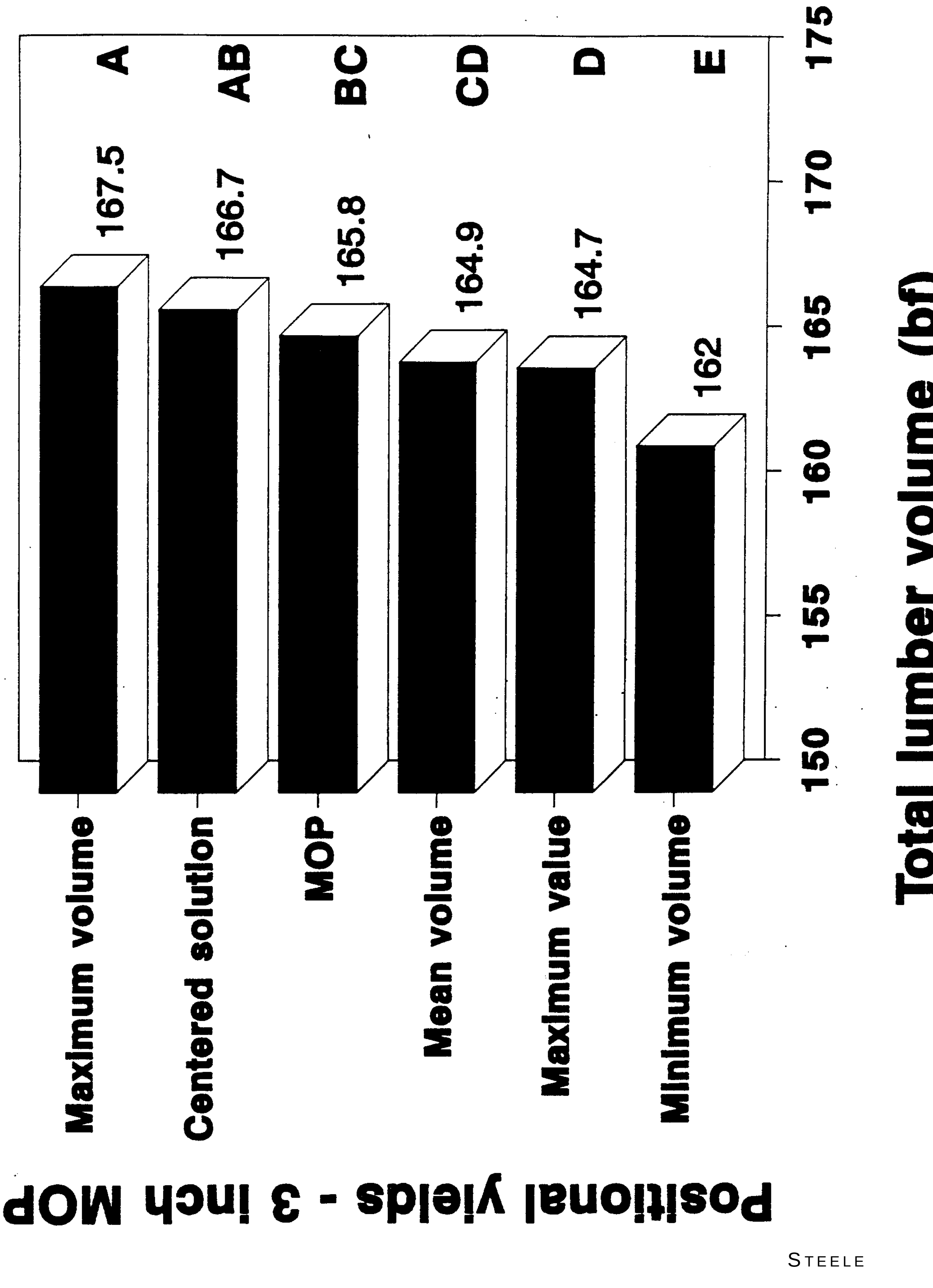

Positional yields - 3 inch MOP
Maximum volume
Centered solution
MOP
Mean volume
Maximum value
Minimum volume
167.5
166.7
165.8
164.9
164.7
162
A
AB
BC
CD
D
E
150
155
160
165
170
175
Total lumber volume (bf)

Figure 3. Lumber value yields by sawing position with results of comparison-of-means tests indicated by letters on the right side of the graph. Sawing position values with different letters differed significantly.

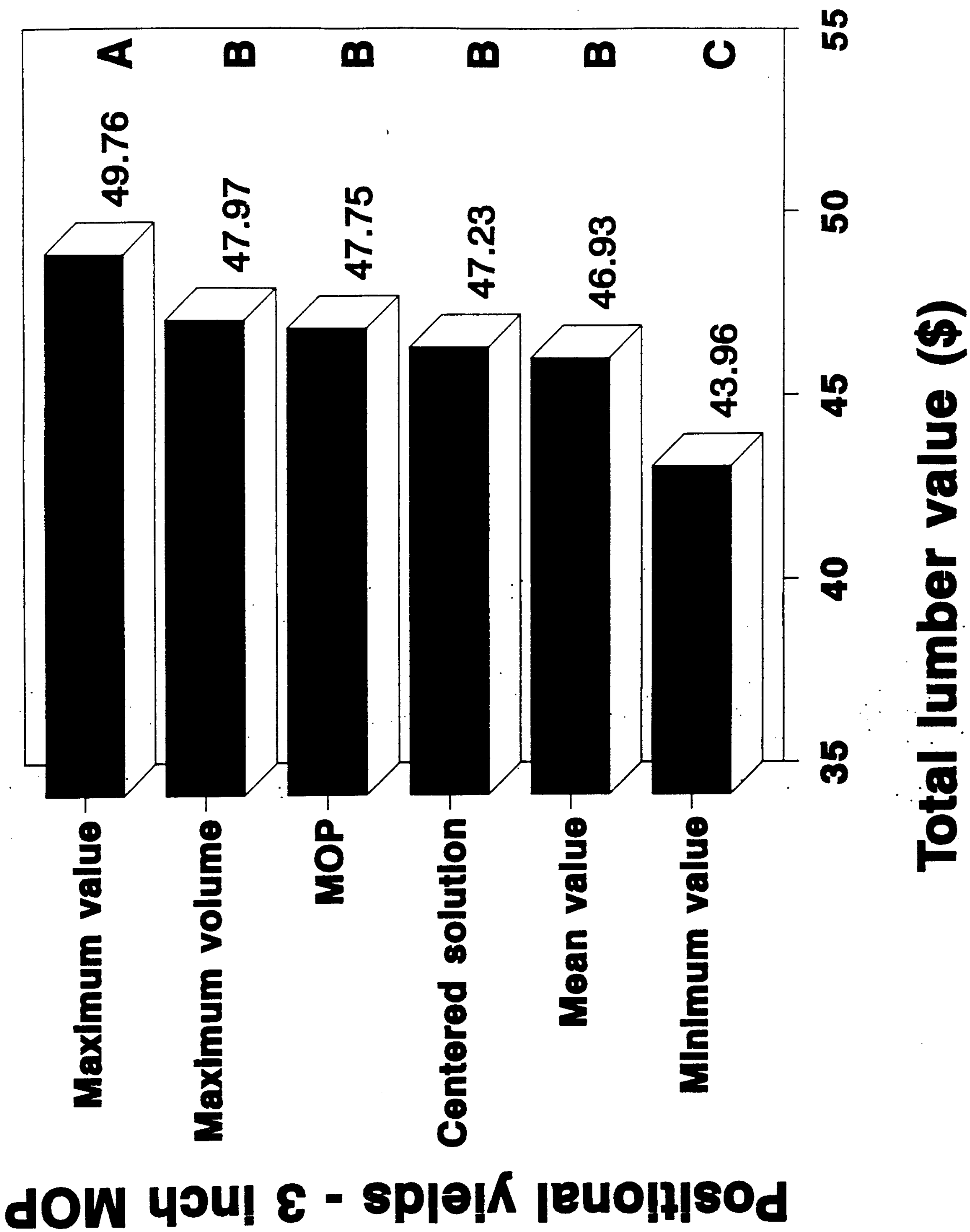
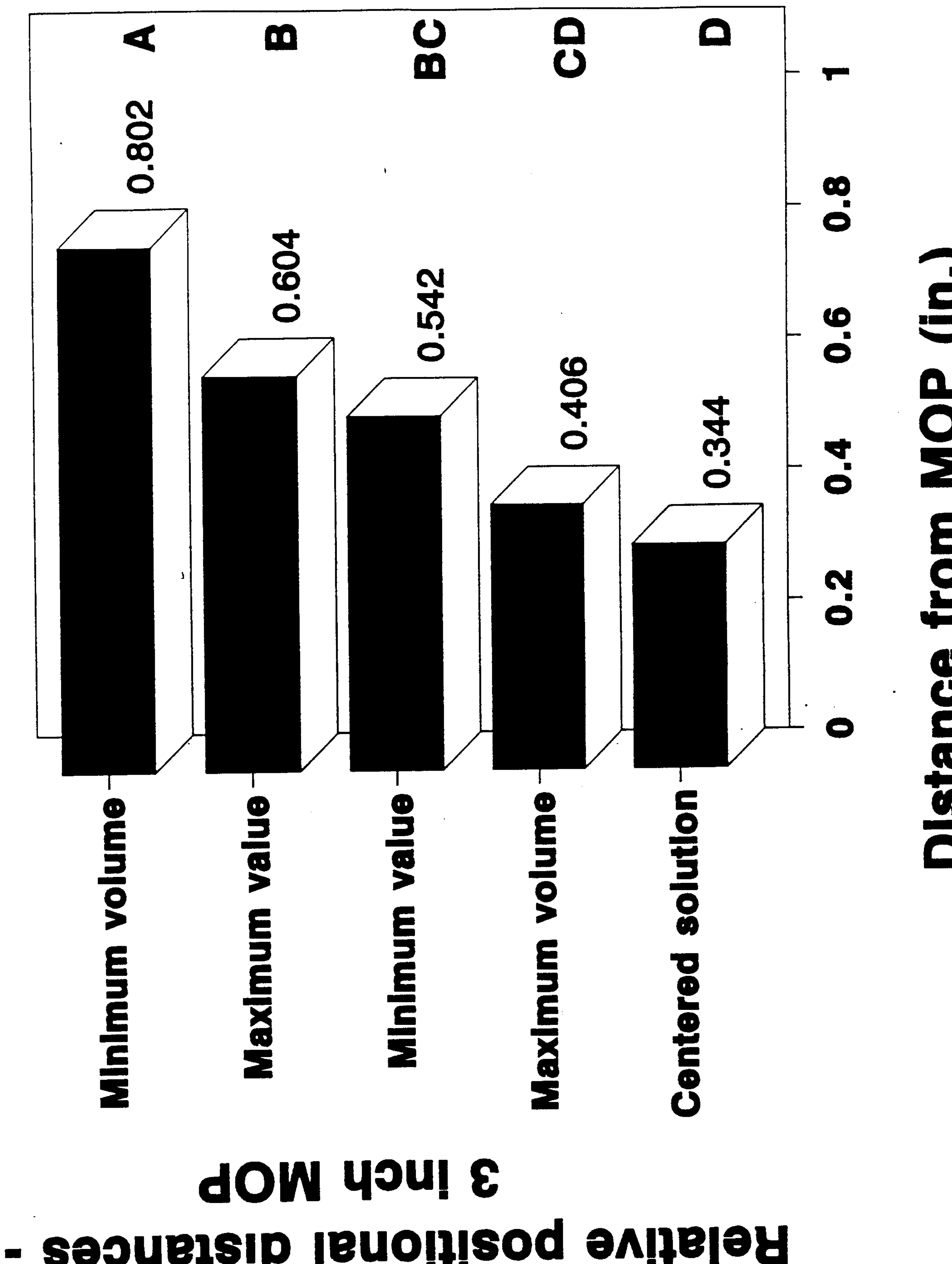
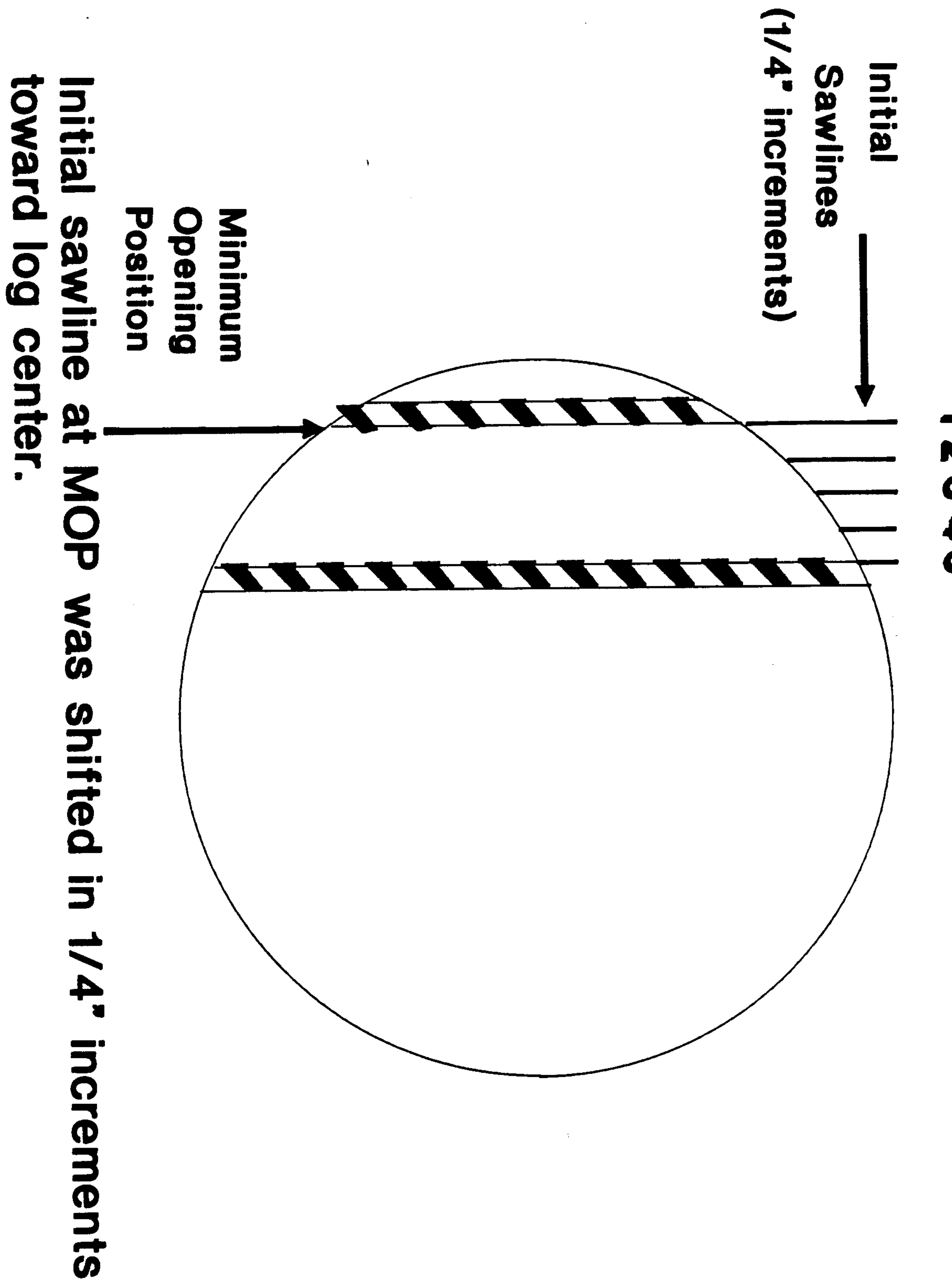
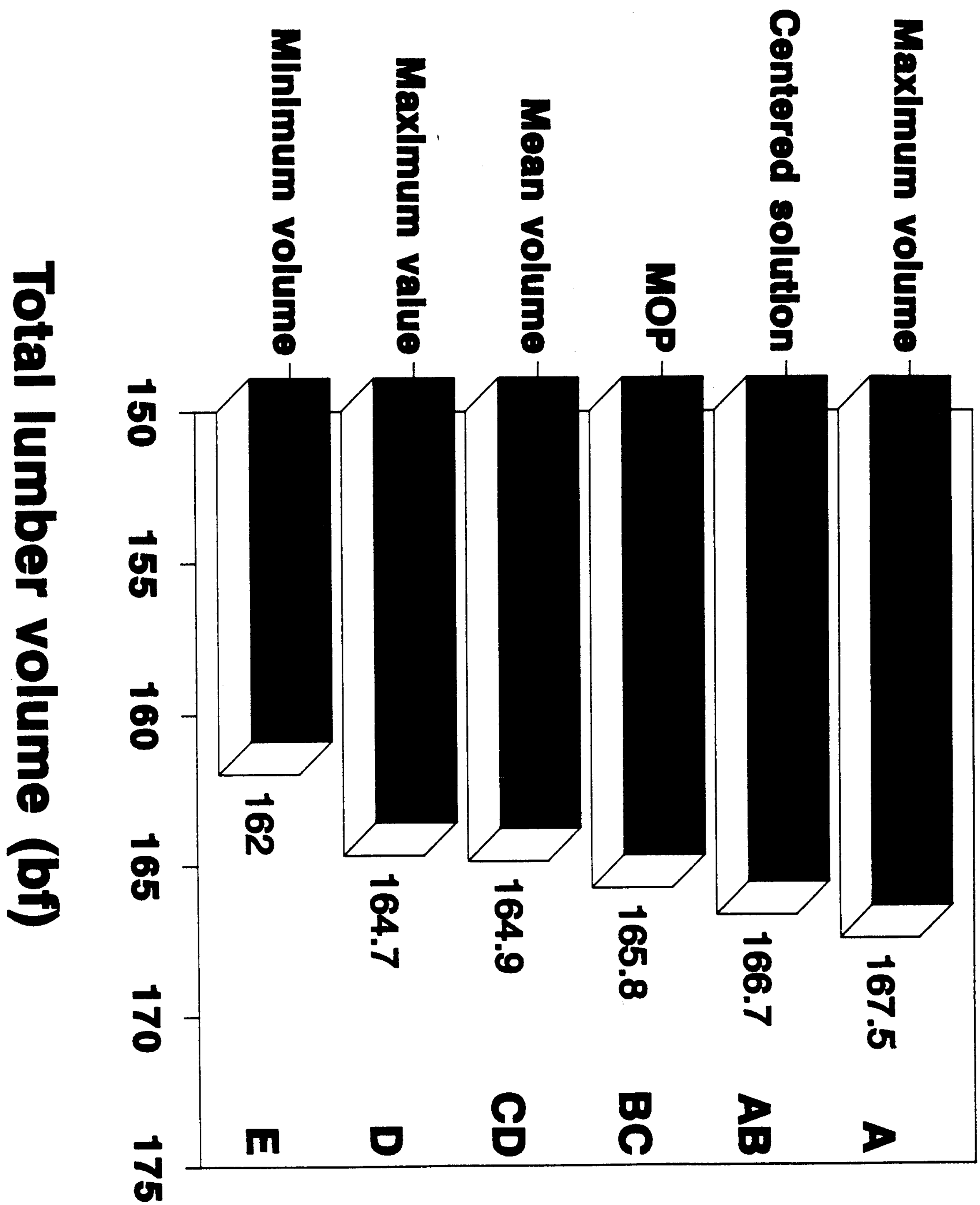

Positional yields - 3 inch MOP
Maximum value
Maximum volume
MOP
Centered solution
Mean value
Minimum value
49.76
47.97
47.75
47.23
46.93
43.96
A
B
B
B
B
C
35
40
45
50
55
Total lumber value ($)

Figure 4. Distance from the MOP by sawing position with results of comparison-of-means tests indicated by letters on the right side of the graph. Sawing position values with different letters differed significantly.

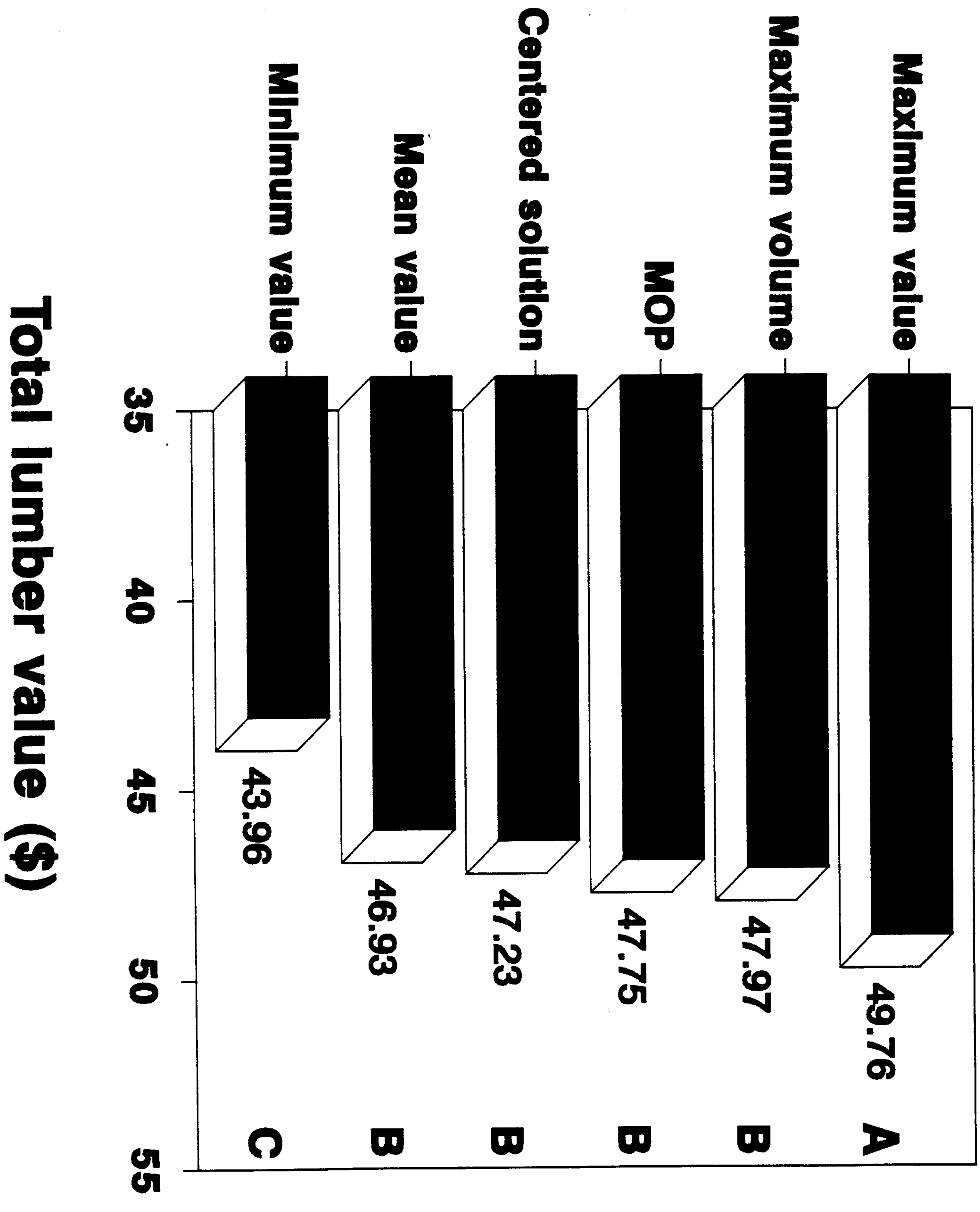

Relative positional distances -
3 inch MOP
Minimum volume
Maximum value
Minimum value
Maximum volume
Centered solution
0.802
0.604
0.542
0.406
0.344
A
B
BC
CD
D
0
0.2
0.4
0.6
0.8
1
Distance from MOP (in.)


1 2 3 4 5
Initial Sawlines (1/4" increments)
Minimum Opening Position
Initial sawline at MOP was shifted in 1/4" increments toward log center.

Positional yields - 3 inch MOP



Positional yields - 3 inch MOP



Relative positional distances - 3 inch MOP