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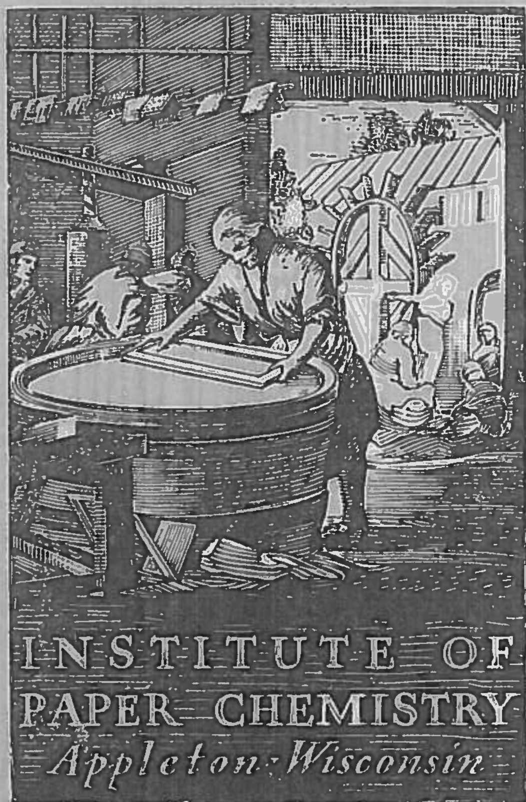

GENETIC IMPROVEMENT OF LARCH

Project 3409

Report Two
A Progress Report
to
MEMBERS OF GROUP PROJECT 3409

March 5, 1982

WOOD QUALITY AND PULPING

WOOD QUALITY OF SELECTED TREES

As stated in Project 3409, Progress Report One, the wood quality of Japanese and European larch was compared with that of several other commonly pulped native species. This comparison was made through a literature search of the wood quality of mature trees of the species involved. European larch specific gravity averaged 0.49, whereas Japanese larch averaged 0.44. Fiber length for both species averaged 3.6 mm.

Wood quality continues to receive a major amount of emphasis in the larch project. Additional selections of outstanding trees were made in 1981, bringing the totals to 46 European larch and 37 Japanese larch selections. Whenever possible, breast-high, 10-mm increment cores were collected from these trees to check specific gravity, fiber length, alcohol-benzene extractives and hot-water extractives. However, in some cases, it was not possible to take cores, because we either could not obtain permission to remove cores or else we received scions from grafted trees and did not have access to the original tree.

Specific Gravity

Specific gravity is obtained on a green volume basis on the complete core of all four cores taken. Rings 14-16 are then cut from two cores and specific gravity measured again, to give an age 15 specific gravity. Because of a decision to concentrate on selecting European larch in 1981 and Japanese larch in 1982, only one Japanese larch selection was made in 1981 from which cores were available. This was a 20-year-old tree from Maine which had a total core specific gravity of 0.343 and an age 15 specific gravity of 0.397. This total core value is below the average of the previous Japanese larch selections (0.374). However, the age 15 specific gravity of 0.397 was greater than anticipated. The reasons for the disparity in specific gravity results were not readily apparent and probably would require a microscopic examination of the wood structure. Whether this tree will be retained in the program is still indefinite.

Total core specific gravity of the 1981 European larch selections measured averaged 0.392; rings 14-16 averaged 0.399. These averages are slightly lower than those obtained for trees selected in 1980 (0.404 - total core and 0.432 - rings 14-16). However, several of the selected trees had total core specific gravity ranging from 0.358 to 0.366, which brought the average down. Again, these trees will have to excel in other respects to be retained in the program.

Fiber Length

The cores used for specific gravity measurements were then sectioned for fiber length determinations. Rings 11-15 were removed from two cores, and rings 14-16 were used from the remaining two cores. The sectioned cores were macerated and 600+ intact fibers measured for each determination. Intact fibers are measured on wood samples to give a better indication of the tree's true fiber length. This is contrasted with pulp samples where all fibers 0.3 mm and longer are measured to give an indication of actual fiber length going into the papermaking process.

Arithmetic average fiber length of rings 11-15 of the 1981 Japanese larch selection averaged 2.91 mm; rings 14-16 averaged 3.16 mm. Fiber lengths of rings 11-15 of the 1981 European larch selections averaged 2.59 mm, whereas rings 14-16 averaged 2.70 mm. Based upon fiber lengths of 16 European larch selections and 13 Japanese larch selections, Japanese larch seems to have a slight advantage over European larch in fiber length. However, fiber lengths for both species are comparable to those reported for any young, fast-growing, short-rotation conifer. Figure 11 depicts fibers from larch selection LD-11-81, rings 14-16.

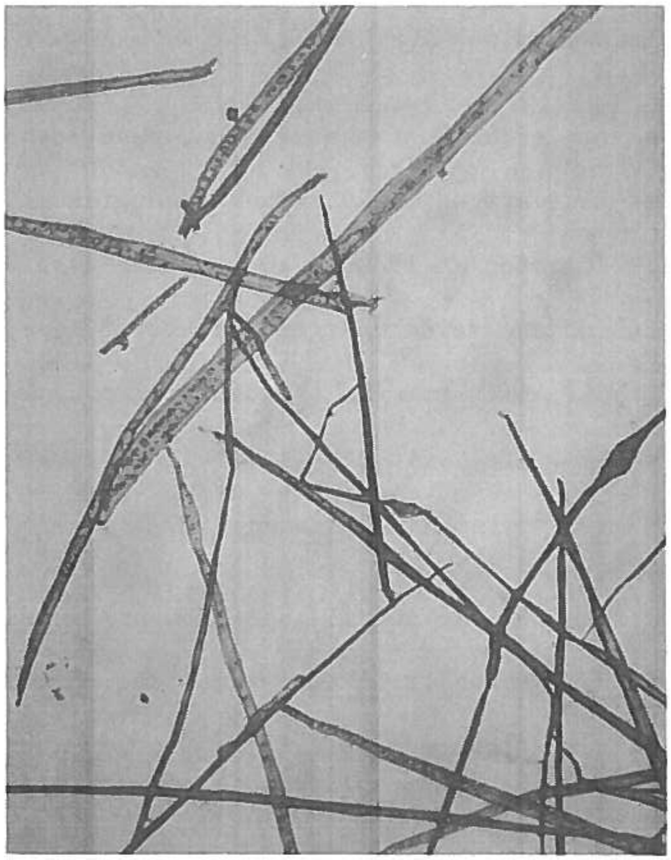

Figure 11. Illustrated are typical L. decidua fibers used in making fiber length determinations. Only intact fibers were measured. Magnification - 50X.

Extractives

Extractive levels have an influence on pulp yield and bleaching characteristics of kraft pulps. A procedure has been developed for comparing differences between parent trees. The procedure used in obtaining hot-water and alcohol-benzene extractives involves removing the first ten rings from four cores collected for specific gravity and fiber length information and obtaining alcohol-benzene and hot-water extractives separately (not consecutively) on a composited sample of all four cores using TAPPI Standards T 204 os-76 (alcohol-benzene) and T 207 os-75 (hot-water).

Alcohol-benzene extractives for the 1981 European larch selections averaged 3.4%, whereas the 1981 Japanese larch selection had an alcohol-benzene extractives content of 4.0%. This compares with 4.4% for the 1980 selected European and Japanese larch.

Average hot-water extractives for the 1981 European larch selections averaged 4.4%, whereas the 1981 Japanese larch selection had a hot-water extractives content of 2.6%. The 1981 values for hot-water extractives were much lower than the 1980 values. The differences obtained were apparently due to a change from one Tappi method to another. Rerunning some samples revealed that we should be employing the method used in 1981 (T 204 os-76). This means we will have to re-collect increment core samples from several trees selected and sampled in 1980. The hot-water extractives data summarized in Table III are based upon 1981 values only. With the addition of wood samples from seven Japanese larch and four European larch presently being processed, meaningful comparisons will be possible.

Extractives have been measured routinely on chip samples of trees cut for pulping studies. The chip samples represent the entire bole without bark to a 4-inch top of three composited trees. Given in Table IV for comparison purposes are the values obtained on these trees. Since these measurements represent the entire bole, it is not surprising that they are fairly low.

Larch continues to be a viable, alternative fiber source based upon information gathered on its wood quality as well as through growth and pulping results.

Table III summarizes wood quality obtained from young Japanese and European larch as part of this project.

TABLE III

WOOD QUALITY COMPARISONS
SELECTED TREES

Property	Japanese Larch	European Larch
Age 15 Specific gravity[a]	0.38 (0.29-0.43)	0.41 (0.35-0.50)
Age 15 Fiber length, mm[b]	2.96 (2.54-3.26)	2.74 (2.48-2.97)
Alcohol-benzene extractives, % First 10 rings[c]	4.4 (3.3-5.6)	4.4 (2.5-7.0)
Hot-water extractives, % First 10 rings[c]	2.6	4.4 (2.3-6.4)

[a]Green volume basis
[b]Arithmetic average of intact fibers only
[c]1981 data only

TABLE IV

EXTRACTIVES INFORMATION[a]
PULPING TREES

Species	Alcohol-Benzene Extractives, %	Hot-Water Extractives, %
23-year-old Japanese larch	3.0	7.4
18-year-old European larch	1.8	3.9
23-year-old hybrid larch	2.5	4.2

[a]Samples used were chip samples representing the entire bole without bark to a 4-inch top of three composited trees for each species.

Mechanical Properties

Although the strength properties of larch are not of direct concern in this project, some information has been gathered to assist companies in assessing the potential of Japanese and European larch in integrated usage for solid wood and paper products. According to Schreiner (7), improvement in mechanical properties of forest trees is possible through a combination of genetics and silviculture. However, for the most rapid improvement, more specific information is needed on the relationship of individual wood characteristics to mechanical properties. Markwardt and Wilson (8) give a conservative estimate of individual variation in mechanical properties. The values are general figures derived from a number of species. Table V summarizes these estimates.

TABLE V

VARIATION IN MECHANICAL PROPERTIES FROM SPECIES AVERAGE

Property	Percent Variation
Static bending:	
Fiber stress at proportional limit	9
Modulus of rupture	7
Modulus of elasticity	9
Work to maximum load	15
Impact bending:	
Fiber stress at proportional limit	8
Work to proportional limit	12
Height of drop	13
Compression parallel to grain:	
Fiber stress at proportional limit	12
Crushing strength	7
Compression perpendicular to grain:	
Fiber stress at proportional limit	14
Hardness:	
End	10
Side	9
Shearing strength parallel to grain	7
Tension perpendicular to grain	12

Olson *et al*. (*9*) measured 23 European larch trees with an average age of approximately 30 years from seed. The trees had been grown in an area of comparatively low fertility and, as a consequence, had an average height of only 47 feet and an average b.h. diameter of 11.4 inches. Summarized in Table VI are the values obtained for basic strength properties. As a comparison, the strength properties of forest-grown trees are also given.

TABLE VI

STRENGTH PROPERTIES OF PLANTATION-GROWN *VS*. FOREST-GROWN EUROPEAN LARCH[a]

Property[b]	Plantation Grown	Forest Grown
Static bending:		
Stress at proportional limit (psi)	4,300	5,700
Modulus of rupture (psi)	8,500	11,400
Modulus of elasticity (1,000 psi)	1,010	1,390
Compression parallel to grain:		
Stress at proportional limit (psi)	2,380	3,400
Maximum crushing strength (psi)	4,280	6,370
Compression perpendicular to grain:		
Stress at proportional limit (psi)	890	780
Hardness:		
End (pounds)	800	1,100
Side (pounds)	610	920
Shear parallel to grain (psi)	1,510	1,455
Cleavage (pounds per inch of width)	220	260
Tension perpendicular to grain (psi)	380	390
Toughness (inch pounds)	127	--

[a]Data taken from Olson *et al*. (*9*).
[b]Measurements made at 12% moisture content for everything except toughness, which was measured at moisture contents ranging from 9 to 20%.

PULP PROPERTIES OF JAPANESE LARCH KRAFT PULPS

Introduction

Most previous larch investigations have examined the wood and pulping characteristics of trees of ages in excess of 50 years. Little is known about wood and pulp properties of European, Japanese, and hybrid larch grown primarily for fiber at rotation ages of 18 to 25 years. The objectives of the larch pulping studies are to determine the usefulness of 18 to 25-year-old larch in the production of bag and bleachable grade papers. Earlier, four sources of larch, including 18-year-old European larch, 23-year-old hybrid larch, 8-year-old hybrid larch, and 55-year-old jack pine (control), were pulped and the results described in Progress Report One (p. 44-64). The report that follows describes the Japanese larch pulping results and compares the data with those from the previously pulped and discussed jack pine and 23-year-old hybrid larch.

Japanese larch wood chips were investigated for their usefulness as bag paper by cooking to a kappa number of approximately 50 and for use as part of the furnish of bleachable grade pulps by cooking to a kappa No. 30. Jack pine was selected as a basis for comparison because of its common use in the Lake States and the Northeast. The 75% jack pine/25% larch mixtures selected were used because it appeared that, with the relatively limited supply of larch, the species would not be cooked alone but in mixtures with other conifers and that very likely these mixtures would contain 25% or less of larch. Data plotting difficulties (space and confusion) preclude comparing the Japanese larch data with all previous larch data. To keep the comparison simple, Japanese larch data were compared with jack pine and 23-year-old hybrid larch values. Progress Report One revealed that 18-year-old European larch had higher pulp yield (3-4%) and cooking rates and strength properties very similar to those of jack pine.

Experimental Materials

The wood pulps used in this comparison came from two sources of larch and a mill-run source of jack pine. Table VII summarizes the age, tree size, percent heartwood, and percent compression wood for the three types of material used in the study. The 22-year-old Japanese larch and hybrid larch were from an Institute planting near Rhinelander, Wisconsin. The jack pine was harvested in northern Wisconsin, and came from the Thilmany Pulp & Paper Company wood pile at Kaukauna, Wisconsin.

TABLE VII

TREE SIZE AND WOOD QUALITY DATA[a]

Type of Material	Age, years	Height, feet	Diam., inches	Bark, %	Breast Height, (4.5 feet) Specific Gravity	Breast Height, (4.5 feet) Fiber Length, Age 15, mm	Compression wood, %	Heart-wood, %
Hybrid larch	23	55.6	7.0	10.1	0.413	2.75	0.4	47.6
Japanese larch	22	56	7.8	10.0	0.384	3.16	-0-	52.3
Jack pine control	55	--	--	--	0.436	--	7.5	28.7

[a]Values based on an average of three trees for the Japanese and hybrid larch, and eight pulpwood bolts for the jack pine.

All materials were debarked, chipped, and screened prior to pulping. Chips passing the 3/4-inch screen and retained on the 1/2 and the 1/4-inch screens were the fractions that were pulped.

Cooking and Bleaching Conditions

Pulping runs were carried out in a stainless steel vessel of about 72 liters capacity, fitted with external circulation and indirect heating. The chips were charged into a stainless steel basket, which closely matched the interior contours of the digester and which could be removed with the contents following cooking. The cooking liquors were prepared from a solution of sodium hydroxide and sodium sulfide of known concentration and density, together with the appropriate amount of dilution water. The pulping conditions employed are given in Table VIII. The pulp was screened through a 0.006-inch cut screen plate in a small Valley flat screen. The rejects were oven dried, weighed, and discarded. The accepted fiber was then used to determine the physical properties of the pulps using TAPPI standard methods after beating in a PFI mill at 10% consistency.

TABLE VIII

PULPING CONDITIONS

Constant Conditions	
Wood charge, kg o.d.	4.0
Water-to-wood ratio, cc/g	4.0
Effective alkali, % o.d. wood	16.0
Sulfidity, %	25.0
Time to 172°C, min	90
Cooking temperature, °C	172

The kappa 30 pulps were bleached using a CEDED sequence prior to physical property evaluation. Bleaching runs were done using heat-sealable polyester bags. Pulp in a crumb form was charged into the bags, diluted with deionized water, and the required bleach solution added to give the appropriate bleach consistency. The bleaching conditions and chemical charges employed are shown in Table IX. Upon completion of the bleaching time, the bag was removed, opened, and the sample of pulp removed from the bleaching chemical. The pulp was thoroughly washed and returned to the bag and the remaining steps in the 5-stage bleaching sequence completed in a similar manner. Pulp from the final chlorine dioxide stage was diluted to a 1% consistency and acidified to pH 3 by bubbling SO_2 gas through the pulp suspension to quench any remaining chlorine dioxide activity. Brightness and handsheet strength properties were determined according to TAPPI standard methods.

TABLE IX

BLEACHING CONDITIONS

Bleach Stage	Bleach Chemical	Chemical Charge, % on o.d. pulp[a]	Consistency, %	Temp., °C	Time, minutes
1	Chlorine (C) Sulfur dioxide	8.3	3.0	Ambient	45
2	NaOH (E)	4.7	10	70	70
3	Chlorine dioxide (D_1)	1.5	10	60	180
4	NaOH (E_2)	1.0	10	60	60
5	Chlorine dioxide (D_2)	0.5	10	60	180
6	Sulfur dioxide	0.5 to pH 3	1	Ambient	1

[a]Pulp o.d. weight 500 g.

Results and Discussion

Introduction

Space limitations make it desirable to reduce and summarize the many observations and extensive data generated in this study. With such an abbreviated approach, some valuable data must be eliminated. As a partial solution to this problem, the decision has been made to prepare an interim Project 3409 report that would go into greater detail than is appropriate at this time. Eventually, the data will be published.

Wood and Fiber Properties

In addition to the wood and fiber properties summarized in Table VII, values based upon disk samples taken at 4.5 feet (breast height), fiber properties of the pulps were measured. This information is summarized in Table X.

TABLE X

PULP FIBER DIMENSIONS

Material	Fiber Length, mm		Width, µm	Thickness, µm	Coarseness, mg/100 m	Kappa No.
	Arith.	Weighted				
Hybrid	1.7	2.2	46.7	5.5	24.6	53.4
larch	1.7	2.2	47.7	5.1	21.2	34.6
Japanese larch	1.8	2.3	48.8	4.6	24.1	55.7
	1.8	2.3	49.1	4.8	23.7	32.5
Jack pine	1.9	2.2	42.1	4.5	22.0	51.1
control	1.9	2.3	44.3	5.7	20.5	34.4
25% Hybrid larch/	1.9	2.3	40.3	5.3	--[a]	52.2
75% jack pine	2.1	2.5	44.2	5.1	--[a]	31.1
25% Japanese larch/	2.0	2.4	42.8	4.7	24.4	53.4
75% jack pine	1.9	2.2	43.7	4.7	21.4	35.3

[a]Original values were found to be in error and are being rechecked.

The specific gravity values for the Japanese larch were lower than for the hybrid larch. The jack pine wood samples were higher in specific gravity than any of the larch samples investigated. The 22-year-old Japanese larch had no compression wood, suggesting that, if compression wood had been present as in the other trees used, the specific gravity would have been modestly higher.

The pulp fiber dimensions summarized in Table X were surprisingly similar for the several sources of larch and larch/jack pine mixtures. Fiber width of the Japanese hybrid larch appeared to be greater than those of the other pulps. Also, the fiber cell wall thickness of this material appeared to be lower than that of the other pulps evaluated. Most of the values given in Table X are consistent with expectation, even the coarseness of the Japanese larch. The values involving Japanese larch were higher than jack pine and comparable to hybrid larch and European larch. Fiber coarseness is weight per unit length (mg/100 m), and, normally, narrow fibers, thin cell walls, and low wood density are usually associated with low fiber coarseness.

Wood Chemical Comparisons

Pulp yields are related to cooking conditions and lignin and extractive levels in the original wood samples. Table XI summarizes this information for the four sources of experimental chips. The Japanese larch lignin level was greater than the other sources of larch and was 1.9% higher than jack pine. Japanese larch alcohol-benzene extractives levels were similar to those of jack pine and hybrid larch and greater than those of European larch. Similarly, hot-water extractives were 5% higher for Japanese larch than for jack pine and about 3.5% greater than hybrid larch and European larch. The lower pulp yield of Japanese larch described in the following section reflects the high lignin and hot-water extractive levels. It should, however, be pointed out that hot-water extractive levels reported for the European and hybrid larch were about 1/2 the levels found in the literature for older larch. Japanese larch extractives levels for old trees are not available but are presumed to be greater than those given in Table XI.

TABLE XI

CHEMICAL PROPERTIES OF WOOD

Type of Material	Lignin, %	Extractives, % Alcohol-Benzene	Extractives, % Hot Water
Hybrid larch	27.94	2.47	4.18
European larch	27.60	1.80	3.90
Japanese larch	29.30	3.00	7.40
Jack pine control	27.45	3.54	2.31

Pulp Yields

The pulping procedure followed was to establish the goals of kappa number* 50 (bag papers) and 30 (bleachable pulps) and then vary cooking conditions (H-factor) to obtain pulps that could be used in pulp strength comparisons. Table XII summarizes these results. The pulp yield information provided several interesting results. Comparing unscreened pulp yields**, for example, consistently demonstrated a 3-4% yield advantage for the earlier pulped 18-year-old European and 23-year-old hybrid larch over the 55-year-old jack pine. The Japanese had a lower pulp yield than European larch and hybrid larch (2.8-3.5%) and a pulp yield that was approximately equal to or slightly higher than that of jack pine.

Equally important is having good pulping rate compatibility between larch and jack pine. Previously reported results on European and hybrid larch revealed pulping at approximately the same rate as jack pine. Japanese larch, however, pulped modestly slower than jack pine (particularly at lower kappa numbers) as is illustrated by Fig. 12. This suggest that preparing low kappa pulps from chip

*Kappa number reflects the lignin remaining in the pulp.
**Even though rejects are high for the 100% 23-year-old hybrid larch, in practice, these fibers would be returned to the digester and pulped further, and the fiber not lost.

mixtures containing Japanese larch will result in modest overcooking of the associated jack pine chips.

TABLE XII

PULPING DATA

Composition	Factor	Kappa No.	Unscreened Yield, % o.d. wood	Screened Yield, % o.d. wood	Screened Rejects, % o.d. wood
100% Jack pine	1850	34.4	43.8	43.2	0.6
	1450	49.2	47.1	46.2	0.9
25% Japanese larch	1925	35.3	43.3	42.8	0.5
	1350	53.4	45.0	43.5	1.5
100% Japanese larch	2000	32.5	45.7	43.5	2.2
	1350	55.7	48.3	43.2	5.1
25% Hybrid larch	1850	31.1	46.6	46.1	0.5
	1350	52.2	49.7	46.8	2.9
100% Hybrid larch	1850	34.6	48.5	47.1	1.4
	1200	53.4	51.8	41.5	10.3

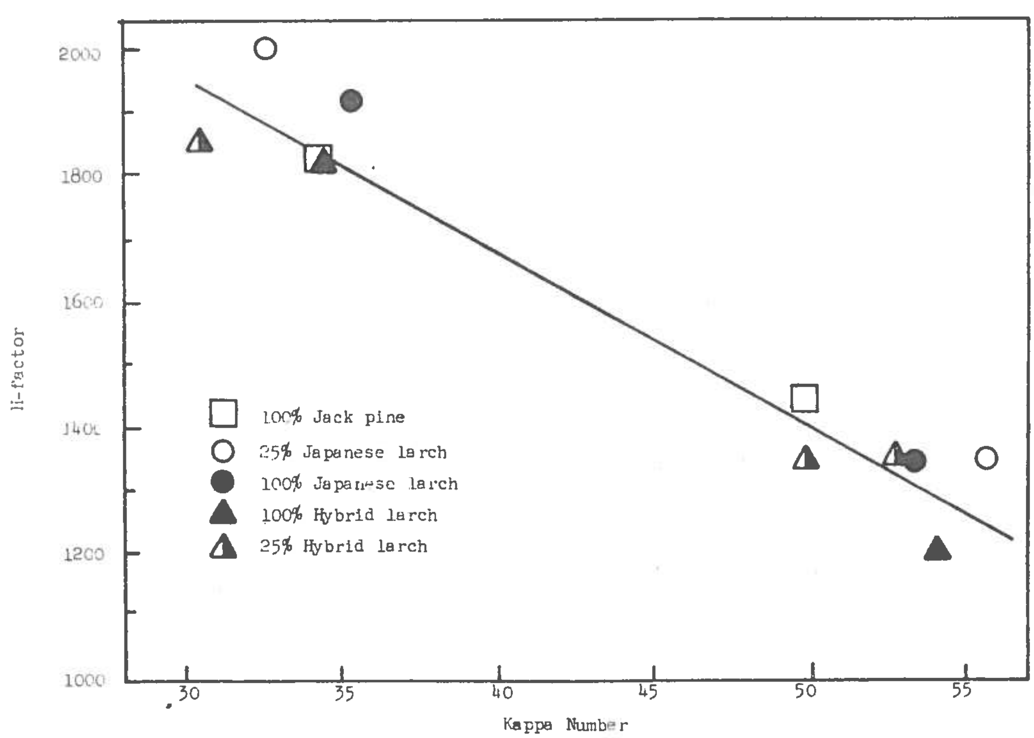

Figure 12. H-factor vs. kappa number.

Kappa 50 Pulp Strength

Table XIX of the Appendix summarizes the physical properties of unbleached kappa 50 pulps. Figures 13 through 16 illustrate several important strength property interrelationships. Figure 13 illustrates the amount of beating required to reach a given breaking length and demonstrates the differences which exist between the pulps in terms of maximum attainable breaking length. Japanese larch beats with more difficulty than jack pine but, in mixture with jack pine, beats at a rate similar to pure jack pine. Japanese larch, on the other hand, is easier to beat than hybrid larch. However, it did not have as high a tear as hybrid larch at the equivalent breaking length. This latter relationship is illustrated in Fig. 14.

Another useful way to compare pulps is to plot tear factor vs. breaking length. This approach assumes the pulps are beaten to improve breaking length and, with increased beating, there will be a tearing strength loss. The better pulps are those that attain good breaking length (9-11 km) and retain tear factor values of 120 or more. Figure 14 illustrates such a comparison for the pulps involved in this study and demonstrated Japanese larch had a tear vs. breaking length strength relationship that was comparable to the 100% jack pine pulp. Pulp strength data for 100% hybrid larch pulp and pulp that is 75% jack pine and 25% hybrid larch were also plotted in Fig. 14. Pulp containing hybrid larch fiber did not attain as high an overall breaking length but had a higher tear (9-10%) at comparable breaking length when compared with the Japanese larch pulp.

Plotting burst factor vs. breaking length (Fig. 15) and breaking length vs. apparent density (Fig. 16) demonstrated that the Japanese larch pulps behaved in a manner typical of most conifers. Interestingly, however, the pulps containing

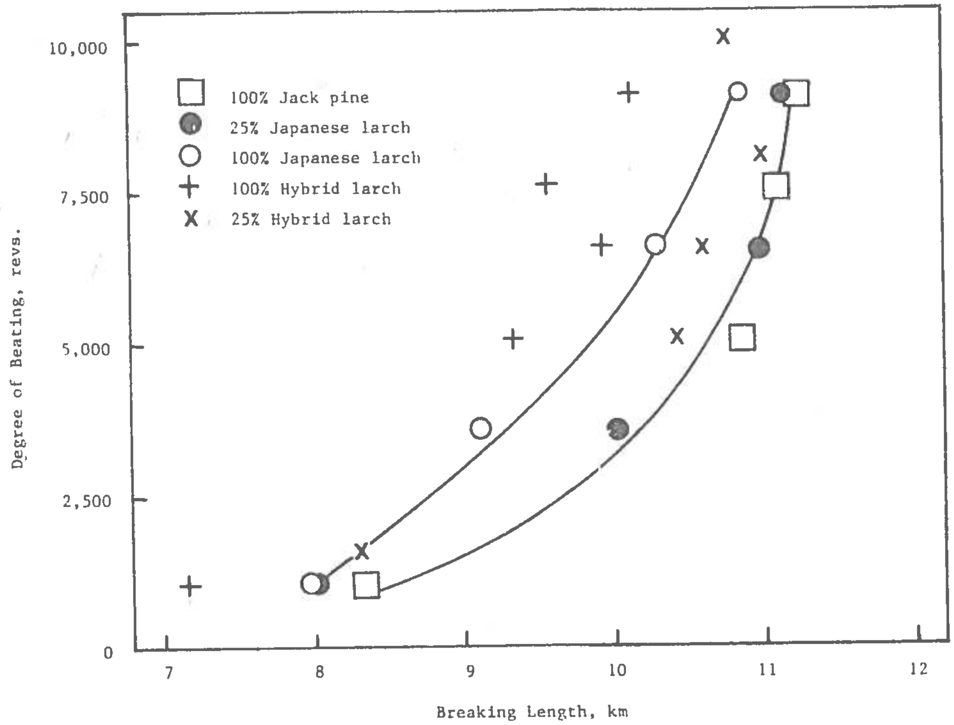

Figure 13. Degree of beating vs. breaking length at kappa 50. The curvilinear relationships illustrated are based upon Japanese larch and jack pine data only.

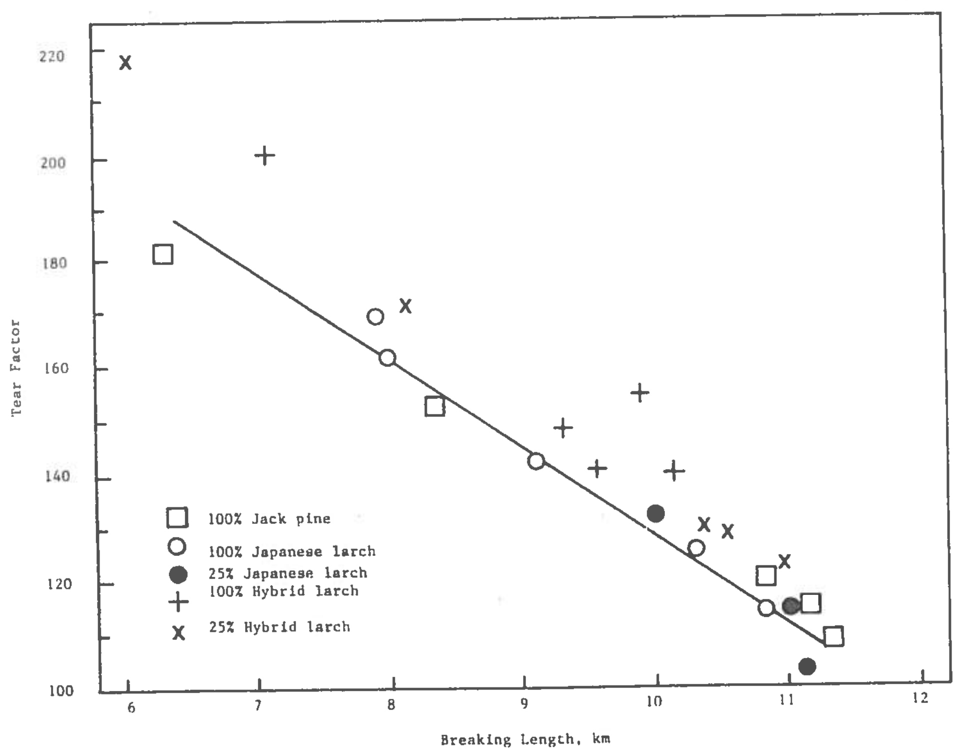

Figure 14. Tear factor vs. breaking length at kappa 50. The linear relationship illustrated is based upon Japanese larch and jack pine data only.

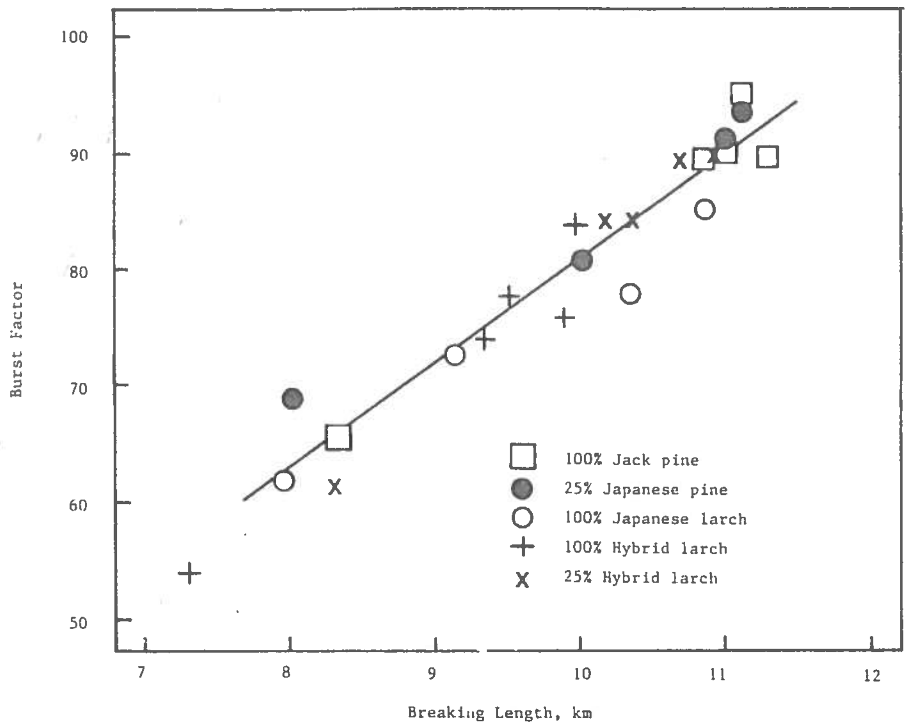

Figure 15. Burst factor vs. breaking length at kappa 50. The linear relationship illustrated is based upon Japanese larch and jack pine data only.

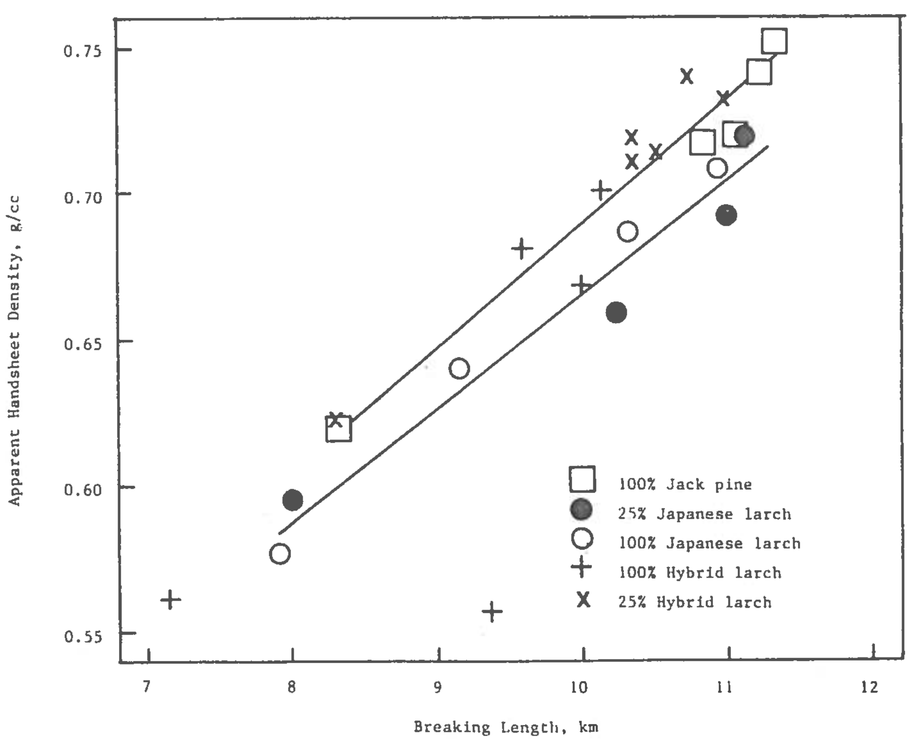

Figure 16. Apparent handsheet density vs. breaking length at kappa 50. The linear relationships illustrated are based upon jack pine and Japanese larch data only.

Japanese larch fiber appear, when sheet density is held constant, to have higher breaking length than the 100% jack pine pulps and the pulps containing hybrid larch fiber (Fig. 16). This, however, is a typical relationship. Conifer pulps having low tear normally would be expected to have above average breaking length.

Kappa 30 Bleaching Results

One papermaking concern, based upon remarks in the literature describing older-aged larch, was the difficulty encountered in bleaching larch pulps. This difficulty was attributed to high levels of hot-water extractives. The bleaching characteristics of kappa 30 Japanese larch pulps were investigated using the previously described CEDED bleaching procedure. This procedure was the same as that used previously (Progress Report One) with European larch and hybrid larch. Table XIII describes the results of the bleaching investigations and includes, for comparison purposes, data on jack pine, hybrid larch, and European larch. The bleached pulps were then evaluated for strength properties. Generally, the Japanese larch was more difficult to bleach, as illustrated by the lower brightness and higher chemical consumption when compared with jack pine, European larch, and hybrid larch.

Kappa 30 Pulp Strength Properties

The kappa 30 bleached pulps were evaluated using procedures similar to those used for the kappa 50 pulps. Appendix Table XX summarizes these evaluations, and Fig. 17 through 20 illustrate the strength properties graphically. The kappa 30 pulp reacted to beating in a similar manner and developed strength similar to the kappa 50 pulps. The principal exception was the development of breaking length. The kappa 30 pulps, as illustrated in Fig. 17, developed higher breaking length than the kappa 50 pulps. The bleached kappa 30 pulp regression lines for burst _vs_. breaking length (Fig. 19) and for handsheet density _vs_. breaking length were almost

TABLE XIII

BLEACHING RESULTS OF 30 KAPPA PULPS

Wood Type	Unbleached Kappa No.	Chlorination Stage (C_1) % Cl_2 Consumed on o.d. Pulp	Extraction Stage (E_1)		Chlorine Dioxide Stage (D_1) % ClO_2 Consumed on o.d. Pulp	Extraction Stage (E_2) End pH	Chlorine Dioxide Stage (O_2) % ClO_2 Consumed on o.d. Pulp	G.E. Brightness, %
			Permanganate No. (25 mL)	End pH				
100% Jack pine	34.4	7.0	5.2	12.0	1.20	10.5	0.40	90.3
100% Japanese larch	32.5	7.3	7.2	12.8	1.40	12.1	0.45	84.4
100% European larch	31.4	7.3	5.3	12.2	1.44	10.9	0.40	88.2
100% Hybrid larch	34.6	7.0	5.7	12.2	1.32	11.3	0.21	88.3
75% Jack pine + 25% Japanese larch	35.3	7.5	6.2	12.8	1.40	12.1	0.32	87.9
75% Jack pine + 25% hybrid larch	31.1	7.0	4.6	12.7	1.27	10.4	0.23	90.2

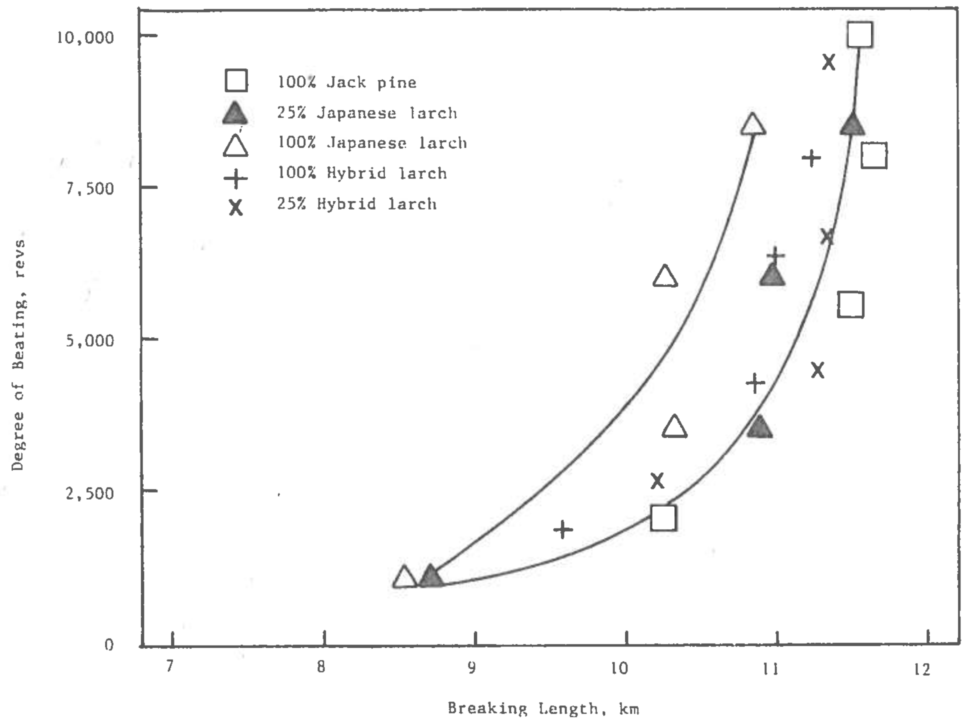

Figure 17. Degree of beating vs. breaking length at kappa 30. The curvilinear relationships illustrated are based upon Japanese larch and jack pine data only

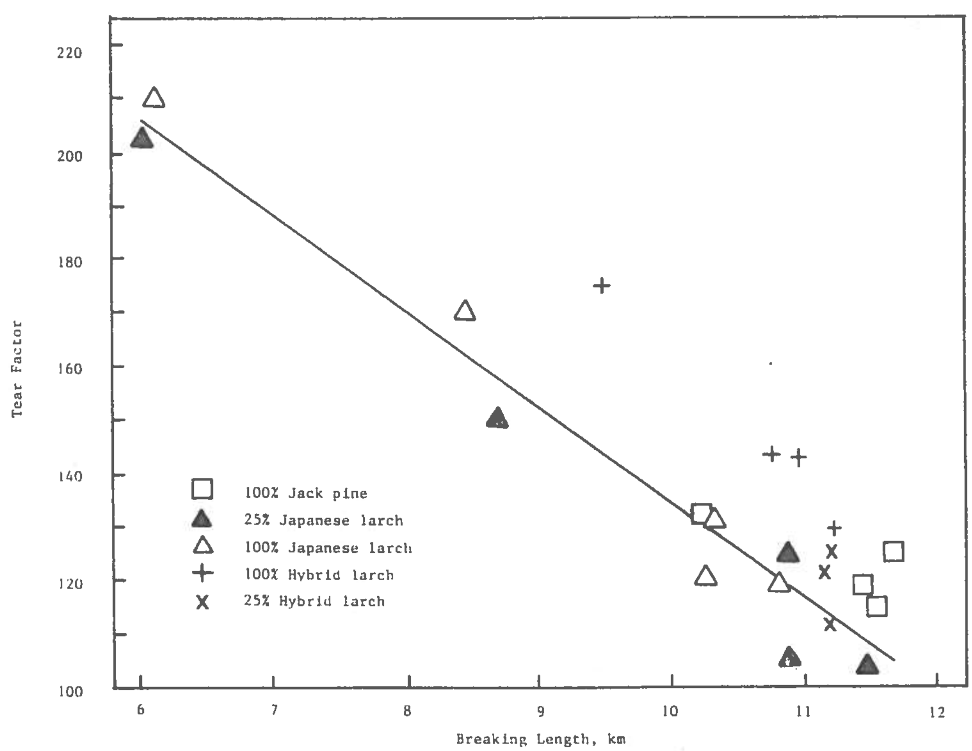

Figure 18. Tear factor vs. breaking length at 30 kappa. The linear relationship illustrated is based upon Japanese larch and jack pine data only.

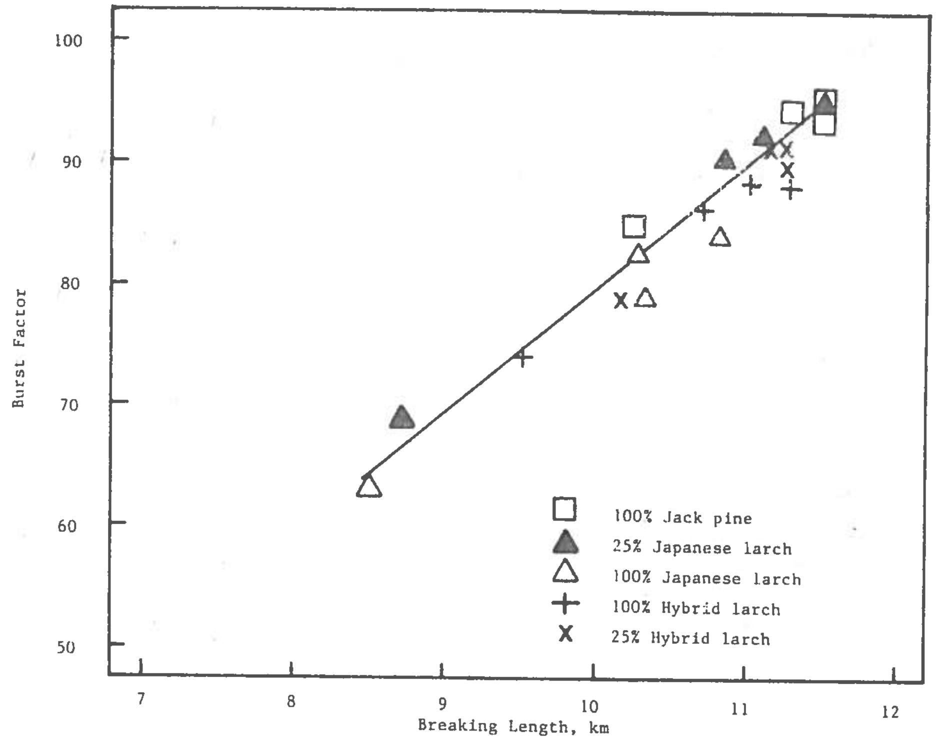

Figure 19. Burst factor vs. breaking length at kappa 30. The linear relationship illustrated is based upon Japanese larch and jack pine data only.

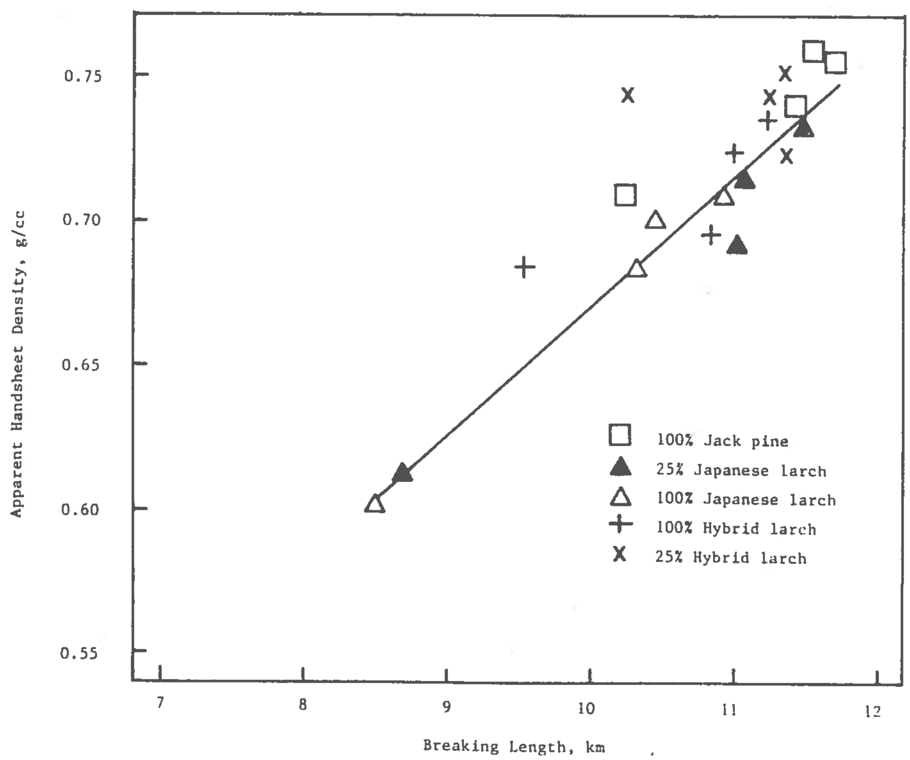

Figure 20. Apparent handsheet density vs. breaking length at kappa 30. The linear relationship illustrated is based upon Japanese larch and jack pine data only.

identical to the kappa 50 pulps regression lines. As was noted in the work with kappa 30 pulps containing hybrid larch and European larch fiber, the Japanese larch kappa 30 pulps also reacted to beating in a manner similar to the jack pine bleached pulp. This appears to have occurred because, when cooking to kappa 30 and bleaching, additional lignin was removed, and removing greater amounts of lignin reduced inherent differences between fiber sources. As a result, all sources reacted to refining in much the same way. Figures 17 through 20 confirm that the bleached kappa 30 pulps tended to respond to refining in a similar manner and have similar burst and breaking length and lower tearing strength than jack pine and hybrid larch kappa 30 pulps.

Strength Properties of Kappa 30 Bleached Conifer/Hardwood Pulp Mixtures

To evaluate the relative usefulness of the bleached kappa 30 pulps for improving the properties of bleached hardwood pulps, mixtures of 50% Japanese larch + 50% bleached hardwood and 50% (75% jack pine + 25% Japanese larch) + 50% bleached hardwood pulps were prepared. Appendix Table XX summarizes the results of these comparisons, and Fig. 21 through 24 illustrate the reaction of these pulp mixtures, in terms of strength properties, to refining. All of the bleached conifer/bleached hardwood mixtures responded in a similar manner as did the 100% conifer pulps. The 100% conifer pulps, however, had a considerably higher breaking length than did bleached conifer/bleached hardwood mixtures when compared at the same level of tear (Fig. 22). When burst factor was compared with breaking length (Fig. 23) and apparent handsheet density was plotted over breaking length, the 100% conifer pulps and the conifer/hardwood pulps could be described with a single linear regression equation. The 100% conifer had the highest breaking length values (Fig. 23 and 24).

Summary

Kappa 50 pulps for use as bag papers and kappa 30 pulps for bleached grade pulps were produced by pulping Japanese larch and jack pine control chips along with a 25% larch/75% jack pine mixture. Standard TAPPI methods were used in evaluating the pulps. The results were compared with those of earlier reported hybrid larch pulps and are summarized as follows:

1. The Japanese larch chip sources and the mixtures with jack pine cooked at a slightly slower rate than jack pine.

2. Unscreened Japanese larch yields were approximately 3% lower than hybrid larch and about 1% greater than jack pine.

3. Japanese larch wood chip alcohol-benzene extractive levels were equal, and hot-water extractives levels were more than double the levels in jack pine.

4. Japanese larch pulps had comparable fiber length, greater fiber width, and higher coarseness than jack pine pulps.

5. The kappa 50 pulps of Japanese larch were more difficult to beat and developed lower ultimate breaking length than the jack pine and the 25% larch/75% jack pine mixtures.

6. The kappa 50 pulps from Japanese larch and the mixtures with jack pine had tear comparable to jack pine but lower tear than the hybrid larch.

7. Japanese larch pulps were more difficult to bleach, i.e., attained lower brightness and required more chemical, than the jack pine and European and hybrid larch pulps.

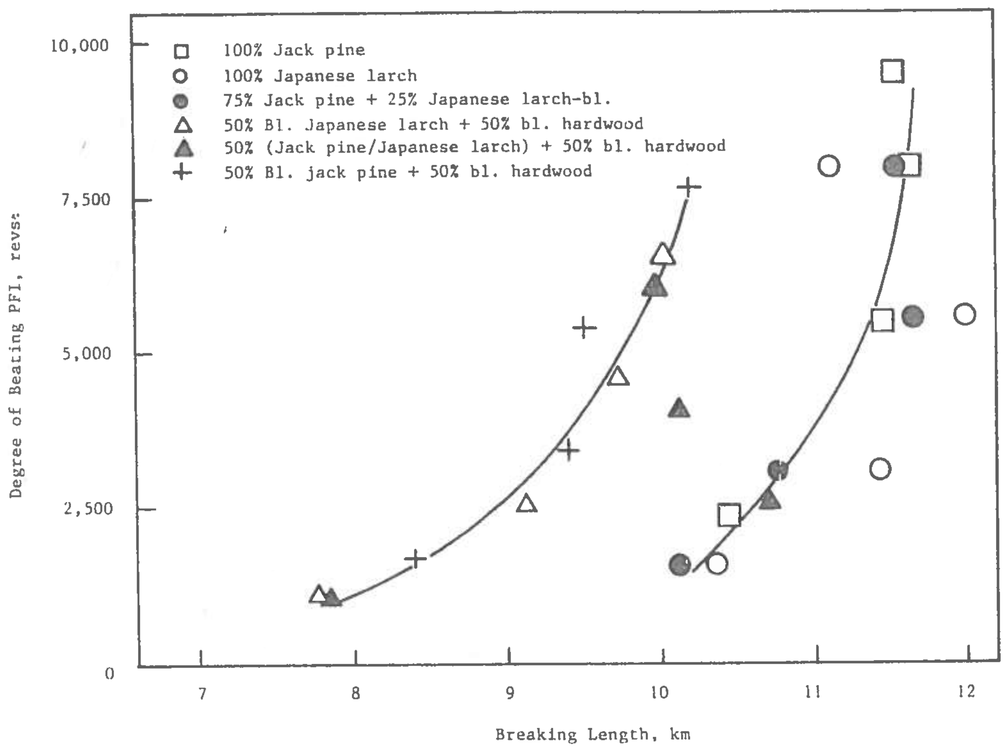

Figure 21. Degree of beating vs. breaking length.

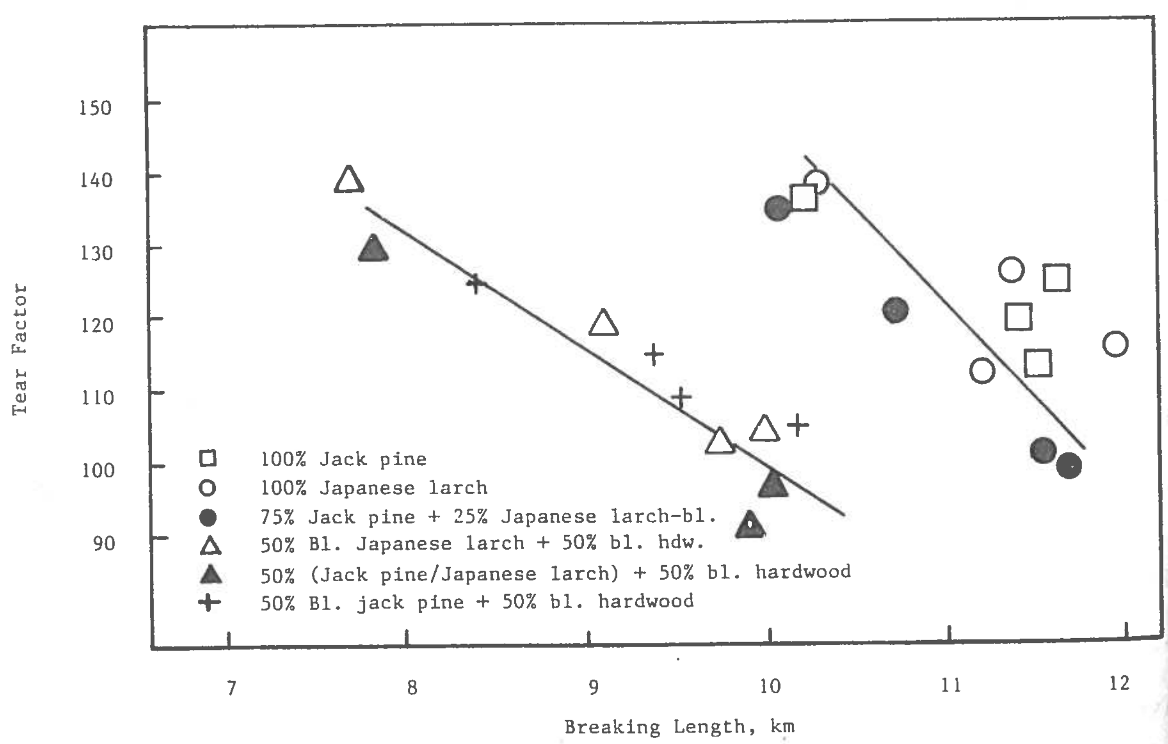

Figure 22. Tear factor vs. breaking length.

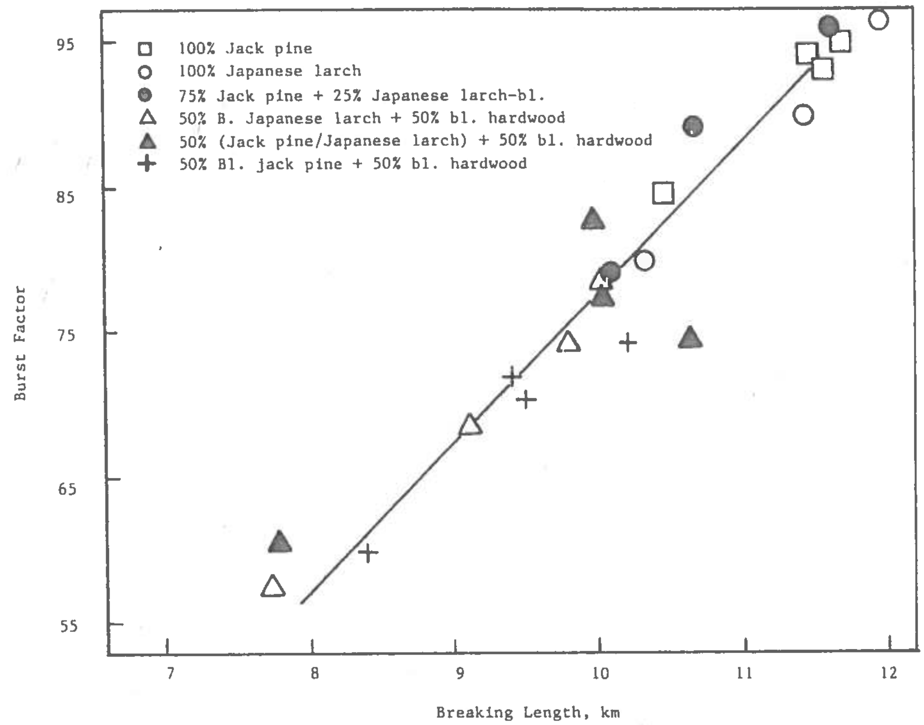

Figure 23. Burst factor vs. breaking length.

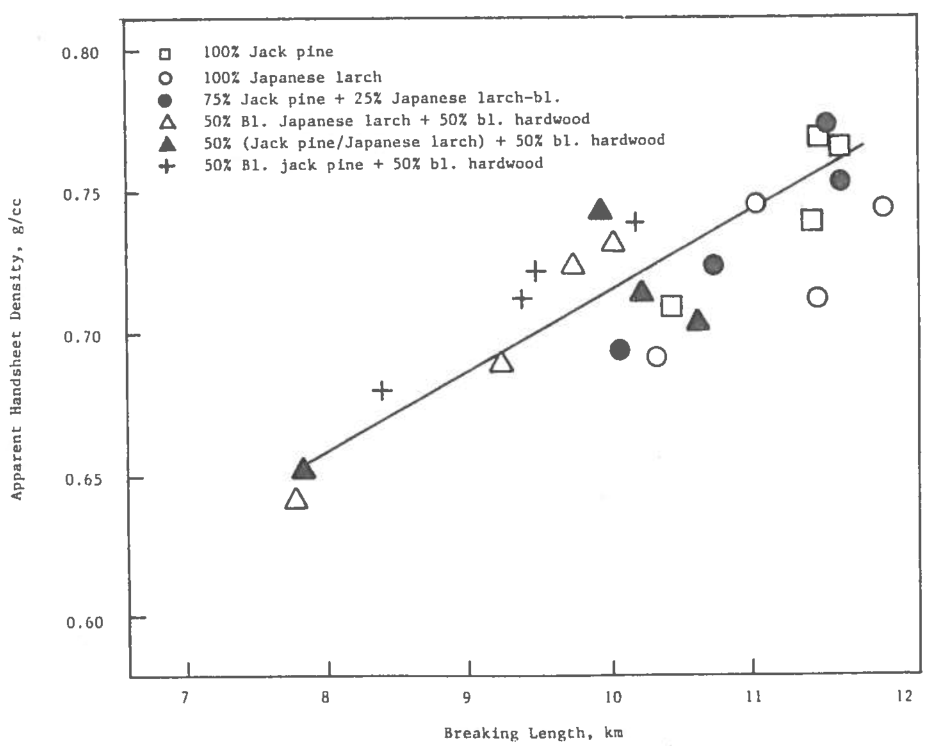

Figure 24. Handsheet density vs. breaking length.

8. Pulping Japanese larch and larch/jack pine mixtures to a kappa 30 followed by bleaching resulted in pulps that refined and had strength properties very similar to the jack pine control.

9. Bleached Japanese larch pulps and mixtures with jack pine gave strength properties that were equivalent to the unbleached properties.

10. When bleached Japanese larch and bleached larch/jack pine pulps were mixed with bleached hardwood pulps, the strength properties were comparable to the strength of pulps prepared from bleached jack pine/bleached hardwood pulp mixtures.