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ECONOMIC FEASIBILITY OF PROCESS FOR HIGH-YIELD LAMINATED STRUCT--ETC(U)

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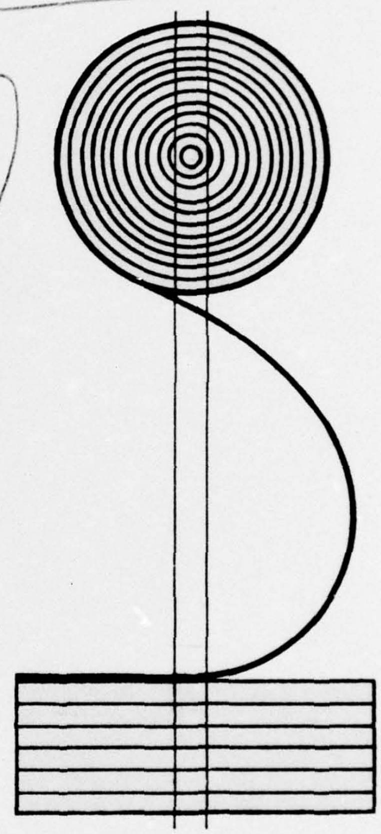

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Abstract

Recovery of lumber-type products from sawlogs can be substantially greater than that by conventional sawing processes if veneer-product production methods are used. Economic analysis based on a hypothetical continuous-process veneer-product facility derives production costs of acceptable levels for producing high-strength and specialty lumber-type products. Continuous laminating presses suitable for the facility evaluated are not yet commercially available but can be replaced with batch laminating presses for producing short-length products such as crossarms and railroad crossties. Methods may be developed to reduce glue costs. Increasing log prices will also increase the economic advantage of high-yield laminating processes.

ECONOMIC FEASIBILITY OF PROCESS FOR HIGH-YIELD LAMINATED STRUCTURAL PRODUCTS

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With the many recent advancements in conventional sawmilling, interest has generated on the use of veneer-product technologies to produce structural lumber-type products.

Lumber-type products generally can be produced by parallel laminating rotary-peeled veneer into thick, wide panels that can be sawn into desired widths. If a continuous panel is produced, lumber-type products of any desired width and length can be produced. By using these methods, yields can be substantially greater than by conventional sawmill processes. Additionally, the upgrading effect gained by randomizing defects between different veneer plies produces lumber-type products more uniform and of higher strength than can be produced by sawing low-grade logs.

Research on a log-to-product processing system on laminated veneer has been conducted at the U.S. Forest Products Laboratory (FPL), and is termed "Press-Lam."

As commercially practicable methods become available to produce laminated structural products, low-grade log supplies can be expected to become increasingly important as supplemental raw material for declining supplies of high-quality sawtimber. Also, with the likely improvement in product yields, the benefits could become sizeable by increasing the primary outputs from diminishing supplies of sawtimber. The development of veneer-product technologies for producing lumber-type materials has been underway for several years at the United States and Canadian Forest Products Utilization Laboratories -- the U.S. Forest Service Southern Forest Experiment Station, the U.S. Forest Products Laboratory, and the Canadian Forest Products Laboratory. Additionally, one pilot plant has commercially produced lumber-type products from laminated veneer -- the Trus Joist Corporation's "Micro-Lam."

Many different Press-Lam product and process options will be possible by the FPL Press-Lam Method. Basic to the process is the fact that the dryer heat left in the veneers from the drying process is the only heat used to cure a thermosetting glue in the laminating process. In a Press-Lam process, heat is not added specifically to accelerate adhesive cure.

Past research on the Press-Lam process has been focused mainly on technical rather than economic feasibility. The FPL plans to conduct a series of investigations to evaluate various Press-Lam options for investment potential.

The objective of this Paper was to analyze the economics of a particular set of process options for producing six-ply nominal 2-inch-thick (1-1/2-in. net) lumber from rotary-peeled Douglas-fir logs (fig. 1) (*8,9*).[2] Therefore, recoveries and manufacturing costs were to be estimated for a hypothetical Press-Lam facility.

[1] Maintained in Madison, Wis., in cooperation with the University of Wisconsin.

[2] Italicized numbers in parentheses refer to Literature Cited at the end of this report.

The principal characteristics of this Press-Lam process that distinguish it from conventional plywood manufacture are production of 1/4-inch (0.259 in.) veneer, use of stored heat from veneer drying to cure a thermosetting glue in a continuous nonheated press system, and use of gang-rip saws and trim saws (fig. 2).

Product Recoveries

Basis for Estimates

Product yields of dressed-dry Press-Lam lumber, solid sawn lumber and plywood sheathing were estimated from previous green veneer and rough, green lumber yield studies by the PNW (Pacific Northwest Forest and Range Experiment Station) (*4, 5, 12*). Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco var. *menziesii*) log grades considered were Special Peeler, No. 2 Sawmill, and No. 3 Sawmill. The percentage of the cubic volumes of logs estimated recoverable as solid sawn lumber, plywood, or dry-finished Press-Lam products was used to compare processing efficiencies (table 1).

The best, low, and high estimates of Press-Lam product recoveries were based on different sets of assumptions about recovery of veneer, sawn lumber from peeler cores, and losses in panel layup and trimming. The "best" estimates were those thought the most realistic, or likely; a second set of "low" and "high" estimates was prepared to indicate the general limits any estimates might be argued to range for at least 80 percent of all possibilities. Net plywood yield was based on the estimated recovery of unsanded, trimmed plywood panels and the recovery of sawn lumber from peeler cores. Net volumes of lumber recovery were based on assumptions of dry-finished sizes for lumber products.

Compared to plywood recovery, the recovery of Press-Lam products is enhanced by two factors:

(1) Press-Lam is not an engineered product; therefore, it does not require that pregraded veneers be used in specified combinations. Ungraded veneers are randomly used for Press-Lam product fabrication in which the resulting product strength can be established by testing each piece.

(2) The Press-Lam process described here produces a continuous panel; a rough-edge trim loss is realized from only two sides instead of four as in the batch systems used for plywood production.

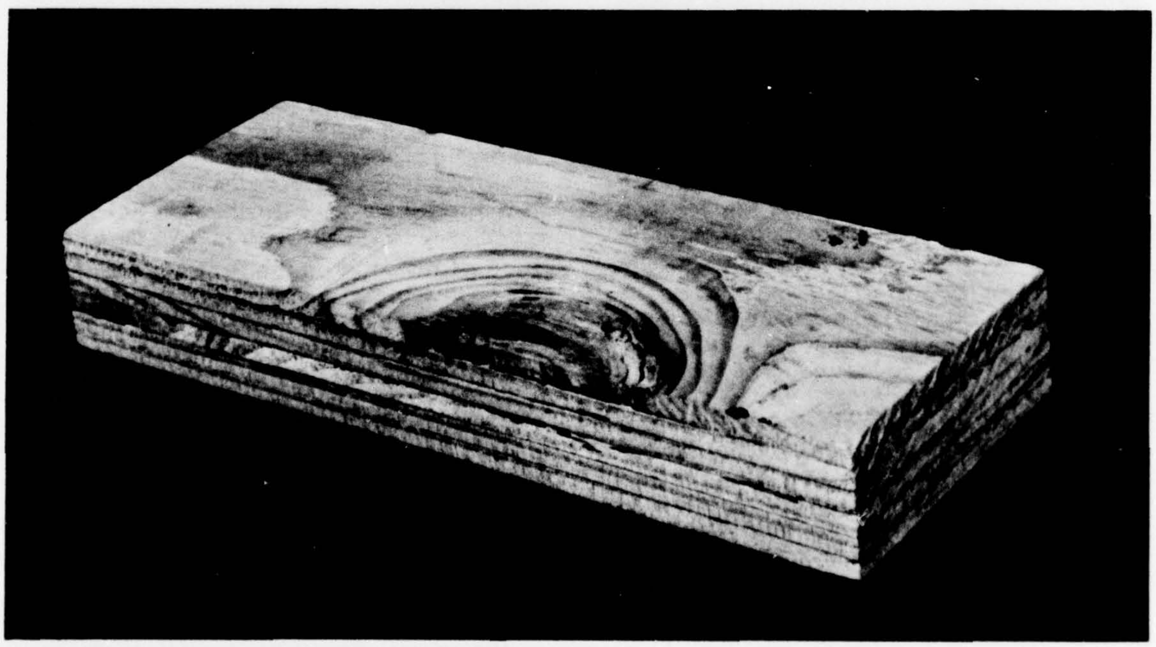

Figure 1.--Press-Lam joist of 6-ply, 1/4-inch Douglas-fir veneer.
(M 143 360)

For the Press-Lam process, the most important differences between log grades are diameter sizes and general suitability for rotary cutting. The minimum allowable diameter sizes allowed by Forest Service log-grading systems for west coast Douglas-fir Special Peeler, No. 2 Sawmill, and No. 3 Sawmill grade logs are 19, 12, and 6 inches, respectively. The residual core diameters from the veneer recovery studies averaged 8.8 inches (5). The minimum desirable small-end log diameter for rotary peeling is generally considered about 9 inches if peeling to a minimal core of 6.5 inches.

In the PNW veneer yield studies, of 733 logs processed from Special Peeler, No. 2 Sawmill, and No. 3 Sawmill grade logs, diameter sizes ranged from 6 to 57 inches (5). Seventy-five percent of the diameters of the logs were between 14 and 30 inches; 11 percent, less than 14 inches. For this Paper, the distributions of the diameter sizes in the Forest Service study were assumed representative of the diameter-size mix that a Press-Lam facility would process.

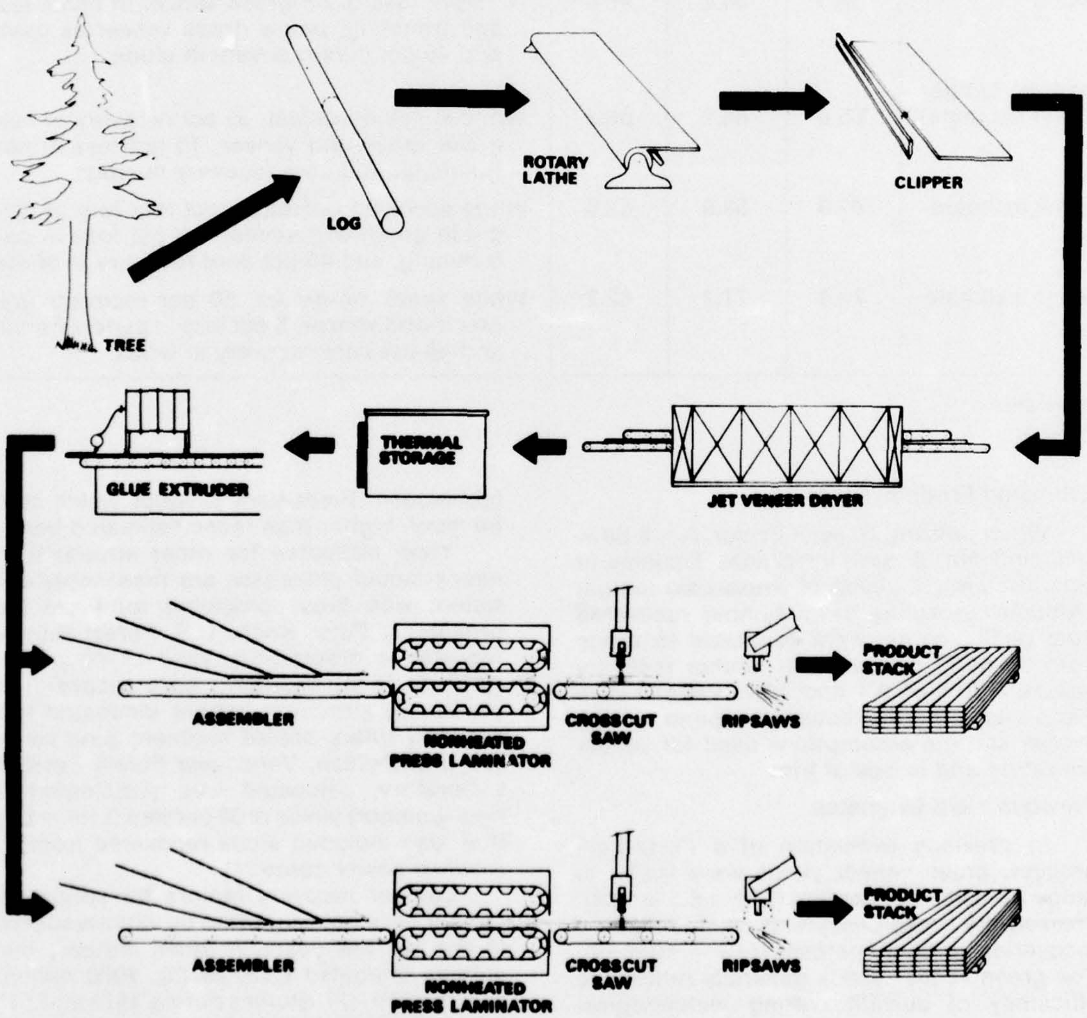

Figure 2.--A Press-Lam processing system--from tree to product.
(M 143 926)

Table 1.--Estimated cubic volume recovery ratios for dry-finished lumber and plywood products produced from woods-length old-growth coast Douglas-fir logs

Product type	Cubic volume recovery ratios			Assumptions used to estimate net cubic volume for dry-finished products
	Special Peeler	No. 2 Sawmill	No. 3 Sawmill	
Solid-sawn lumber	49.7	52.0	48.7	Net to nominal product ratios 6/4 × 9.25 (1.41 × 9.25 in.) board rules for Molding, Shop, and Factory Select; 6/4 × 10 (1.41 × 9.25 in.) lumber tallies, for Selects; and 1 × 8 (0.75 × 7.25 in.) and 2 × 8 (1.5 × 7.25 in.) lumber tallies for boards and dimension.
Plywood	55.5	54.2	46.6	A 16-pct loss of on-grade veneer in panel layup and trimming, below grade veneer as usable, and 46 pct core recovery in studs.
Press-Lam lumber				
Best estimate[1]	65.9	64.7	56.3	White speck no-defect, 35 pct recovery of below grade green-end veneer, 10 pct loss in panel trimming, and core recovery in studs.
Low estimate	61.8	58.8	52.9	White speck no-defect, 25 pct recovery of below grade green-end veneer, 16 pct loss in panel trimming, and 46 pct core recovery in studs.
High estimate	72.4	71.2	62.2	White speck no-defect, 50 pct recovery grade green-end veneer, 5 pct loss in panel trimming, and 46 pct core recovery in studs.

[1]Most realistic.

Estimated Product Yields

When utilizing Special Peeler, No. 2 Sawmill, and No. 3 Sawmill grades Douglas-fir logs, theoretical yields of Press-Lam lumber products, including sawn lumber recovered from peeler cores, were estimated to range from 53 to 72 percent with lumber recovery factors (LRF) of 9.4 and 12.7. Variations in Press-Lam product recovery depend on log grades and the assumptions used for veneer utilization and losses of trim.

Previous Yield Estimates

In previous evaluation of a Press-Lam process, green veneer yields were found to range from 48 to 78 percent (LRF = 8.5 to 13.8); dressed-dry Press-Lam yields, excluding core recoveries, to be 60 percent (LRF = 10.6) (*9*). The green veneer yields generally reflect the efficiency of current cutting technologies. Theoretic yields of green veneer run much higher, from 70 to 90 percent if sound bolts with 12- to 18-inch diameters are peeled to 6.5-inch cores. With improved veneer-cutting techniques, Press-Lam product yields could be much higher than those estimated here.

Yield estimates for other structural veneer-product processes are reasonably consistent with those projected for Press-Lam processes: Peter Koch, U.S. Forest Service, reported a dressed-dry yield of 60 percent (LRF = 10.6), including core recovery, for producing structural lumber laminated from 1/4-inch rotary-peeled southern pine veneer (*3*). J.C. Bohlen, Vancouver Forest Products Laboratory, estimated LVL (Laminated-Veneer-Lumber) yields of 62 percent (LRF = 10.9) that also included studs recovered from the residual peeler cores (*1*).

Lumber recovery factors for solid sawn lumber have been reported by various sources in the last few years. A forest industry consultant estimated 6.73, as the 1970 national average LRF (*7*). Studies during 1973 and 1974 by the State and Private Forestry division of the U.S. Forest Service indicated that from a sample of 190 sawmills evaluated throughout the United States LRF's averaged about 7.5 (*6*).

The greater product recoveries estimated for Press-Lam products than those for plywood products are due to assumed increases in the utilization of scrap grades of veneer and reductions in the losses typically experienced in plywood panel layup and trimming. Because in the Press-Lam process rotary peeling can be at a much slower rate than is typical for conventional veneer mills, apparently it is also possible to gain greater veneer yields than estimated in this study. To substantiate this speculation, a veneer yield study would, however, be required.

Product Quality

Experimental evaluations have indicated the Press-Lam process is capable of producing structural framing materials more uniform in strength and averaging between one and two grades higher than structural materials sawn from the same grade of logs (*1, 2, 9, 10*). The improvements in strength properties of lumber produced from Press-Lam processes are attributed to elimination of juvenile wood that occurs in the peeler core section of logs, to minimization of cross-sectional areas of knots due to rotary cutting of veneer, and to random dispersion of defects among different plies of veneer.

A grading and quality-control system has not been developed for production of Press-Lam materials, but would be essential for the commercial development of the Press-Lam process. To estimate grade recoveries of Press-Lam products, structural lumber stiffness yields were imputed from the grade recoveries of solid-sawn lumber found in the Forest Service's PNW study of lumber yields from old-growth west coast Douglas-fir (*4*) (table 2).

Economic Assessment

Value Added by Press-Lam Process

Log cost and the converted value of Special Peeler, No 2 Sawmill, and No. 3 Sawmill grade Douglas-fir logs were compared on the basis of the previous estimates of product yields, grade recoveries, and assumed prices (tables 2, 3, and fig. 3). Price assumptions for

Table 2.--Estimated product grade recoveries from Douglas-fir logs based on nominal 2-inch-thick products

Product grades	Wood-length log grades		
	Special Peeler	No. 2 Sawmill	No. 3 Sawmill
		Pct	
Solid-sawn lumber			
Selects	14.1	11.3	3.9
Factory	6.5	12.2	8.8
Select Stud	32.4	12.4	4.6
Construction	28.7	28.0	22.1
Standard	9.5	16.9	24.3
Utility	6.7	14.2	27.1
Economy	2.1	5.0	9.2
Press-Lam structural lumber[1]			
MOE[2] $\geq$ 2.0E	35.5	23.8	15.2
1.8E $\leq$ MOE $<$ 2.0E	32.9	31.8	28.8
1.5E $\leq$ MOE $<$ 1.8E	19.8	25.8	30.9
1.2E $\leq$ MOE $<$ 1.5E	10.9	16.7	22.3
MOE $<$ 1.2E	.9	1.9	2.8

[1]Press-Lam yields imputed from grade-recoveries of solid-sawn Douglas-fir lumber reported by the U.S. Forest Service (*4*).

[2]MOE, modulus of elasticity.

Table 3.--Price assumptions for west coast Douglas-fir products

Product	Assumed estimates[1]		
	Best[2]	Low	High
Woods-length logs ($/Mfbm, log scale)			
Special Peeler	165	150	185
No. 2 Sawmill	145	130	165
No. 3 Sawmill	125	105	145
Solid-sawn lumber ($/Mfbm)			
C & Better Select	500	NU	NU
D Select	450	NU	NU
Molding	310	NU	NU
Factory Select	300	NU	NU
No. 1 Shop	275	NU	NU
No. 2 Shop	230	NU	NU
Select Structural	165	125	208
Construction	150	113	188
Standard	110	83	138
Utility	80	60	100
Economy	35	25	45
Press-Lam lumber ($/Mfbm)			
MOE[3] ≥ 2.0E	300	275	325
1.8E ≤ MOE < 2.0E	225	200	250
1.5E ≤ MOE < 1.8E	175	140	215
1.2E ≤ MOE < 1.5E	120	100	150
MOE > 1.2E	100	80	125
Residues ($/200 cubic foot unit)	40	NU	NU

[1]NU, not used.
[2]Most realistic.
[3]MOE, modulus of elasticity.

Douglas-fir logs, structural framing lumber, specialty products, wood chips, and peeler cores were judgmentally selected from the range of prices prevailing in the Arcata-Eureka, California, area during 1974 and 1975 (table 3).

The log volumes that would yield high-value Select and Factory grades of lumber in conventional sawmilling are randomly combined as veneer plies in Press-Lam products. The loss of Select lumber in the Press-Lam process, however, is more than offset by increased product yields and improvements in the average quality of the structural Press-Lam materials produced. Additionally, the Press-Lam process has the ability to produce lumber-type products to desired widths and lengths without being restricted by log sizes as in sawing processes.

Production Costs

To provide a base for construction and operating costs, a hypothetical Press-Lam facility was designed (appendix A). On the basis of a two-press system, detailed estimates were made of the capital requirements for plant and equipment, direct labor costs, plant maintenance, operation, general administrative costs, and estimates of production rates. Annual production rates were based on the capacities of the two continuous, unheated laminating presses. Low and high estimates of annual production ranged from 55 to 65 million board feet; the best estimate was 60 million board feet.

Total cost for construction of the Press-Lam facility described here was estimated at $10,049,500 -- including cost of land -- as of January 1, 1975 (table 4).

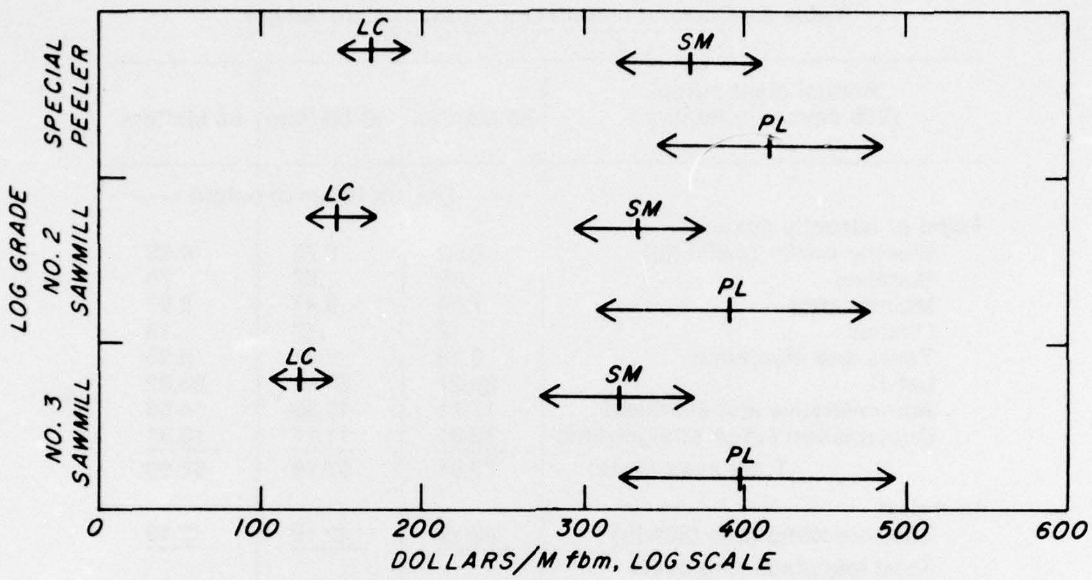

Figure 3.--Cost of logs and value of converted west coast Douglas-fir logs. [Log cost, LC; values via sawmill process, SM; and FPL Press-Lam process, PL. Estimated values are the following: Low (←); high (→); and best, or most realistic, (+)].

(M 144 714)

Table 4.--Estimate of cost of facility to manufacture Press-Lam lumber with two continuous unheated (8-ft 0-in. × 60-ft 0-in. × 60-ft) pressing surfaces and estimated annual output of 60 MMfbm/year[1]

Item	Cost
	Dollars
Equipment:	
Log process	373,000
Veneer processing	1,110,500
Press-Lam process	5,720,000
Waste utilization	705,000
Miscellaneous	391,000
Total equipment (including design engineering)	8,299,500
Installation and construction management	690,000
Total equipment installed	8,989,500
Land (20 acres)	60,000
Site preparation	90,000
Building and structures	694,000
Mobile equipment	216,000
Total capital cost	10,049,500

[1]See appendix A.

Table 5.--Costs of manufacturing Press-Lam lumber

Annual plant output (250 days/yr operation)	55 MMfbm	60 MMfbm	65 MMfbm
	----- Dollars/Mfbm of output ------		
Fixed or capacity costs:			
Electric power (1,000 hp)	0.82	0.75	0.69
Supplies	.89	.82	.75
Maintenance	7.05	6.47	5.97
Utilities	.18	.17	.15
Taxes and insurance	6.18	5.67	5.23
Labor	28.27	25.91	23.92
Administrative and overhead	17.71	16.23	14.98
Depreciation (15-yr straight-line)	12.81	11.17	10.31
Total fixed costs	73.91	67.19	62.00
Unit cost:			
Thermosetting glue (30¢/lb)	42.19	42.19	42.19
Total manufacturing costs excluding log costs	116.10	109.38	104.19
Total manufacturing costs per cubic foot of solid wood output	2.05	1.93	1.84

Table 6.--Cost assumptions for west coast Douglas-fir logs[1]

Roundwood costs	Special Peeler			No. 2 Sawmill			No. 3 Sawmill		
	Best	Low	High	Best	Low	High	Best	Low	High
	------- Dollars -------								
Cost/Mfbm log scale	165.00	150.00	185.00	145.00	130.00	165.00	125.00	105.00	145.00
Cost/Mfbm, Press-Lam lumber	90.84	74.62	109.20	79.76	65.53	100.64	63.96	48.09	79.56
Less revenues for wood chips[2]	15.15	11.41	17.95	15.66	11.83	19.94	23.22	18.31	26.61
Net log costs	75.69	63.21	91.25	64.10	53.70	80.70	40.74	29.78	52.95

[1]Based on estimated f.o.b. mill, Arcata, Calif., costs for woods-length Douglas-fir logs. "Best" estimates are most realistic; "Low" and "High" estimates, the typical range of costs.

[2]Peeler cores and other Press-Lam byproducts are assumed converted to wood chips (75 pct) and hogged fuel (25 pct). Wood chips (solid wood content) are assumed worth $40 per 72 ft^3; hogged fuel is assumed fully utilized to produce dryer heat and process steam.

On the basis of the best estimate of production volume, cost for manufacturing Press-Lam lumber, excluding log cost, is estimated at approximately $109 per thousand board foot (table 5). This is about $25 per thousand board foot higher than estimated by Schaffer and Tschernitz for a similar Press-Lam process based on 1973 costs (*11*). As in most preinvestment engineering cost analyses, the manufacturing costs estimated here exclude, in addition to log cost, marketing costs, taxes, profits, interest, and the nondepreciable cost of land, the cost of interest on borrowed capital and other commercialization costs that may be related to the time value of money.

Economic Feasibility

Internal rates of return (IRR) are used as an index of economic feasibility. This rate is the particular discount rate required to discount the stream of annual net cash-flows generated from an investment venture to a current value of zero. From an investor's standpoint, the internal rate of return is the rate of interest return to the funds required to finance the venture.

In the financial analyses used to calculate the IRR for the Press-Lam process, a 7-percent selling cost, a double-declining depreciation schedule converting to straight-line in the sixth year, a 51-percent effective state and Federal tax rate, a 5-percent inflation rate, a promotional cost of $35,000 for each of the first 3 years, a working capital fund equal to 6 percent of the current annual cost of manufacturing, and log costs were considered in addition to the manufacturing costs and product prices reviewed (tables 5 and 6).

Assuming 10 years the useful life of a Press-Lam facility, the processing of Special Peeler Douglas-fir logs yielded an IRR of 15 percent; processing No. 2 Sawmill Douglas-fir logs, 11 percent; and processing No. 3 Sawmill grade logs, 16 percent (fig. 4 and appendix B).

The low-high estimates of production volumes, log costs, glue costs, and product prices suggest the results of financial analyses using the best estimates deserve further consideration. The variability inherent in these estimates can be more fully assessed by assuming that costs, prices, and production volumes may vary randomly and that random values will be at or between the low and high estimates 80 percent of the time. Using these assumptions, statistical simulation analyses indicate that 80 percent of all random calculations for IRR's will range from 8 to 21 percent for processing Special Peeler logs; from 4 to 18 percent for No. 2 Sawmill logs; and from 11 to 23 percent for No. 3 Sawmill logs.

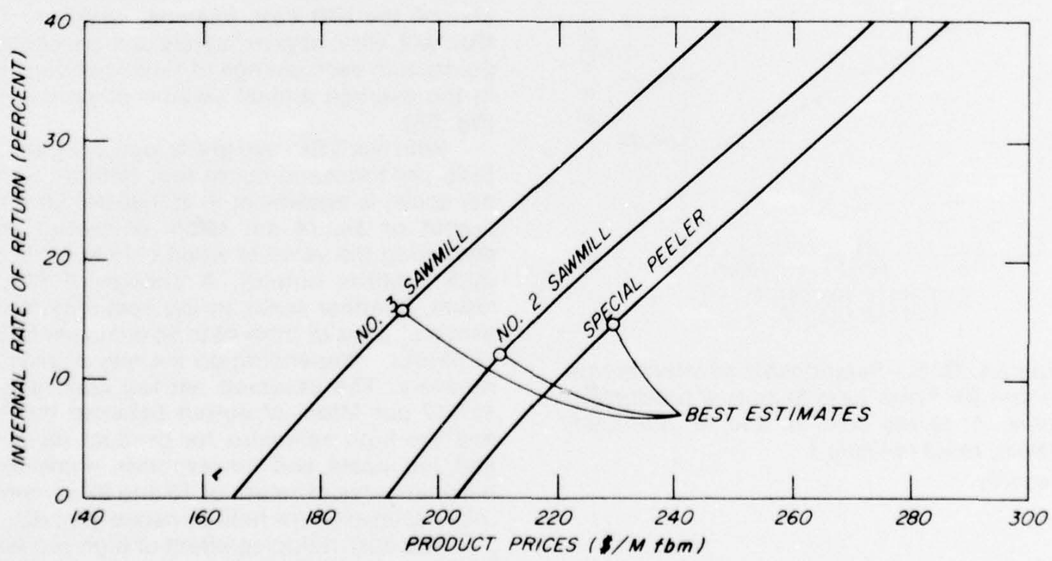

Figure 4.--Stump-to-market costs for producing Press-Lam lumber vary, and are dependent on log grade processed and rate of return required for investment capital. (0, Best, most realistic, estimates.)

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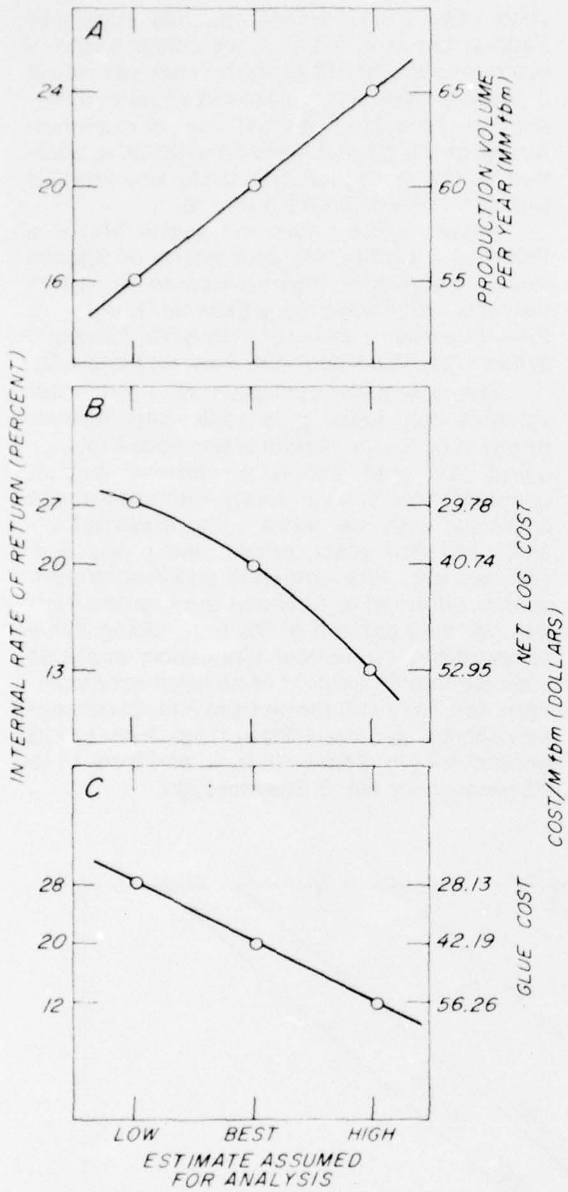

Figure 5A, B, C.--Relationship of internal rate of return for Press-Lam to annual production volume, A; to log cost, B; and to glue cost, C; (Best, most realistic.)

(M 143 762)

In these analyses the first year's production volume was assumed 50 percent of the capacity of the facility, 75 percent of full-operating cost ($3,361,000/first year), with 100 percent capacity of the facility in succeeding years and full-cost increasing 5 percent per year. The possibilities of any investment tax credits were not considered. The minimum IRR attractive to industrial investors was assumed 20 percent, after taxes. Using the best estimates of annual production and log and glue costs, initial analyses indicated a 20-percent IRR most likely would occur if average mill prices were $241, $228, and $202 per thousand board foot for output from Special Peeler, No. 2 Sawmill, and No. 3 Sawmill Douglas-fir logs, respectively (fig. 4).

Profitability of Processing Low-Grade Logs

The most effective use of the Press-Lam process can be expected from using low-grade logs whereby knots, knotholes, and other defects are dispersed among the different plies of veneer. Thus, product quality would be substantially upgraded. If half or more of the output from processing No. 3 Sawmill grade logs could be sold for high-strength uses, the Press-Lam process should be an attractive commercial investment.

Sensitivity of Financial Results

A financial summary for processing No. 3 Sawmill logs (appendix B) was based on an annual production capacity of 60 million board feet of output per year. Variations in annual production volumes will have an important effect on average unit manufacturing costs and on the IRR from financial analyses. The IRR will vary approximately 0.8 percentage points with each change of 1 million board feet in the average annual volume of production (fig. 5A).

With No. 3 Sawmill grade logs, a log cost of $125 per thousand board foot (Mfbm), Scribner scale, is equivalent to $63.96 per Mfbm of output or $40.74 per Mfbm of output after deducting the value of wood chip byproducts ($23.22/Mfbm output). A change of $1 per Mfbm, Scribner scale, in log cost may represent a change of from 46 to 55 cents per Mfbm of output -- depending on the rate of product recovery. The assumed net log cost ranged $23.17 per Mfbm of output between the low and the high estimates for product recovery and log costs and corresponds nonlinearly between rates of return of 13 and 27 percent if other estimates are held constant (fig. 5B).

The cost-reducing effect of high product-recovery increases with any increase in log cost. With low log cost and high product recovery, net log costs are $9.52 per Mfbm of output less than with low product recovery. With high log cost this difference increases to $13.15 per Mfbm.

The production cost of Press-Lam lumber is sensitive to the uncertainties of glue cost. A change of 1 cent per pound in glue cost results in a change of approximately $1.41 per Mfbm output. A change of 10 cents per pound in glue cost results in a change of approximately 8.0 percentage points on the IRR in the financial analysis (fig. 5C).

Conclusions

Economic evaluations indicate that the Press-Lam process can produce high-strength lumber from low-grade logs and is of sufficient economic importance to warrant serious consideration as an investment opportunity.

Of the technological obstacles for the continuous process Press-Lam facility evaluated here, the most important obstacle is lack of a commercially available continuous laminating press. For commercialization, Press-Lam facilities could be designed to use batch-processing systems, single- or multiple-opening laminating processes, especially for the manufacture of short-length products such as pallet parts, crossarms, and railroad crossties. Another obstacle is lack of an accepted method for assigning product strength values to Press-Lam. Assigning structural use-values on the basis of stress-tested stiffness would greatly facilitate the marketing of Press-Lam products for their highest end-use value.

Reducing the cost of glue might improve the economic attractiveness of Press-Lam processes more than any other possible development in Press-Lam processing technologies. This might be accomlished by using less costly thermosetting glue formulations, by decreasing the spread-rate of available formulations, and possibly, by using thicker veneers to decrease the number of gluelines in a particular product.

An increase in log price should cause a proportionately smaller rise in total product costs for Press-Lam than for conventional sawmilling systems. Thus, with increasing log prices, Press-Lam processes should become an increasingly attractive investment.

Trade or proprietary names are included solely for the benefit of the reader and do not imply any endorsement by the Forest Service of the U.S. Department of Agriculture.

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APPENDIX A

ESTIMATES OF CONSTRUCTION AND OPERATING COSTS FOR A FACILITY TO MANUFACTURE HIGH-YIELD LAMINATED STRUCTURAL PRODUCTS

The purpose of this investigation was to furnish engineering cost estimates for capitalizing and operating a process to produce high-yield laminated structural products for a hypothetical site in the Humboldt County area of Northern California. The process is referred to as "Press-Lam."

The design and testing of the manufacturer's equipment have not been completed in the layup and continuous press operation of the Press-Lam facility. The prototype machine and the glue layup machinery is undergoing tests in Belgium by Bison-Werke of Springe, West Germany. Therefore, approximate dimensions are used as are conservative estimates of the machinery costs in the layup and pressing section. World inflation subjects any cost estimate to increase; estimates here are based on cost as of January 1, 1975.

BASIS FOR PLANT DESIGN

Finished Lumber Production per 250 Day-Year

Production = 50,000,000 fbm lumber 1-1/2 in. thick
= 33,333,333 ft² lumber 1-1/2 in. thick

Composition = six-ply of (0.295 in.) green veneer for 1-1/2 in. net dry size (2 in. nominal)
= 200,000,000 ft² veneer 1/4 in. thick
or
= 133,333.333 ft² veneer 3/8 in. basis

Log Scale Requirements

Lumber Production
= 50,000,000 fbm
or
= 133,333,333 ft² veneer on 3/8 in. basis

Assume, since low-grade peelable logs are used, that recovery would be 2.0 square feet of 3/8 inch veneer per board foot log scale, Scribner Decimal C scale (normal plywood recovery from No. 1 and No. 2 peelers is 2.6 ft²/fbm).

$$\text{Log scale required} = \frac{133{,}333{,}333}{2.0} = 66{,}666{,}667 \text{ fbm log scale.}$$

Number of Logs Required

Assume average log Douglas-fir (Humboldt Co.) to be 24 inches in diameter at small end.

Fbm/34-ft log = 850 fbm approximately Scribner Decimal C

$$\text{Number of 34-ft logs/yr} = \frac{50{,}000{,}000 \text{ fbm/yr}}{850 \text{ fbm/log}}$$

$$\text{Number of 34-ft logs/day} = \frac{58{,}823 \text{ logs/yr}}{250 \text{ days/yr}} = 235 \text{ logs/day}$$

$$\text{Number of 8-ft blocks/day} = 4 \times 235 = 940 \text{ blocks/day}$$

$$\text{Number of 8-ft blocks/h} = \frac{940 \text{ blocks/day}}{16 \text{ hs/day}} = 59 \text{ blocks/h}$$

$$\text{Number of 8-ft blocks/min} = \frac{59}{60 \text{ min}} = 0.98 \text{ block/min}$$

or

= *one block in 1 min*

SITE AND FACILITIES

For practicality, an actual area was selected--Arcata, Humboldt County, Calif.,--and all costs are for that area as of January 1, 1975.

Site of Buildings

The site selected is level, on rails, and has good paved access roads. The author estimated a 20-acre site would be sufficient to store 12 to 15 million board feet of logs (6-mo supply, since logging is normally limited to 6 mos in that area), 4 to 5 million board feet of finished lumber with plant area of 1-1/2 acres plus ample room for offices and plant expansion.

The average price per acre for land of this type in this area is approximately $3,000, and is used for this investigation.

The plant buildings are to be of wood with truss-type roof-support beams approximately 80,000 square feet in an L-shaped configuration.

Equipment

Mobile equipment, one 966-C log handler, one shovel-boom-type log stacker, and three forklifts, two large and one small, should be ample.

Log processing would include 30-foot-wide infeed log deck and chip saw infeed conveyors to twin block cutoff saws. The outfeed conveyor from the cutoff saws would be equipped with block bins for sorting and storage. A re-entry barked-block deck would permit introduction of blocks into the system as required.

From the outfeed conveyor the blocks would be transferred to the block infeed conveyor to the lathe charger. The 110-inch lathe charger would feed a Coe 110-inch veneer lathe to cut 1/4-inch thick veneer. A core conveyor would feed a 48-inch core chipper while the veneer waste conveyor would feed a standard veneer clipper. An automatic tipple would deliver the 8-foot-wide veneer to a five-tray storage system 150 feet long with automatic tray loading and unloading controls in front of the clipper. A green chain outfeed from the clipper would permit odd-sized veneer sheet sorting while the 4-foot widths would go in an automatic veneer stacker.

Two veneer dryers would be used to dry the sapwood and the heartwood veneer pieces separately. Since the retained heat in the veneer would be used to cure the glue, it would be necessary to retain this heat in a thermal holding box prior to the layup and gluing operation.

The layup and gluing operation would utilize board feeders, glue-spreaders on cross-feed units to glue and layup veneers just prior to entering the two continuous unheated press portions. A continuous 48-inch wide board, 1-1/2 inches thick, would be pressed and fed to a traveling crosscut saw. The board is then received by pinch rolls and ripsaws to make finished dimension lumber 4 to 16 inches wide by 24 feet long.

After transfer to a 24-foot trimmer, the boards would be stacked on pallets for shipment by an automatic lumber stacker.

Sawdust and trim ends would be collected in an underfloor waste system; trim ends would go to a waste hog; then with the sawdust, the hogged bark would be transferred by blower system to the boiler fuel bin and waste fuel boiler to generate steam for the veneer dryers.

Veneer and core chips would be screened and blown to chip storage bins for loading on a truck and moved on to nearby pulpmills. Fines would be used for boiler fuel.

GENERAL SPECIFICATIONS

Land and Buildings

The site selected shall be level, well-drained, with minimum allowable soil pressure rating of 2,500 pounds per square foot.

The buildings to enclose the plant production facilities shall be of wood construction with heavy timber trusses, panelized plywood roof deck with built-up asphalt roofing and medium-density overlay plywood siding. Standard foundation piers and a 6-inch concrete slab shall be provided.

Paving approximately 50,000 square feet around the building for truck roadways and parking shall be included.

Sprinkler protection shall be provided in the building.

Approximately 500 feet of new railroad spur track shall be included.

Process Machinery

Log-Processing Equipment.--Foundations shall be provided for outside steel structures to support anticipated loads based on soil rating of 2,500 pounds per square foot.

The infeed log deck shall be five-strand H-124 chain runways on heavy structural members 30 feet, 0 inches long, 25 horsepower reversible gearmotors with double sets of air-operated pin stops.

The infeed log conveyor shall be with twin strands of H-124 chain with log cradles at 8 feet 0 inches in 1/2-inch reinforced log trough with replaceable wear strips and 20-horsepower reversible gearmotors. The mechanical log debarker shall be for 35-inch diameter logs; it shall be hydraulically operated with an oversize log bypass mounted on heavy structure supports, an enclosed deck, and operator's platform.

The outfeed log conveyor shall be twin strain H-124 chain, 1/2-inch log trough synchronized with barker infeed.

The twin-block cutoff saws shall operate together to cut a standard block for peeling. The saws shall be controlled by the barker operator.

The block conveyor with two H-124 chains and 20-horsepower gearmotors shall be equipped with four sets of air-operated kickers to divert the blocks to the plant, to sorting bins, or to a re-entry deck.

The re-entry deck shall be three strands H-82 chain 20 feet, 0 inches long, 10-horsepower gearmotor.

Underneath the log system a complete bark and trash conveyor system shall be provided with H-110 chain running in 1/4-inch trough conveyors to the bark hog.

The bark hog shall be capable of handling all bark and trash from a 35-inch debarker and of reducing the material to 6 inches or lesser sizes for air conveying.

Veneer-Processing Equipment.--The block infeed conveyor shall be two-strand H-124 chain approximatelv 40 inches long, 110 inches wide including motor drive, block even-ender, and block-lowering device.

The lathe charger shall be Coe 110-inch mode 249D with Redco 150-horsepower AC/DC lathe drive and 200-horsepower motor generator set or equal.

The tray system shall have automatic tray loading, unloading, two-speed clipper table drive, and tray gap-closing unload drive.

The veneer clipper shall be capable of clipping 1/4-inch veneer 8 inches, 0 inches wide at speed of 450 feet per minute.

The veneer stacker shall be capable of handling 4-foot by 8-foot sheets of 1/4-inch veneer.

The knife grinder shall be Coe 135-inch model 431 with magnetic chuck, covered ways, and DC carriage drive or equal.

The two jet veneer dryers shall be Coe 16-section, 4-line, steam-heated model 72 without cooling sections. The veneer sheet feeder for the dryer feeder shall be complete with preload conveyor, X-life, and feeding mechanism or equal.

Two veneer moisture detectors shall be Lauck's model 232C or equal.

A Coe universal veneer patch machine, strip saw, and blank saw or equal shall be provided.

Press-Lam Production.--The Press-Lam equipment for glue spreading, layup, and cold pressing must be adequate to spread 60 pounds per 1,000 square feet of phenol resorcinal glue on five sheets of 4-foot by 8-foot veneer to make up 6-ply Press-Lam sheets to enter into the continuous unheated press in 30 seconds.

Each continuous unheated press shall be similar to the press manufactured by Bison-Werke, 8 feet, 0 inches wide by 60 feet, 0 inches long (4 ft by 0 in. pressing surface) to press the veneer layup at 150 pounds per square inch and 23.5 feet per minute, or 100 board feet per minute based on:

100 fbm/min = 6 Mfbm/h

30 MMfbm/yr = 5,000 hs/yr or
= 20 hs/day, or 250 days/yr

22 MMfbm/yr = 4,167 hs/yr or
16 hs/day, 250 days/yr

The cutoff, rip, and crosscut saw line shall be capable of reducing the continuous 4 feet, 0 inches side Press-Lam board to dimension lumber 4 inches to 16 inches wide by 24 feet, 0 inches or less long.

A standard lumber stacker manufactured by Irvington or equal shall be provided at the end of the line to palletize the lumber.

Waste Utilization.--The core conveyor from the veneer lathe shall be complete with the H-106 chain in flared trough with 5-horsepower drive.

The 48-inch core chipper, 150 horsepower motor V-belt, three-knife horizontal feed with bottom discharge shall be Soderhamn or equal.

The veneer waste "cleanup" conveyor to the veneer chipper shall be a 24-inch-wide belt in a U-shaped trough with 10-horsepower drive.

The 84-inch veneer chipper, 200-horsepower motor V-belt drive, eight-knife horizontal feed, bottom discharge shall be Soderhamn or equal.

A double H-116 chain conveyor (10-horsepower drive with 1/4-inch trough and hardwood wear plates) mounted below both chippers to feed the bucket elevator shall be provided. The elevator (20-horsepower drive) shall be twin 16-inch by 8-inch buckets mounted on a 36-inch belt in 3/16-inch steel casing on approximately 30-foot centers.

A radar pneumatic or equal surge bin (10 units) shall be provided.

A vibrating screen for chips, double deck, 50 square feet of surfaced Soderhamn CS-27 or equal shall be provided.

The "overs" conveyors (to convey oversized chips and sawdust) to the waste-blowing system shall be 12-inch-wide H-78 chain and flights in 3/16-inch U-shaped trough with hardwood wear strips and powered with a 2-horsepower gearmotor.

The "overs" conveyors to convey oversized chips back to the core chipper for rechipping shall be a 12-inch wide belt conveyor in U-shaped No.10-gallon trough powered by a 2-horsepower gearmotor.

The fines conveyor (to convey the undersized chips and sawdust) to the waste-blowing system shall be 12-inch-wide H-78 chain and flights in 3/16 inch U-shaped trough with hardwood wear strips 2-horsepower gearmotor.

A 42-unit chip storage and truck-loading bin with hydraulic power unit (Peerless or equal) shall be proved.

The Press-Lam cutup system shall be provided with underfloor waste conveyors to collect sawdust and trim ends with H-116 chain in 1/4-inch-plate waste troughs that discharge into Montgomery 36-inch wide hog or equal.

The discharge conveyor from the waste hog to the waste blower infeed shall be furnished with H-116 chain in a 1/4-inch waste trough and 10-horsepower gearmotor.

A waste-blowing system to handle 20 units per hour, pipe radar pneumatic or equal, from the collection point to the 160-unit fuel bin, shall be provided.

The self-feeding fuel stroage bin, 160 units, shall be Larry Wellons and Associate or equal with automatic feeding conveyors to water tube boiler.

The waste-fuel boiler shall be a Wellons Cyclo-Blast cell system boiler capable of producing 40,000 pounds of steam per hour at 250 pounds per square inch operating pressure. The boiler shall be enclosed in sheet metal housing and steampiped to veneer dryers and thermal holding box.

Installations

The equipment shall be installed on concrete foundations according to manufacturer's specifications to provide a completely operational facility.

All electrical equipment shall be provided and installed as required to provide power and control to the described equipment.

Mobile Equipment

A caterpillar 966-C log handler or equal shall be required to feed logs to the infeed log deck from log storage.

A shovel-crane preferrably used with a log boom is recommended to deck the logs for storage in the yard.

Two large rubber-tired forklifts, 7-1/2 tons, plus one small lift, 2 tons, shall be required.

Also, miscellaneous plant vehicles, pickups, service truck, etc. shall be provided.

Miscellaneous

Water, sewage, and natural gas connections shall be made from sources adjacent to the plant site.

A 25-horsepower air compressor and adequate receiver shall be provided to operate log-processing equipment and miscellaneous air equipment.

Sprinklers shall be required in the thermal box and the veneer dryers for fire protection.

General plant and log storage fire protection shall be provided from the city water source.

Sufficient space-heating units are required to heat space 80,000 square feet by 22 feet high.

ESTIMATE OF TOTAL

Facilities Cost		
Land and Buildings	$ 844,000	
Process Machinery	7,908,500	
Installation	690,000	
Mobile Equipment	216,000	
Miscellaneous	391,000	
Total	$10,049,500	
Land and Buildings		
Land--20 acres, $3,000/acre	$ 60,000	
Grading	10,000	
Excavation	5,000	
Buildings		
Office 2,000 ft² $25/ft²	50,000	
Plant 80,000 ft² $7/ft²	560,000	
Boiler house	25,000	
Miscellaneous	10,000	
Sprinklers--fire protection	49,000	
Paving--50,000 ft² $0.50/ft²	25,000	
Railroad spur	50,000	
Total	$ 844,000	$ 844,000

Process Machinery

Log Processing		
Foundations	$ 40,000	
Infeed log deck, 30 ft	30,000	
Log conveyor, 50 ft	40,000	
35-in. debarker	75,000	
Log conveyor, 40 ft, 0 in.	35,000	
Block cutoff saws	13,000	
Outfeed block conveyor, 60 ft	15,000	
Barker and saw structure of housing	15,000	
Waste conveyors to hog and blower	20,000	
Bark hog	25,000	
	$ 373,000	$ 373,000
Veneer Processing		
Block infeed conveyor	$ 25,000	
Coe 100-in. lathe charge	46,000	
Coe 110-in. model 249D	106,000	
150 hp drive	38,000	
Tray system, 8 ft wide × 150 ft long, 5 deck, 5 belts per deck	35,000	
Automatic tray load, unload drives, and control	38,000	
Knife grinder	20,000	
Veneer stitching system veneer chipper, veneer stacker	40,000	
Two veneer sheet feeders to dryer feeder	27,000	
Two Coe model 72 veneer dryer feeders	61,000	
Two Coe 16-section, 4-line steam-heated model 72 veneer dryers with jet-cooling sections	619,500	
Veneer moisture detector	5,000	
Veneer thermal box	20,000	
Patching-equipment	30,000	
	$ 1,110,500	$ 1,110,500
Press-Lam Production		
Layup and gluing machinery	$ 600,000	
Continuous unheated press	5,000,000	
Cut-up plant, saws trimmer, lumber, stacker strapper	120,000	
	$ 5,720,000	$ 5,720,000
Waste Ulilization		
Core conveyor	$ 8,000	
Core chipper, 48-in.	11,000	
Veneer waste conveyor	10,000	
Veneer chipper, 84-in.	43,000	
Chip conveyor	5,000	
Bucket elevator	18,000	
Surge bin over screen	12,000	

Screen	5,000	
Conveyor to chip bin	15,000	
Overs conveyor	5,000	
Fines conveyor	5,000	
42-Unit chip bin	20,000	
Press-Lam waste conveyor	18,000	
Waste hog	15,000	
Waste blowing system to fuel bin	30,000	
Wellons 160-unit bin	65,000	
Wellons waste boiler, 40,000 lb/h 250 lb/in.²	335,000	
	$ 705,000	$ 705,000
Total Process machinery	$ 7,908,500	$ 7,908,500
Installation		
Mechanical equipment		
21 pct of process equipment cost less Section B-3 (furnished installed)	$ 470,000	
Electrical	180,000	
Mechanical piping	40,000	
Total	$ 690,000	$ 690,000
Mobile Equipment		
Log handler 966-C	$ 86,000	
Log crane--boom	50,000	
Forklifts	60,000	
Plant vehicles	20,000	
Total	$ 216,000	$ 216,000
Miscellaneous		
Utilities		
Natural gas	$ 5,000	
Water	5,000	
Sewer	8,000	
Air compressor and piping	25,000	
Fire protection-sprinklers (dryer)	36,000	
Fire protection-underground (outside)	40,000	
Plant heating	32,000	
Miscellaneous	40,000	
Engineering cost	200,000	
Total	$ 391,000	$ 391,000

ESTIMATE OF OPERATING COST ESTIMATES, YEARLY BASIS

Labor (2 shifts basis, 250 days/yr)		
Equipment operators @ $5/h × 2,000 hs × 2 shifts	$ 100,000	
Three log handling operators @ $5/h × 2,000 hs × 2 shifts	60,000	
Veneer-processing operators (3) @ $5/h × 2,000 hs × 2 shifts	60,000	
20 Veneer-processing laborers @ $4/h × 2,000 hs × 2 shifts	320,000	
13 Press-Lam operators @ $5/h × 2,000 hs × 2 shifts	260,000	
Five shipping laborers @ $4/h × 2,000 hs × 2 shifts	80,000	
Four boiler plant operators @ $5/h × 2,000 hs × 2 shifts	80,000	
Three maintenance mechanics @ $5/h × 2,000 hs × 2 shifts	60,000	
Two quality control technicians @ $5/h × 2,000 hs × 2 shifts	40,000	
Four office personnel @ $3/h × 2,000 hs × 1 shift	24,000	
Three supervisors @ $6/h × 2,000 hs × 2 shifts	72,000	
One manager (per year)	40,000	
Total labor	$ 1,196,000	$ 1,196,000
Payroll taxes, insurance, fringe benefits (30 pct of above)	$ 359,000	
Total (Labor, taxes, insurance, fringe benefits)	$ 1,555,000	$ 1,555,000
Overhead Expenses		
Electric power (1,000 hp)	45,000	
Utilities (water, sewer)	10,000	
Insurance	340,000	
Supplies	49,000	
Maintenance	388,000	
General overhead	974,000	
Total operating cost	$ 3,361,000	$ 3,361,000

APPENDIX B

Cash-Flow Analyses of Hypothetical Press-Lam Lumber Manufacturing Facility

Cash-flow analyses of a hypothetical Press-Lam facility for processing Special Peeler, No. 2 Sawmill, and No. 3 Sawmill Douglas-fir sawlogs are shown in the three tables on the following pages.

Table A-1.--PRESS-LAM ★ ★ TWO PRESS SYSTEM ★ ★ SPL PEELER D.F. LOGS **MARCH 5, 1976**

YEARS CONSIDERED	10	FACILITIES SALVAGE VALUE	$ 60000.
TAX RATE	.511	PRESENT VALUE OF INVESTMENT	$ -1387460.
DISCOUNT RATE	.200	INTERNAL RATE OF RETURN	.145

FINANCIAL SUMMARY

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
UNIT SALES	30000.	60000.	60000.	60000.	60000.	60000.	60000.	60000.	60000.	60000.
UNIT PRICE	$ 229.21	$ 240.67	$ 252.70	$ 265.34	$ 278.61	$ 292.54	$ 307.16	$ 322.52	$ 338.65	$ 355.58
GROSS SALES	$ 6876300.	$14440199.	$15161999.	$15920399.	$16716599.	$17552399.	$18429599.	$19351199.	$20318999.	$21334799.
VARIABLE MFG COST	$ 3536400.	$ 7426200.	$ 7797600.	$ 8187600.	$ 8596800.	$ 9027000.	$ 9478200.	$ 9952200.	$10449600.	$10972200.
SELLING EXPENSE	481341.	1010814.	1061340.	1114428.	1170162.	1228668.	1290072.	1354584.	1422330	1493436.
OTHER VAR. COST	35000.	35000.	35000.	0.	0.	0.	0.	0.	0.	0.
TOTAL VAR COST	$ 4052741.	$ 8472014.	$ 8893940.	$ 9302028.	$ 9766962.	$10255668.	$10768272.	$11306784.	$11871930.	$12465636.
UNIT VAR COST	$ 135.09	$ 141.20	$ 148.23	$ 155.03	$ 162.78	$ 170.93	$ 179.47	$ 188.45	$ 197.87	$ 207.76
PROFIT CONTRI	$ 2823559.	$ 5968186.	$ 6268060.	$ 6618372.	$ 6949638.	$ 7296732.	$ 7661328.	$ 8044416.	$ 8447069.	$ 8869164.
P.C. RATIO	41.06%	41.33%	41.34%	41.57%	41.57%	41.57%	41.57%	41.57%	41.57%	41.57%
FIXED MFG COST	$ 2520600.	$ 3528840.	$ 3705282.	$ 3890546.	$ 4085073.	$ 4289327.	$ 4503793.	$ 4728983.	$ 4965432.	$ 5213704.
OVERHEAD COST	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL F.C.	$ 2520600.	$ 3528840.	$ 3705282.	$ 3890546.	$ 4085073.	$ 4289327.	$ 4503793.	$ 4728983.	$ 4965432.	$ 5213704.
FACILITIES COST	$10049500.	$ 0.	$ 0.	$ 0.	$ 0.	$ 0.	$ 0.	$ 0.	$ 0.	$ 0.
WORKING CAPITAL	365520.	293882.	32871.	32416.	36224.	38067.	39940.	41951.	44031.	46252.
INVESTMENT	$10415020.	$ 293882.	$ 32871.	$ 32416.	$ 36224.	$ 38067.	$ 39940.	$ 41951.	$ 44031.	$ -1031154.
DEPRECIATION	$ 1997900.	$ 1598320.	$ 1278656.	$ 1022925.	$ 818340.	$ 654672.	$ 654672.	$ 654672.	$ 654672.	$ 654672.
AFTER TAX PROFIT	$ -828826.	$ 411262.	$ 627936.	$ 833696.	$ 1000604.	$ 1150486.	$ 1223900.	$ 1301112.	$ 1382386.	$ 1467385.
A.T. EARNINGS	1169074.	2009582.	1906592.	1856621.	1818944.	1805158.	1878572.	1955784.	2037058.	2122057
A.T. NET CASH FLOW	-9245946.	1715699.	1873721.	1824206.	1782720.	1767091.	1838632.	1913833.	1993027.	3153211.
ACUM NET CASH FLOW	$ -9246.M	$ -7530.M	$ -5657.M	$ -3832.M	$ -2050.M	$ -283.M	$ 1556.M	$ 3470.M	$ 5463.M	$ 8616.M

INTERNAL RATES OF RETURN ★ ★ ★ AT ADJUSTED INPUT VALUES

	80 PCT	90 PCT	100 PCT	110 PCT	120 PCT
UNIT SALES	.036	.093	.145	.194	.240
UNIT PRICE	-.156	.021	.145	.254	.359
UNIT VAR COST	.285	.216	.145	.069	-.016
TOTAL F.C.	.206	.176	.145	.114	.081
FACILITIES COST	.189	.165	.145	.128	.113

Table A-2.--PRESS-LAM ★ ★ TWO PRESS SYSTEM ★ ★ NO 2 D.F. LOGS **MARCH 5, 1976**

YEARS CONSIDERED	10	FACILITIES SALVAGE VALUE	$ 60000.
TAX RATE	.511	PRESENT VALUE OF INVESTMENT	$ -2189956.
DISCOUNT RATE	.200	INTERNAL RATE OF RETURN	.112

FINANCIAL SUMMARY

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
UNIT SALES	30000.	60000.	60000.	60000.	60000.	60000.	60000.	60000.	60000.	60000.
UNIT PRICE	$ 209.97	$ 220.47	$ 231.49	$ 243.07	$ 255.22	$ 267.98	$ 281.38	$ 295.45	$ 310.22	$ 325.73
GROSS SALES	$ 6299100.	$13228140.	$13889519.	$14584019.	$15313199.	$16078859.	$16882799.	$17726939.	$18613259.	$19543919.
VARIABLE MFG COST	$ 3188700.	$ 6696000.	$ 7030800.	$ 7382400.	$ 7752000.	$ 8139600.	$ 8546400.	$ 8973600.	$ 9422400.	$ 9893400.
SELLING EXPENSE	440937.	925970.	972266.	1020881.	1071924.	1125520.	1181796.	1240886.	1302928.	1368074.
OTHER VAR. COST	35000.	35000.	35000.	0.	0.	0.	0.	0.	0.	0.
TOTAL VAR COST	$ 3664637.	$ 7656970.	$ 8038066.	$ 8403281.	$ 8823924.	$ 9265120.	$ 9728196.	$10214485.	$10725328.	$11261474.
UNIT VAR COST	$ 122.15	$ 127.62	$ 133.97	$ 140.05	$ 147.07	$ 154.42	$ 162.14	$ 170.24	$ 178.76	$ 187.69
PROFIT CONTRI	$ 2634463.	$ 5571170.	$ 5851453.	$ 6180738.	$ 6489276.	$ 6813739.	$ 7154604.	$ 7512454.	$ 7887931.	$ 8282445.
P.C. RATIO	41.82%	42.12%	42.13%	42.38%	42.38%	42.38%	42.38%	42.38%	42.38%	42.38%
FIXED MFG COST	$ 2520600.	$ 3528840.	$ 3705282.	$ 3890546.	$ 4085073.	$ 4289327.	$ 4503[illegible]3.	$ 4728983.	$ 4965432.	$ 5213704.
OVERHEAD COST	0.	0.	0	0.	0.	0.	0.	0.	0.	0.
TOTAL F.C.	$ 2520600.	$ 3528840.	$ 3705282.	$ 3890546.	$ 4085073.	$ 4289327.	$ 450[illegible]3.	$ 4728983.	$ 4965432.	$ 5213704.
FACILITIES COST	$10049500.	$ 0.	$ 0.	$ 0.	$ 0.	$ 0.	$ 0.	$ 0.	$ 0.	$ 0.
WORKING CAPITAL	344658.	270932.	30675.	30112.	33848.	35511.	37276.	39143.	41115.	43156.
INVESTMENT	$10394158.	$ 270932.	$ 30675.	$ 30112.	$ 33848.	$ 35511.	$ 37276.	$ 39143.	$ 41115.	$ -966426.
DEPRECIATION	$ 1997900.	$ 1598320.	$ 1278656.	$ 1022925.	$ 818340.	$ 654672.	$ 654672.	$ 654672.	$ 654672.	$ 654672.
AFTER TAX PROFIT	$ -921294.	$ 217121.	$ 424215.	$ 619694.	$ 775487.	$ 914303.	$ 976112.	$ 1040983.	$ 1108968.	$ 1180480.
A.T. EARNINGS	1076606.	1815441.	1702871.	1642619.	1593827.	1568975.	1630784.	1695655.	1763640.	1835152.
A.T. NET CASH FLOW	-9317552.	1544509.	1672196.	1612507.	1559979.	1533464.	1593508.	1656511.	1722525.	2801578.
ACUM NET CASH FLOW	$ -9318.M	$ -7773.M	$ -6101.M	$ -4488.M	$ -2928.M	$ -1395.M	$ 199.M	$ 1855.M	$ 3578.M	$ 6379.M

INTERNAL RATES OF RETURN ★ ★ ★ AT ADJUSTED INPUT VALUES

	80 PCT	90 PCT	100 PCT	110 PCT	120 PCT
UNIT SALES	.002	.060	.112	.159	.204
UNIT PRICE	-.193	-.010	.112	.214	.312
UNIT VAR COST	.241	.178	.112	.039	-.044
TOTAL F.C.	.175	.144	.112	.078	.043
FACILITIES COST	.150	.129	.112	.096	.083

Table A-3.--PRESS-LAM ★ ★ TWO PRESS SYSTEM ★ ★ NO 3 D.F. LOGS   MARCH 5, 1976

YEARS CONSIDERED	10	FACILITIES SALVAGE VALUE	$ 60000.
TAX RATE	.511	PRESENT VALUE OF INVESTMENT	$ -996747.
DISCOUNT RATE	.200	INTERNAL RATE OF RETURN	.161

FINANCIAL SUMMARY

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
UNIT SALES	30000.	60000.	60000.	60000.	60000.	60000.	60000.	60000.	60000.	60000.
UNIT PRICE	$ 194.10	$ 203.81	$ 214.00	$ 224.70	$ 235.93	$ 247.73	$ 260.11	$ 273.12	$ 286.77	$ 301.11
GROSS SALES	$ 5823000.	$12228600.	$12840000.	$13481999.	$14155799.	$14863799.	$15606599.	$16387199.	$17206199.	$18066599.
VARIABLE MFG COST	$ 2487900.	$ 5224800.	$ 5485800.	$ 5760000.	$ 6048000.	$ 6350400.	$ 6667800.	$ 7001400.	$ 7351800.	$ 7719000.
SELLING EXPENSE	407610.	856002.	898800.	943740.	990906.	1040466.	1092462.	1147104.	1204434.	1264662.
OTHER VAR. COST	35000.	35000.	35000.	0.	0.	0.	0.	0.	0.	0.
TOTAL VAR COST	$ 2930510.	$ 6115802.	$ 6419600.	$ 6703740.	$ 7038906.	$ 7390866.	$ 7760262.	$ 8148504.	$ 8556234.	$ 8983662.
UNIT VAR COST	$ 97.68	$ 101.93	$ 106.99	$ 111.73	$ 117.32	$ 123.18	$ 129.34	$ 135.81	$ 142.60	$ 149.73
PROFIT CONTRI	$ 2892490.	$ 6112798.	$ 6420400.	$ 6778260.	$ 7116894.	$ 7472934.	$ 7846337.	$ 8238696.	$ 8649966.	$ 9082938.
P.C. RATIO	49.67%	49.99%	50.00%	50.28%	50.28%	50.28%	50.28%	50.28%	50.27%	50.27%
FIXED MFG COST	$ 2520600.	$ 3528840.	$ 3705282.	$ 3890546.	$ 4085073.	$ 4289327.	$ 4503793.	$ 4728983.	$ 4965432.	$ 5213704.
OVERHEAD COST	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL F.C.	$ 2520600.	$ 3528840.	$ 3705282.	$ 3890546.	$ 4085073.	$ 4289327.	$ 4503793.	$ 4728983.	$ 4965432.	$ 5213704.
FACILITIES COST	$10049500.	$ 0.	$ 0.	$ 0.	$ 0.	$ 0.	$ 0.	$ 0.	$ 0.	$ 0.
WORKING CAPITAL	302610.	224708.	26247.	25468.	28952.	30399.	31912.	33527.	35211.	36928.
INVESTMENT	$10352110.	$ 224708.	$ 26247.	$ 25468.	$ 28952.	$ 30399.	$ 31912.	$ 33527.	$ 35211.	$ -835962.
DEPRECIATION	$ 1997900.	$ 1598320.	$ 1278656.	$ 1022925.	$ 818340.	$ 654672.	$ 654672.	$ 654672.	$ 654672.	$ 654672.
AFTER TAX PROFIT	$ -795119.	$ 481977.	$ 702430.	$ 911882.	$ 1082392.	$ 1236649.	$ 1314370.	$ 1396115.	$ 1481602.	$ 1571921.
A.T. EARNINGS	1202781.	2080297.	1981086.	1934807.	1900732.	1891321.	1969042.	2050787.	2136274.	2226593.
A.T.NET CASH FLOW	-9149329.	1855589.	1954839.	1909339.	1871780.	1860922.	1937130.	2017259.	2101063.	3062555.
ACUM NET CASH FLOW	$ -9149.M	$ -7294.M	$ -5339.M	$ -3430.M	$ -1558.M	$ 303.M	$ 2240.M	$ 4258.M	$ 6359.M	$ 9421.M

INTERNAL RATES OF RETURN ★ ★ ★ AT ADJUSTED INPUT VALUES

	80 PCT	90 PCT	100 PCT	110 PCT	120 PCT
UNIT SALES	.048	.107	.161	.210	.259
UNIT PRICE	-.074	.057	.161	.253	.343
UNIT VAR COST	.262	.212	.161	.106	.048
TOTAL F.C.	.221	.192	.161	.129	.096
FACILITIES COST	.207	.182	.161	.142	.126

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L-1

U.S. Forest Products Laboratory.

Economic feasibility of process for high-yield laminated structural products, by George B. Harpole and Lloyd W. Aubry. Madison, Wis., For. Prod. Lab. 1977. 22 p. (USDA For. Serv. Res. Pap. FPL 285).

A financial analysis is offered for the production of veneer-lumber products utilizing low-grade logs.

KEYWORDS: Economic analysis, veneer products, Press-Lam facility, laminated lumber, manufacturing costs, financial analysis.

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