

UTILISATION OF POPLAR

REPORT NO. 3

EFFECTIVENESS OF PRESSURE TREATMENT

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Date: May 1976

Forest Products

Laboratory Report

Timber Drying No. FP/TD 39

Project: FP/TD 1

Sub-project: FP/TD1/3

Work Plan: FP/TD1/3/3

ODC 847.2:176.1 Populus spp.

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SUMMARY

Twelve 2.4 m long boards of 100 x 25 mm and twelve of 75 x 50 mm Populus deltoides from locally-grown trees were pressure treated to approximately C3 retention.

Segments of the length were tested

- (a) immediately after treatment
- (b) after one week's storage wrapped in plastic
- (c) after kiln drying at 70°C/60°C immediately after treatment
- (d) ditto at 40°C/35°C
- (e) air dried.

None of these treatments appeared to improve the pattern of preservative distribution and, although uptake and retention levels were generally at acceptable levels, the presence of dry unpenetrated patches in the majority of cross-sections demonstrated that a normal commercial pressure treatment cycle is not wholly satisfactory for the treatment of poplar.

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INTRODUCTION

This report is one of a series on various aspects of poplar utilisation designed to eventually cover sawing, grading, seasoning, preservative treatment and end use.

The present study was carried out to define the problem of obtaining complete penetration of preservative solution in sawn timber, following incomplete penetration found in an earlier investigation primarily concerned with kiln drying properties of the species (Williams, 1975). References to general utilisation of poplar will also be found in that report.

MATERIAL AND METHOD

Boards from an experimental 2.4 m long kiln charge of P. deltoides dried at 40°C/35°C i.e. on a low temperature schedule were pressure-treated with a proprietary water-borne multi-salt preservative solution in the larger treatment cylinder at the Institute.

Cycle used was:

- (i) vacuum, - 85 kPa, 30 minutes
- (ii) pressure 1379 kPa, 138 minutes
- (iii) vacuum, - 85 kPa, 69 minutes

with a treatment solution whose concentration was 1.91% (1.91 kg of salt per 100 litres of water), equivalent to 11.15 kg/m³ nett dry salt retention, and giving average overall solution uptake of 586 kg/m³ for 75 x 25 mm material and 594 kg/m³ for 100 x 25 mm (being 84% and 85% of theoretical maximum saturation respectively).

Immediately after treatment a 150 mm long cross-section was cut out of the centre of each length for analysis and a 15 mm x-section had dry patches marked. The two remaining halves of each board were then again subdivided into two halves giving four equal lengths per board. These were each given the board number, and an identifying letter A-D progressively down the board. All except C series were sealed on the ends. Allocation was:

Series	Allocated
A	Kiln dried 70/60°C
B	Low temp. dried 40/35°C
C	Stored in plastic one week
D	Air dried

From each sub-sample, at the conclusion of each of these periods, a 150 mm long piece was cut from one end and oven dried to provide some guide to moisture content, a second 150 mm length was dissected for analysis, and a 15 mm cross-section was examined for untreated zones.

Photographs of cross-sections were taken and analysis figures computed, providing details for five conditions, two wet and three dry.

RESULTS

The following photographs show series' cross-sections, untreated portions being marked in black.

The accompanying tables show retention levels for cross-section and "core" (the central one-ninth of the cross-section) taken as active elements expressed as a percentage of the dry wood substance.

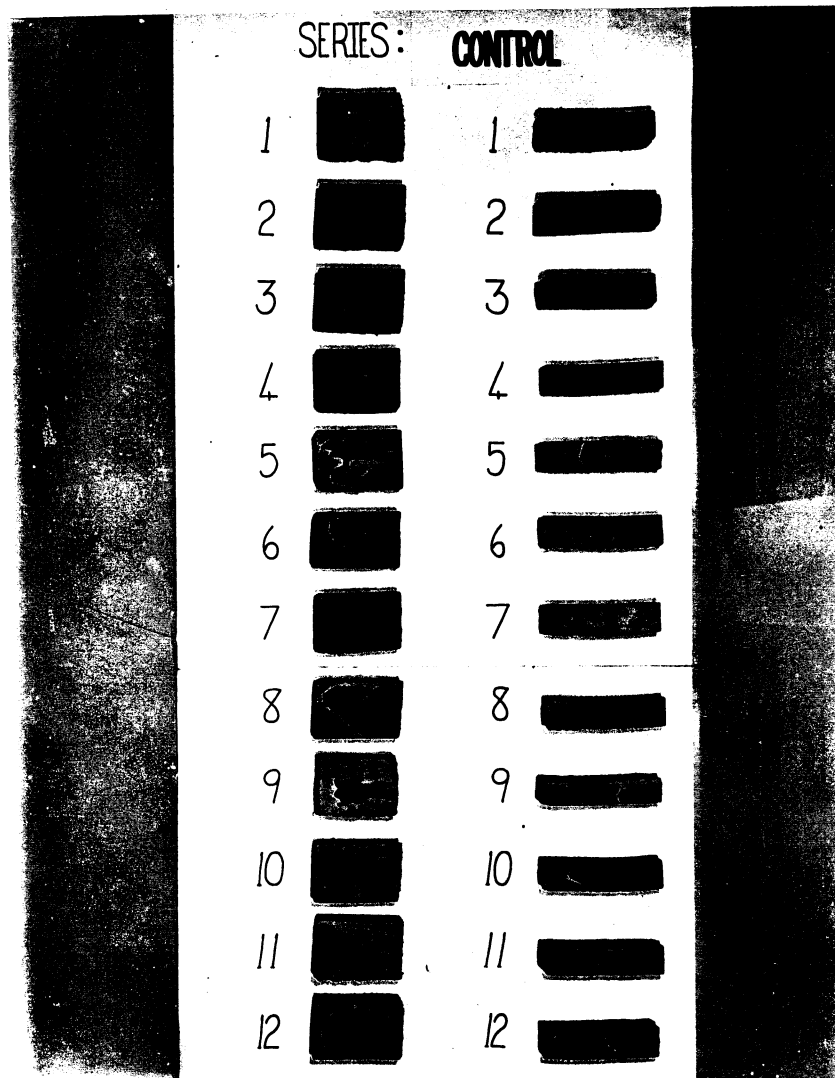


FIG. 1: CONTROL

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CONTROL

Size (mm) 100 x 25	X-SECT			CORE		
	Cu	Cr	As	Cu	Cr	As
1	0.32	0.37	0.56	0.32	0.35	0.51
2	0.41	0.42	0.61	0.40	0.47	0.78
3	0.46	0.47	0.80	0.47	0.38	0.85
4	0.38	0.42	0.51	0.44	0.47	0.83
5	0.37	0.48	0.65	0.36	0.41	0.67
6	0.36	0.40	0.66	0.23	0.26	0.39
7	0.40	0.44	0.68	0.47	0.43	0.80
8	0.32	0.36	0.52	0.48	0.41	0.76
9	0.41	0.44	0.76	0.43	0.45	0.83
10	0.27	0.32	0.42	0.10	0.15	0.19
11	0.48	0.42	0.69	0.33	0.37	0.59
12	0.33	0.41	0.63	0.30	0.35	0.50

75 x 50	Cu	Cr	As	Cu	Cr	As
1	0.33	0.37	0.63	0.46	0.39	0.80
2	0.35	0.35	0.56	0.41	0.35	0.54
3	0.40	0.44	0.74	0.44	0.46	0.76
4	0.29	0.34	0.48	0.28	0.30	0.47
5	0.25	0.30	0.33	0.24	0.25	0.32
6	0.33	0.36	0.54	0.36	0.29	0.57
7	0.40	0.41	0.69	0.45	0.44	0.84
8	0.24	0.31	0.39	0.20	0.19	0.24
9	0.22	0.30	0.33	0.18	0.16	0.30
10	0.31	0.34	0.50	0.47	0.44	0.67
11	0.40	0.48	0.74	0.48	0.47	0.76
12	0.31	0.38	0.56	0.42	0.47	0.78

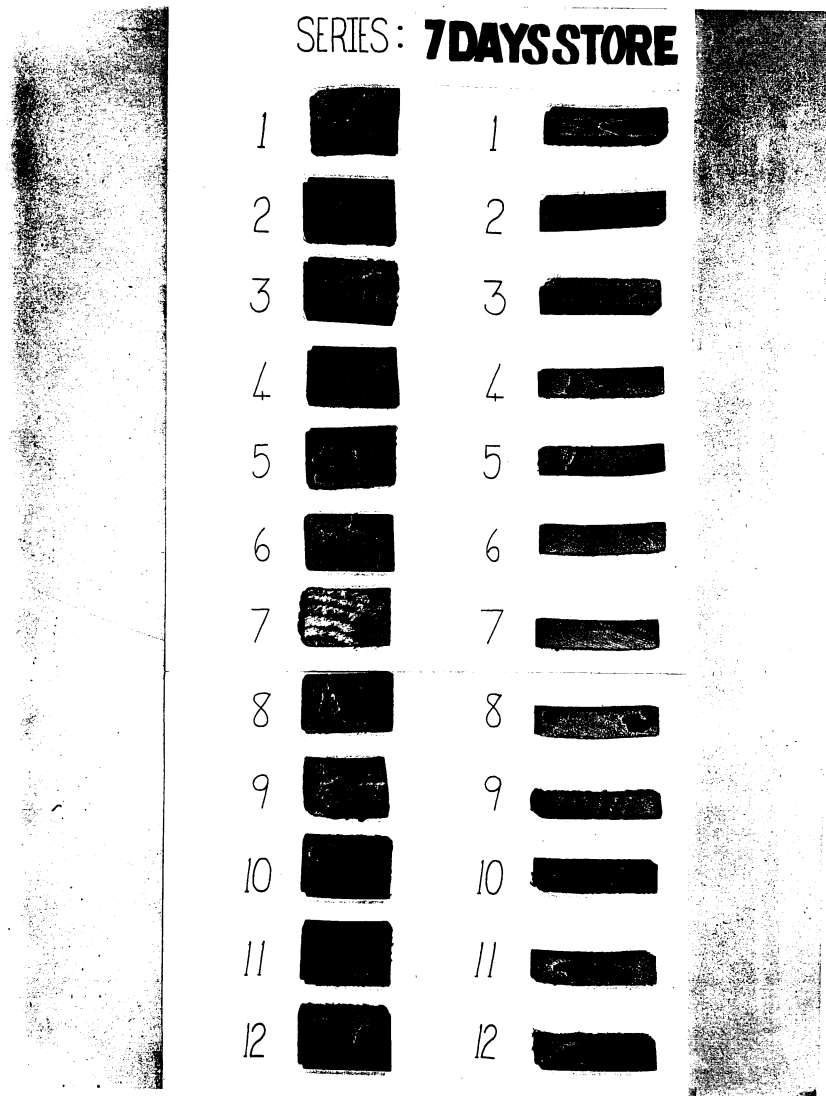


FIG. 2: AFTER 1 WEEK STORAGE
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AFTER STORAGE

Size (mm) 100 x 25	X-SECT			CORE		
	Cu	Cr	As	Cu	Cr	As
1	0.26	0.31	0.55	0.12	0.13	0.21
2	0.47	0.44	0.64	0.39	0.42	0.72
3	0.41	0.47	0.68	0.48	0.44	0.71
4	0.50	0.51	0.76	0.30	0.38	0.53
5	0.48	0.41	0.69	0.43	0.46	0.70
6	0.46	0.40	0.65	0.48	0.42	0.73
7	0.44	0.43	0.75	0.41	0.43	0.65
8	0.31	0.30	0.54	0.46	0.43	0.72
9	0.48	0.45	0.73	0.49	0.42	0.71
10	0.33	0.36	0.53	0.09	0.13	0.16
11	0.38	0.44	0.63	0.21	0.29	0.47
12	0.44	0.43	0.68	0.38	0.47	0.67

75 x 50	Cu	Cr	As	Cu	Cr	As
1	0.42	0.42	0.67	0.51	0.38	0.71
2	0.39	0.33	0.59	0.23	0.17	0.31
3	0.43	0.43	0.68	0.37	0.38	0.63
4	0.48	0.41	0.70	0.45	0.41	0.74
5	0.35	0.34	0.57	0.22	0.20	0.31
6	0.47	0.41	0.70	0.47	0.31	0.63
7	0.49	0.42	0.72	0.56	0.49	0.80
8	0.35	0.32	0.59	0.23	0.17	0.30
9	0.38	0.38	0.69	0.42	0.39	0.67
10	0.36	0.36	0.58	0.37	0.38	0.64
11	0.50	0.52	0.82	0.47	0.47	0.90
12	0.36	0.36	0.62	0.33	0.22	0.44

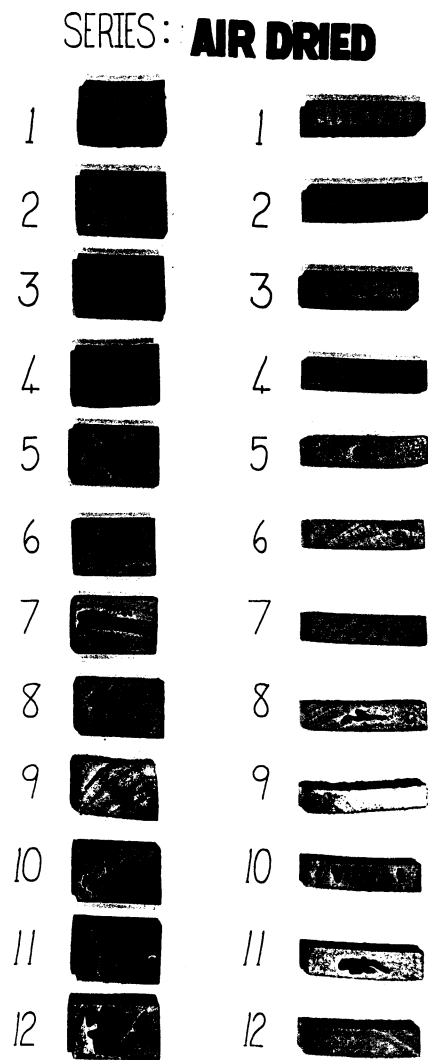


FIG. 3: AIR DRIED
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AIR DRIED

Size (mm) 100 x 25	X-SECT			CORE		
	Cu	Cr	As	Cu	Cr	As
1	0.45	0.38	0.66	0.37	0.30	0.54
2	0.46	0.44	0.82	0.45	0.39	0.69
3	0.42	0.43	0.74	0.43	0.36	0.68
4	0.42	0.41	0.74	0.49	0.39	0.69
5	0.40	0.42	0.70	0.38	0.35	0.59
6	0.41	0.43	0.72	0.46	0.39	0.75
7	0.45	0.44	0.72	0.38	0.34	0.60
8	0.45	0.40	0.69	0.22	0.26	0.38
9	0.45	0.38	0.65	0.33	0.32	0.50
10	0.37	0.35	0.60	0.30	0.29	0.45
11	0.38	0.33	0.64	0.35	0.30	0.52
12	0.53	0.47	0.80	0.46	0.30	0.60

75 x 50	Cu	Cr	As	Cu	Cr	As
1	0.39	0.34	0.59	0.39	0.30	0.60
2	0.38	0.38	0.69	0.27	0.29	0.49
3	0.47	0.42	0.74	0.52	0.44	0.78
4	0.44	0.37	0.63	0.40	0.34	0.60
5	0.35	0.34	0.55	0.06	0.05	0.08
6	0.49	0.39	0.72	0.50	0.35	0.68
7	0.28	0.29	0.46	0.43	0.34	0.57
8	0.41	0.43	0.69	0.39	0.25	0.42
9	0.40	0.42	0.69	0.38	0.33	0.58
10	0.34	0.35	0.62	0.19	0.16	0.30
11	0.51	0.49	0.72	0.47	0.41	0.73
12	0.32	0.29	0.55	0.08	0.07	0.11

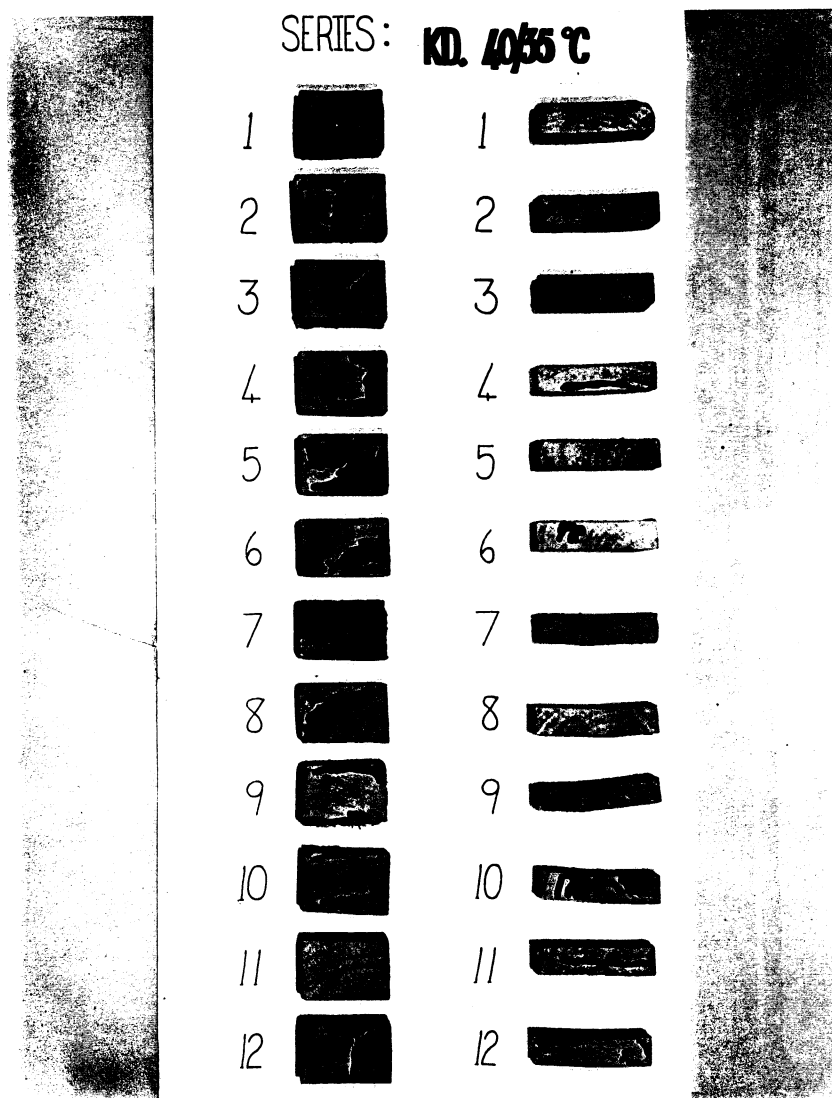


FIG. 4: KILN DRIED 40/35°C
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KILN DRIED 40/35°C

Size (mm) 100 x 25	X-SECT			CORE		
	Cu	Cr	As	Cu	Cr	As
1	0.42	0.35	0.58	0.38	0.36	0.61
2	0.50	0.44	0.83	0.38	0.31	0.60
3	0.49	0.45	0.74	0.42	0.39	0.73
4	0.42	0.41	0.73	0.29	0.28	0.46
5	0.49	0.51	0.83	0.43	0.41	0.68
6	0.38	0.38	0.64	0.32	0.28	0.51
7	0.50	0.46	0.73	0.41	0.38	0.61
8	0.49	0.41	0.73	0.37	0.37	0.64
9	0.50	0.45	0.77	0.48	0.40	0.76
10	0.30	0.29	0.47	0.25	0.25	0.42
11	0.48	0.41	0.68	0.26	0.21	0.42
12	0.40	0.39	0.72	0.48	0.40	0.71

75 x 50	Cu	Cr	As	Cu	Cr	As
1	0.41	0.36	0.69	0.48	0.37	0.70
2	0.27	0.32	0.55	0.10	0.10	0.22
3	0.51	0.44	0.76	0.46	0.44	0.74
4	0.38	0.35	0.60	0.30	0.48	0.63
5	0.26	0.24	0.35	0.17	0.16	0.23
6	0.39	0.30	0.57	0.43	0.37	0.63
7	0.51	0.44	0.72	0.56	0.43	0.82
8	0.43	0.34	0.65	0.40	0.40	0.67
9	0.32	0.32	0.54	0.37	0.36	0.59
10	0.41	0.38	0.69	0.37	0.45	0.62
11	0.40	0.47	0.72	0.44	0.45	0.73
12	0.34	0.32	0.60	0.41	0.43	0.68

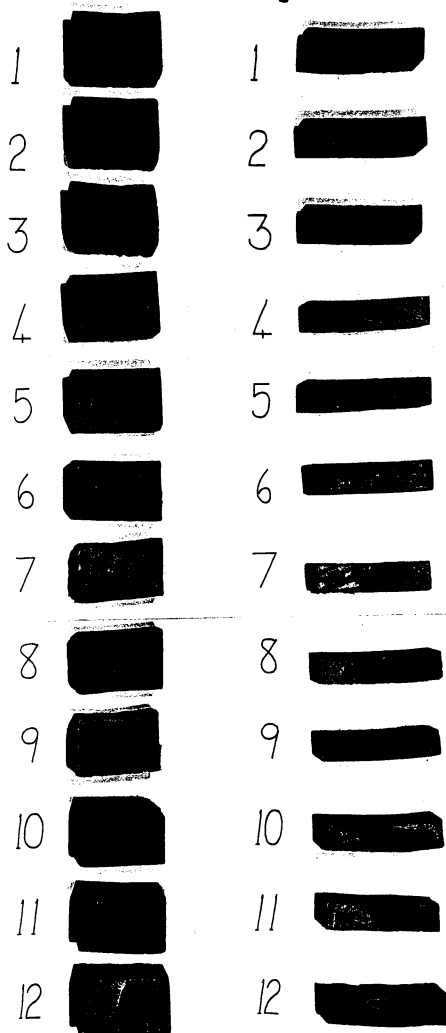
SERIES: **K.D. 70/60°C**

FIG. 5: KILN DRIED 70/60°C
NEG. 32468

KILN DRIED 70/60°C

Size (mm) 100 x 25	X-SECT			CORE		
	Cu	Cr	As	Cu	Cr	As
1	0.19	0.18	0.28	0.39	0.38	0.58
2	0.28	0.30	0.46	0.40	0.40	0.60
3	0.37	0.33	0.53	0.44	0.40	0.71
4	0.26	0.25	0.39	0.41	0.38	0.63
5	0.44	0.38	0.60	0.47	0.45	0.75
6	0.43	0.38	0.61	0.45	0.39	0.65
7	0.35	0.30	0.54	0.43	0.43	0.70
8	0.22	0.19	0.36	0.47	0.40	0.67
9	0.49	0.47	0.68	0.59	0.55	0.87
10	0.05	0.09	0.12	0.38	0.34	0.47
11	0.34	0.37	0.36	0.46	0.43	0.64
12	0.42	0.39	0.67	0.43	0.38	0.54

75 x 50	Cu	Cr	As	Cu	Cr	As
1	0.45	0.47	0.72	0.48	0.45	0.68
2	0.42	0.45	0.72	0.53	0.40	0.68
3	0.51	0.47	0.75	0.57	0.44	0.78
4	0.40	0.41	0.63	0.48	0.40	0.56
5	0.25	0.27	0.35	0.03	0.04	0.04
6	0.40	0.39	0.63	0.46	0.32	0.51
7	0.51	0.47	0.66	0.42	0.44	0.69
8	0.48	0.45	0.73	0.53	0.32	0.57
9	0.38	0.35	0.52	0.36	0.31	0.45
10	0.42	0.38	0.61	0.54	0.38	0.66
11	0.48	0.44	0.72	0.55	0.43	0.74
12	0.40	0.36	0.57	0.20	0.15	0.24

DISCUSSION

Some indication of size effect on uptake of preservative solution may be gained from the fact that average treated moisture contents for the four series taken from different areas of the twelve boards of 100 x 25 mm was 166.1%, that for a similar number of samples of 75 x 50 mm being 151.9%.

Preservative retention levels may be expressed in one of three ways - as active chemical elements expressed as a percentage of dry weight of wood, as the retention of commercial dry salt expressed as for elements, or as retention in kilograms of preservative salt per cubic metre of wood (kg/m^3).

Chemical analysis is done on the basis of the first of these. At the preservative level used here TPA regulations (1969 et seq.) for the "retention zone" are:

C3

8.3 Retention Zone - The main retention zone requirement is for a minimum total active element loading of 0.66% of oven dry wood weight. In addition minimum elemental loadings are:

Cu 0.13% of oven dry wood weight
 Cr 0.17% of oven dry wood weight
 As 0.20% of oven dry wood weight

- a clause that ensures an adequate preservative loading with certain minimum levels for copper, chrome and arsenic to ensure imbalance does not adversely affect effectiveness.

For the purposes of this experiment only, the retention zone may be regarded as either cross-section or core, in that the ideal is complete preservative penetration.

On this basis, number of samples rejected would be:-

Series	Size			
	75 x 100 mm		100 x 25 mm	
	No. of Rejects (out of 12 samples)			
	X-Sect	Core	X-Sect	Core
Control	-	1	-	1
Stored	-	-	-	2
A/D	-	1	-	-
KD 40/35°C	-	2	-	-
KD 70/60°C	-	2	1	-

which, by comparison with Figs. 1-5, could perhaps be regarded as an incomplete assessment.

The test of whether post-treatment variables have materially affected preservative distribution is in the comparison between core and cross-section.

Averages for these are:-

Series	Size					
	75 x 100 mm			100 x 25 mm		
	Nett Dry Commercial Salt Retention %					
	X-Sect	Core	Diff	X-Sect	Core	Diff.
Control	2.76	2.93	+0.17	3.18	3.10	-0.08
Stored 1 week	3.30	2.94	-0.36	3.32	2.93	-0.39
A/D	3.17	2.47	-0.70	3.48	2.92	-0.56
KD 40/35°C	3.06	3.03	-0.03	3.52	2.93	-0.59
KD 70/60°C	3.30	2.97	-0.33	2.45	3.38	+0.93

Cross-sectional retentions cannot increase after treatment and it follows that variations between series represent average within-board variations.

From the above Table it may also be seen that there is no evidence that any storage or drying treatment has improved preservative distribution, in spite of the anomalous increase in core retention of the last series of 100 x 25 mm.

It was not anticipated that any improvement would take place. This is not a diffusion situation which depends upon capillary flow in a saturated or near-saturated medium, but a pressure process forcing preservative solution into dry timber. The fact that some areas remain unpenetrated under the cycle quoted here indicates the impermeability of the timber and the unlikelihood of any further ingress when the pressure is released. Variations in results here are due to irregular zonal responses to the treatment cycle, not to chemical re-location.

Although poplar is low in density and extractive content, there is no a priori reason why a pressure treatment regime laid down for the preservative treatment of radiata pine and other permeable timbers should be suitable for this hardwood.

However, it is a normal part of the investigation process to use a known, defined technique as a control and to proceed from there to apply any adaptation required to produce the required response.

In the case of preservative treatment, specifications are laid down by the Timber Preservation Authority (op. cit.). At the treatment level tested here (C3, for posts and sawn timbers in contact with the ground) poplar is approved by the Authority for rounds, part rounds and sawn timber while the "penetration required" is given as minimum penetration:

P4	All approved species	Rounds	10 mm or 75 percent of sapwood depth whichever is the greater.
		Part rounds	As above with 10 mm in exposed heartwood . Where heartwood is exposed and is less than one-third of the original diameter - no penetration is required in heartwood.
		Sawn timbers	Complete sapwood penetration and not less than 10 mm envelope.

for the process described as:-

"Bethell (Full Cell) Vacuum Pressure Process - P.4.

As the name implies, a pressure impregnation plant must be used for this method. Such a plant comprises a cylinder into which the timber is usually moved on bogies, tanks for mixing and storing the preservative solution, vacuum and pressure pumps with attendant control valves and pipes.

The timber to be treated is placed in the pressure vessel and a vacuum of at least minus 85 kPa is applied to remove a substantial proportion of the air from the wood cells. This vacuum is maintained while the treating solution is flooded into the cylinder, and the system is then subjected to hydraulic pressure in the region of 1 400 kilopascals.

Deep penetration is obtained in the sapwood of most New Zealand grown timbers, but some difficulties have been experienced at times, with the sapwood of Douglas fir, larch, and macrocarpa. These latter species can usually be treated to meet the requirements of commodity C8, by extending the pressure period.

The heartwood of most species of timber cannot be penetrated sufficiently deeply to give long-term protection if the timber is exposed to ground contact or conditions where the decay hazard is high. For these latter conditions, pinus timber should be used and the requirements for heartwood penetration are clearly set out in the relevant commodity specification.

As this method shows the quantity of timber to be accurately determined, and a measured volume of solution of known concentration is injected into the timber, the Bethell process is generally regarded as the most easily controlled method of treatment."

Examination of photographs of specimens (Figs. 1-5) will show that a substantial number of cross-sections would not meet these requirements, that penetration is patchy and haphazard, that untreated portions are often relatively close to one surface and that, because of this, analysis figures may be misleading, though accurate in themselves.

Analysis survey is done upon cross-section and upon the central one-ninth of the cross-section. High retentions in some zones of the cross-section may ensure an adequate average figure, while if the untreated zones do not happen to fall within the central one-ninth, analysis of the zone may well show a retention as high, or higher, than that of the cross-section.

Presumably specifications are laid down with the unwritten proviso that the product will be treated in its final form and not recut thereafter, and this may well be so for posts or half rounds where, particularly in softwood species, end penetration of high concentrations of preservative ensures some degree of protection on exposure.

For sawn timber, no such assumption can be made and, while heartwood of some softwoods may have a certain natural durability, no such claim can be made for poplar, a timber noted for its susceptibility to stain and decay in its untreated form. Hence, recutting of sawn poplar of timber after pressure treatment may well expose substantial untreated areas of the cross-section.

In addition, as may be seen from Fig. 6, end penetration cannot be relied upon too heavily. These specimens, 0.5 m long and with unsealed ends, were cut into 10 equal portions each some 5 cm long to show the progression of the untreated zone, and it may be seen that even 5 cm from the end substantial untreated portions occur.

Anatomically it is perhaps surprising that poplar should be semi-impermeable in the dry state. Although vessels are small, the species is diffuse porous and hence vessels are well distributed; perforation plates are simple; rays abundant; there is no evidence of tyloses; tension wood or black heart appears no less impermeable than normal wood; some photo-micrographs will be found at the end of the report (Figs 7-9).

Drying rates from green show the species to be amongst the more permeable of the hardwoods (100 x 25 mm material averaged 2.6 days to reach 15% moisture content, 75 x 50 mm 6.4 days at 70°/60°C in a small experimental charge (Williams, 1975)).

Nevertheless the fact remains that post-drying impenetrability is demonstrated by the presence of dry zones following pressure-treatment and it must be concluded that the passages of flow are either interrupted or occluded as part of a physical response to the drying process. Photo-micrographs of various portions after treatment show whether that portion is treated or untreated, not necessarily why it is treated or untreated. Further work on anatomy, fibre penetration by solutions, directional permeability and screening effects is recommended.

This study has shown that poplar may not be totally penetrated under the normal pine treating schedule. Further investigations into e.g. steaming prior to treatment, the use of extra-high pressure in the treating cylinder, extending the treating time, etc., will supply a remedy for this.

That the problem is at least known overseas may be seen by an extract from a report on properties and utilisation of Canadian poplars (Irwin and Doyle, 1961):

PRESERVATIVE TREATMENT

In conditions favouring decay, poplar shows little resistance to deterioration. For such conditions some form of preservative treatment is necessary to secure moderate service life, otherwise poplar in its natural condition will last a very short time.

Poplar sapwood receives preservatives satisfactorily by means of pressure or diffusion treatments. On the other hand, poplar heartwood receives preservative in an unsatisfactory manner. Penetration is patchy, some areas being so impermeable as to receive no preservative. This distinction in treating behaviour means that, for practical purposes, round timber (since it is encircled by sapwood) treats satisfactorily, while squared or sawn stock (from a large part of which the sapwood has probably been removed) receives patchy and unsatisfactory penetration. Thus for use under decay hazard, poplar in the round should be used to take advantage of its good sapwood penetration characteristics."

Some discussion on the above is warranted. Certainly there can be little argument that poplar has a low natural durability even though specific trials have not been carried out, and that preservative treatment is essential.

It would, however, be a mistake to assume that the lighter-coloured portions of the cross-section are sapwood. The presence of a coloured central zone of bacterially-infected heartwood creates an "artificial" heart/sap boundary, whereas the true sapwood is undifferentiated and often only 25 mm thick. It may sometimes be detected by the naked eye on freshly-cut pieces and, while the outer portions of the tree certainly appear to be more treatable than central zones, this is by no means always the case, as may be seen in Fig. 6.

Recommending the use of poplar in the round this shows a lack of awareness of the realities of pressure treatment of this species as well as ignoring the well-known tendency of posts and poles to form deep and extensive surface checking which would expose untreated sub-surface zones in service. There are, of course, other reasons why poplar species may prove unsuitable for the roundwood market - low strength, poor nail or staple holding ability, etc.

However, from a utilisation point of view other forms of preservative treatment may be preferable to attempted pressure treatment and may influence end use. Boron diffusion is one obvious possibility and this will be investigated in a future study.

ACKNOWLEDGEMENTS

D.H. Revell for supply of sawn material, L.C. Carter for preservative treatment, N.H.C. Cummins and staff for preservative analysis.

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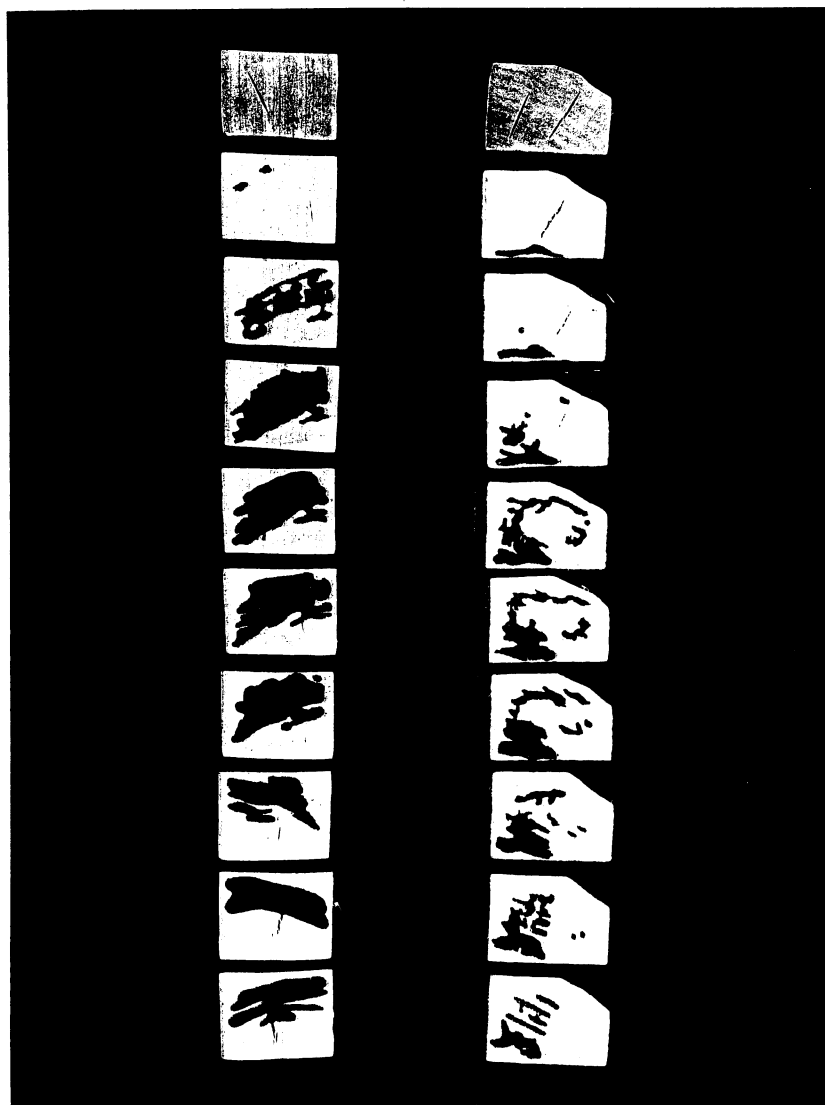


FIG. 6: 0.5 M LENGTHS OF BLANK, UNSEALED KILN SAMPLES
DISSECTED AT 50 MM INTERVALS

NEG. 32469

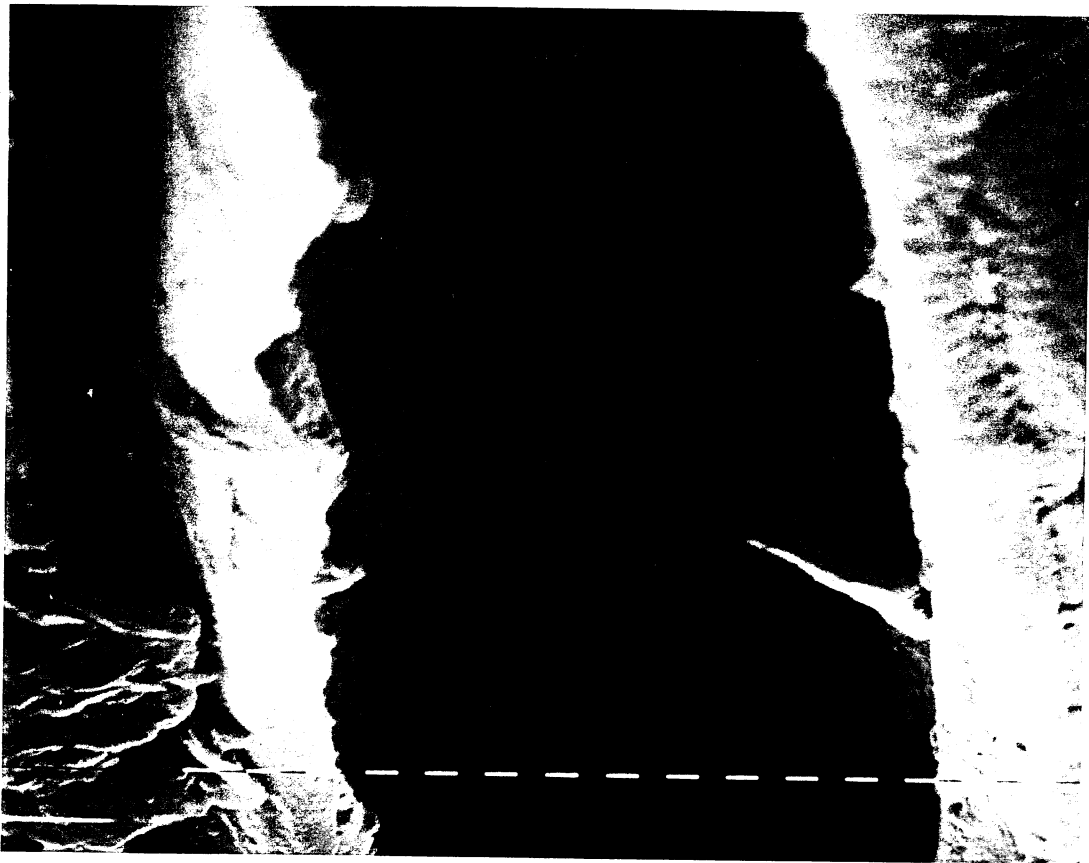


FIG. 7: PRESERVATIVE LAYER ON FIBRE WALL (X5200)

NEG. 115/10

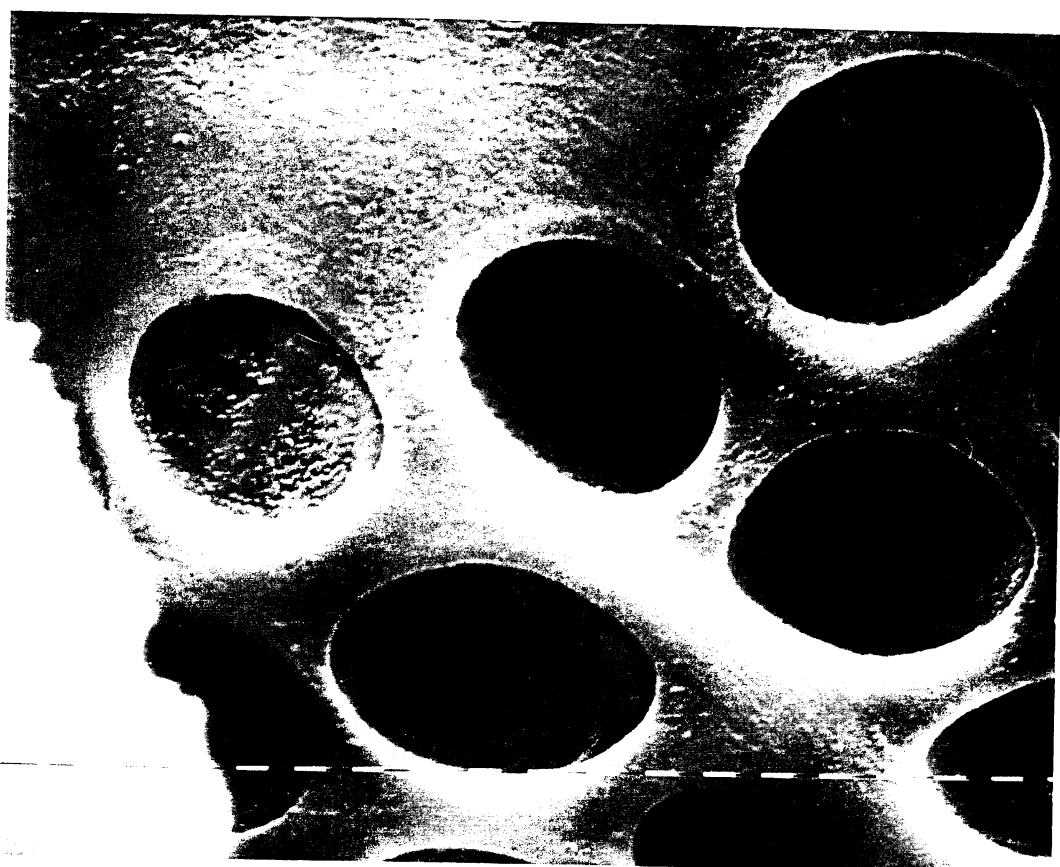


FIG. 8: OCCLUSION OF VESSEL/RAY PITS (X3800)

NEG. 117/20

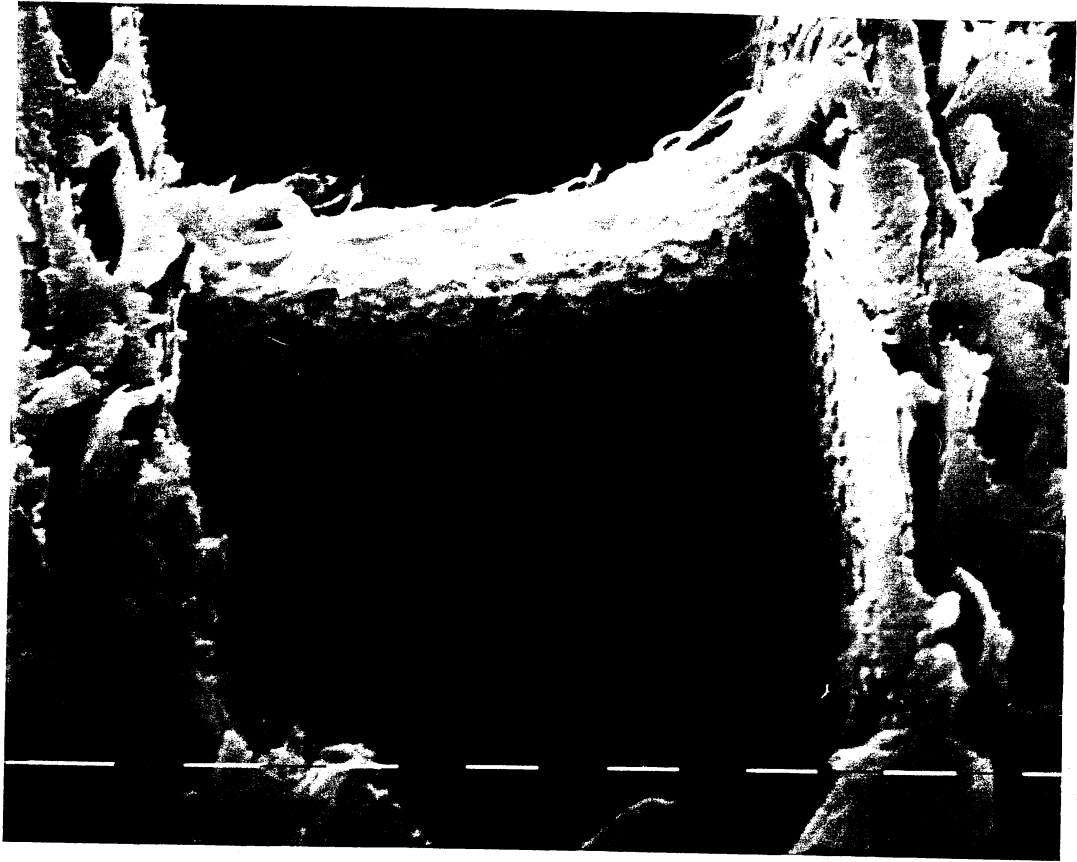


FIG. 9: PRESERVATIVE COATING ON VESSEL WALLS (X950)

NEG. 117/24