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PRESERVATIVE TREATMENT OF POPLAR WOOD FROM CHINA

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ABSTRACT*

Sawn timber and roundwood of fifteen poplar trees from Linyi County in China were preservative treated using several diffusion and pressure treatment systems. Dip diffusion treatments of sawn timber with saturated boron solutions have good results in six to eight weeks, depending on the temperature in the diffusion area. Similar treatments with roundwood were not satisfactory because insufficient preservative was retained on the very smooth surface. Hot and cold bath treatment of partly dry roundwood with boron, followed by three weeks in diffusion stack, gave satisfactory treatment results. Pressure/diffusion treatment of the same material was also successful. Double diffusion treatment with boron and copper, using momentary dips to apply the preservatives, gave inadequate copper retention and penetration. Air drying followed by pressure treatment with copper-chrome-arsenate preservative resulted in variable, patchy penetration, similar to that observed in poplar timber from other sources.

* Note: This material is unpublished and must not be cited as a literature reference.

Preservative Treatment of Poplar Wood from China.

Summary

Fifteen plantation grown poplar trees from Linyi County in China were cut into sawn timber and small roundwood for preservative treatment tests.

Eight sets of 50mm thick sawn timber samples were treated using dip/diffusion and boron. These compared the effects of different solution strengths, dipping times and diffusion temperatures. Dipping times did not greatly affect treatment results. The sawn timber samples dipped in 18% solution and stacked inside during diffusion were relatively well treated within six weeks. The samples dipped in 18% solution and stacked outside took eight weeks to reach a similar standard of preservative penetration. Samples treated with a 12% solution did not reach the required treatment standard because preservative uptake was inadequate.

One set of freshly sawn timber samples was pressure treated with a 2% boron solution and after four weeks diffusion was more than adequately treated.

A final set of sawn timber was air dried and pressure treated with copper-chrome arsenate preservative using a full-cell process. Preservative uptake was similar to that expected with radiata pine but penetration was patchy, particularly near the heartwood. This pattern of preservative penetration has been observed in poplar from other sources.

Two sets of roundwood samples were dip/diffusion treated with boron, one set as they were when they were removed from the shipping container and the other set resaturated with water, to duplicate freshly sawn produce. Preservative uptake on these was inadequate to give reasonable treatment results, even after a second dip in preservative solution. This was largely influenced by the smooth surface of the debarked logs which retained very little preservative when the wood was removed from the bath.

One set of roundwood was pressure treated and another treated using the hot and cold bath system with boron. Both were placed in diffusion stack for a short period and were very well treated.

A fifth set of roundwood was pressure treated with CCA preservative after air drying. As with the sawn timber, preservative uptake was adequate but penetration was patchy. In this case, part of the penetration problem was caused by small amounts of inner bark left on the logs after debarking.

Generally, the material treated reasonably easily using both diffusion and pressure processes. Successful diffusion treatment will only occur if adequate preservative is retained on the surface. Pressure treatment will give variable results and may not be satisfactory for commodities to be used in situations where there is a high decay hazard.

PRESERVATIVE TREATMENT OF POPLAR WOOD FROM CHINA.

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ABSTRACT

Sawn timber and roundwood of fifteen Poplar trees from Linyi County in China were preservative treated using several diffusion and pressure treatment systems. Dip diffusion treatments of sawn timber with saturated boron solutions gave good results in six to eight weeks, depending on the temperature in the diffusion area. Similar treatments with roundwood were not satisfactory because insufficient preservative was retained on the very smooth surface. Hot and cold bath treatment of partly dry roundwood with boron, followed by three weeks in diffusion stack, gave satisfactory treatment results. Pressure/diffusion treatment of the same material was also successful. Double diffusion treatment with boron and copper, using momentary dips to apply the preservatives, gave inadequate copper retention and penetration. Air drying followed by pressure treatment with copper-chrome-arsenate preservative resulted in variable, patchy penetration, similar to that observed in Poplar timber from other sources.

INTRODUCTION

This project was undertaken to investigate the possibility of improving the utilisation of plantation grown Poplar from China by preservative treatment. Currently Poplar is not treated and is regarded as inferior to other timbers, such as larch, for general building purposes.

The options investigated included simple systems that could be used on a small scale with limited equipment. In New Zealand, momentary dip/diffusion treatment with boron is used commercially for protection of radiata pine against insect attack. This treatment system requires little more than a dip tank and waterproof diffusion stack covers. Boron has a low mammalian toxicity rating and is produced in China.

Tests were to include roundwood and sawn timber. Different solution strengths, dipping times and diffusion temperatures were chosen as the variables most likely to affect treatment results. Hot and cold bath/diffusion with boron was also regarded as likely to give reasonable treatment results.

Conventional full-cell pressure treatment with copper-chrome-arsenate preservatives was included as the commercial process most likely to be used. Test results could be compared with those from other Poplar species to indicate whether the Poplar from China had any special treatment characteristics.

MATERIALS AND METHODS

Five trees were selected from each of the following areas of plantation and shelterbelt trees;

Populus x euramericana clone I - 69/55 from Yingzi village, planted 1983.

Populus x euramericana clone I - 89/55 from Yingzi village, planted 1983.

Populus x tomentosa from Xaipo village, planted 1978.

Both Yingzi and Xaipo villages are in Yitang town, of Linyi County in the Peoples Republic of China. The trees were felled and the selected logs debarked before being shipped to New Zealand in a sealed container. After discs for wood quality measurements had been cut from the logs, the remaining material was cut up for preservative treatment trials. All logs with a small end diameter larger than 180 mm were sawn to 50 mm thick boards, mainly 75 x 50 mm. Smaller logs were used in roundwood treatment trials. Five pieces of roundwood, approximately 0.8m long and ten pieces of sawn timber 75 x 50 mm, 0.8m long, were cut from each tree. One piece from each tree was assigned to each of the treatment groups in Table 1.

Table1 - Preservative Treatment Groups

Group	Size	State	Treatment Process	Preservative
AO	75 x 50 mm	ex ship	10 min. dip/cool diffusion	12% H ₃ BO ₃
AI	75 x 50 mm	ex ship	10 min. dip/warm diffusion	12% H ₃ BO ₃
BO	75 x 50 mm	ex ship	2 min. dip/cool diffusion	18% H ₃ BO ₃
BI	75 x 50 mm	ex ship	2 min. dip/warm diffusion	18% H ₃ BO ₃
CO	75 x 50 mm	ex ship	2 min. dip/cool diffusion	12% H ₃ BO ₃
CI	75 x 50 mm	ex ship	2 min. dip/warm diffusion	12% H ₃ BO ₃
DO	75 x 50 mm	ex ship	10 min. dip/cool diffusion	18% H ₃ BO ₃
DI	75 x 50 mm	ex ship	10 min. dip/warm diffusion	18% H ₃ BO ₃
EB	75 x 50 mm	ex ship	full cell pressure/diffusion	2% H ₃ BO ₃
EC	75 x 50 mm	air dry	Bethell, full cell pressure	2.5% CCA
FA	Rounds	ex ship	5 min. dip/warm diffusion	18% H ₃ BO ₃
FW	Rounds	rewet	5 min. dip/warm diffusion	18% H ₃ BO ₃
GB	Rounds	ex ship	full cell pressure/diffusion	2% H ₃ BO ₃
GC	Rounds	air dry	Bethell, full cell pressure	2.5% CCA
GH	Rounds	ex ship	hot & cold bath/diffusion	5% H ₃ BO ₃

When the samples were cut to length a 25 mm biscuit was taken from one end to be oven dried for moisture content calculations. The ends of all treatment samples were sealed with aluminium epoxy paint and samples were labelled with treatment group,

tree number and sample number eg. AO 14-1. One extra sample was included in each sawn timber treatment group to make up packets four samples wide by four samples high.

For treatment groups AO to DI, a 12% solution of boric acid was made up by dissolving 1627g of Fbor (Disodium octaborate tetrahydrate) in 10 litres of hot water (or for the 18% solution, 2240g of Fbor) and making the final volume up to 16 litres. A mouldicide (2-n-octylisothiazolin-3-one) was added at the rate of 0.5%. Samples of all treatment solutions were taken before and after treatment for chemical analysis.

The length plus thickness and width at mid-length were recorded for each sample immediately prior to treatment. The samples were weighed, immersed in the preservative solution for the required time, removed to a sloped draining rack, allowed to drain for two minutes and then reweighed.

For diffusion the samples were placed in a close-stacked packet and the packet wrapped in polythene film. The position of all pieces in the packets was random and was recorded so that they could be returned to their original position after each penetration sampling. Four of the packets, AI to DI, were placed in the main wood preservation laboratory where the temperature is kept close to 20°C. The other four packets, AO to DO, were placed outside the preservation laboratory where the temperature over the diffusion period did not rise above 15°C and averaged about 11°C.

Because a considerable amount of drying had taken place from the time the logs were debarked until they were cut up, particularly in the smaller diameter pieces, one set of rounds (group FW) was resaturated before treatment. They were stacked in a large tank which was filled with water and placed in a pressure treatment cylinder. A vacuum of -90 kPa was drawn and held for 20 minutes followed by one hour at 660 kPa.

Rounds from groups FA and FW were weighed, immersed in the 18% Boric acid solution for five minutes, allowed to drain for two minutes and reweighed. The diameter at both ends plus the length of all roundwood samples was recorded immediately prior to treatment. They were placed in a pyramid stack and covered with polythene in the laboratory.

A 2% solution of boric acid was made up by diluting some of the 12% and 18% solutions with water. The group EB sawn timber samples and the group GB rounds were treated by placing them in a plastic tank, filling the tank with preservative solution and placing the tank in a pressure treatment cylinder. A vacuum of -90 kPa was drawn on the cylinder and held for 30 minutes, followed by a pressure cycle of 660 kPa for one hour. The samples were weighed before and after treatment. The dimensions were recorded as for other groups and they were covered and placed with the other samples in the laboratory.

A 5% solution of boric acid was made up from the surplus solutions used for earlier treatments and placed in two tanks. The group GH rounds were weighed and immersed in one of the tanks of preservative which had been heated to 90°C. The samples and solution were reheated to 90°C and held at that temperature for one hour. They were then removed from the hot bath and immersed in the other tank of solution, which was at ambient temperature (about 18°C), and allowed to cool overnight. After being removed from the solution, the samples were drained, and reweighed. Dimensions were recorded before the samples were placed in covered diffusion stacks with the other rounds.

The group EC sawn timber and group GC rounds were placed in filleted stack in the laboratory to air dry. When the moisture content of the larger rounds had fallen below 30% the samples were stacked in a pressure treatment cylinder and treated with a 2.5% solution of copper-chrome-arsenate (BTB type C supplied by Chemicca Ltd). The treatment schedule used was;

- 85 kPa vacuum, held for 20 minutes
- Flood while maintaining a vacuum of -80 kPa or better
- Pressure of 1400 kPa, held for one hour
- Drain and apply vacuum of -85 kPa, held for 20 minutes

For all samples, dimensions plus weights before and after treatment were recorded. A sample of the treatment solution was taken before and after treatment for chemical analysis. Both the group EC and the group GC samples were wrapped in polythene and stacked in the laboratory for seven days to allow the preservative to fix in the wood before penetration and analytical samples were taken.

The dip/diffusion samples, Groups AO to DI, FA and FW were assessed for preservative penetration after four six and eight weeks or until complete penetration was achieved. About 100 mm (discarded) and a 20 mm thick biscuit were cut from one end of the sample. The freshly cut surface was sprayed with Pyrocatechol violet reagent and a phosphate buffer, to indicate how far the boron had penetrated. This reagent changes from a bright yellow to a bright pink in the presence of boric acid, above 0.1% retention in wood. The boundary of distinct colour change was marked with an indelible pencil and the tested surface photocopied on a colour photocopier. The colour change fades quickly, particularly on wet samples, therefore the pencil lines are a better indication of the reaction boundary than the colour of the photocopies. Samples were returned to diffusion stack immediately after each penetration test. Other biscuits were taken for chemical analysis after diffusion was complete, to determine preservative retention.

The pressure/diffusion boron treated samples in groups EB and GB were similarly tested for preservative penetration and retention after three weeks in diffusion stack. The hot and cold bath treated rounds in group GH were tested after only two weeks in diffusion stack.

The CCA treated groups were cross-cut and spot tested with Rubenic acid reagent and an ammonia buffer, which react with copper to give a black colour. Results were photocopied and analytical tests carried out as for boron treated samples.

When boron diffusion was complete in the group EB samples, the cut ends were resealed with epoxy paint. The samples were weighed, dipped in a 25% copper-sulphate solution for 5 minutes and reweighed, before being returned to diffusion stack. This procedure was repeated a week later. The samples were tested for copper penetration, three, five and seven weeks after the second dip. The testing procedure was the same as that used previously with rubeanic acid reagent. Samples were taken at the end of the trial for chemical analysis, to determine copper retention.

RESULTS AND DISCUSSION

Wood Moisture Content

The moisture content of samples is summarised in Table 2.

During shipment from China to New Zealand the logs had partly dried, particularly towards the small end, the section used for roundwood treatments. The sawn timber was all above 60% moisture content because it was sawn from the larger section of the trees and much of the dry wood near the surface was removed, as slabwood, during sawing. The moisture content of many of the roundwood pieces was below 60% and the surface of some could have been lower than 30%. Such low moisture contents were expected to prevent or disrupt diffusion, resulting in limited and patchy preservative penetration (5).

Table 2 - Moisture Content Summary

Tree Number	Sawn Timber Moisture Content %		Roundwood Moisture Content %	
	Average	Range	Average	Range
1	112	88-131	61	38-68
2	100	75-109	57	46-71
3	110	92-126	58	44-72
4	102	74-123	76	66-80
5	93	81-109	52	41-62
6	111	87-129	66	56-80
7	127	101-150	64	54-79
8	112	74-144	66	63-71
9	109	95-123	70	65-80
10	96	82-119	65	61-73
11	128	85-153	73	41-93
12	88	74-100	73	62-87
13	93	84-103	71	56-87
14	150	103-107	73	55-89
15	89	86-90	61	60-63

To overcome drying during shipment, the group FW rounds were resaturated with water. This increased the average moisture content from 69% (range 41-86%) to

156% (range 132-195%). It is likely that the moisture content of the resaturated samples was higher than the original moisture content of the wood in the standing trees. However, it was expected to give a better indication of the treatability of freshly felled and debarked logs than the partly dry samples in group FA.

Moisture content varied considerably within roundwood treatment groups. For example, in group FA the moisture content of the smallest post was only 44% compared with 87% in the largest post. Roundwood had been randomly allocated to each of the treatment groups so that there was a range of sizes in any group and hence similar moisture content variability.

In Group GC the moisture content range before air drying was 47-77% which was reduced to 16-31% by drying. The samples at the extremes of the ranges were one of the smallest and the largest diameter respectively.

Preservative Treatment of Sawn Timber

Full preservative treatment details for sawn timber are given in Appendix I and summarised in Table 3.

Table 3 - Summary of Preservative Treatment of Sawn Timber Samples

Treatment Group	Solution Strength (% H ₃ BO ₃)	Dipping Time (minutes)	Solution Uptake (litres/m ³)	Estimated Retention (kg/m ³)
AO	11.5	10	10.2	1.17
AI	11.5	10	10.7	1.23
BO	17.9	10	11.2	2.01
BI	17.9	10	11.3	2.02
CO	11.5	2	11.7	1.34
CI	11.5	2	10.4	1.19
DO	17.9	2	9.7	1.74
DI	17.9	2	9.8	1.75
EB	2.2	NA	240	5.22
EB(CuSO ₄)	26.8	5	17.7	4.76
EC (CCA)	1.6	NA	512	3.21

Commercial dip/diffusion treatment of radiata pine sawn timber with boron compounds usually involves a relatively short dip period of one or two minutes and a solution concentration of 18-20% (3). At temperatures below 20°C crystallisation is likely to occur and most treatment tanks are heated to ensure that the boron compounds remain in solution. The use of high solution concentrations and heating may not be practicable in small or isolated treatment plants hence longer dip times and a lower solution strength were used for several of the sawn timber groups.

Partial drying was also of concern and it was hoped that longer dip times would improve preservative uptake.

Preservative uptake and retention figures show that there was a slight improvement in uptake with the longer dipping time only for the 18% solution. Solution concentration had a much greater influence on final retention figures.

The New Zealand Timber Preservation Council specifications for boron treatment require 0.2% boric acid equivalent in the central one-ninth core of wet hardwood timber, approximately equivalent to a cross-section retention of 3.7 kg/m^3 (3). Calculated retention figures suggested that this would not be easily achieved with any of the dip/diffusion groups because solution uptakes were too low. The relatively smooth surface on the sawn timber and the handling of individual pieces during treatment and re-weighing would have lowered uptakes. However, because the Poplar timber was relatively low density, core retentions of 0.2% were still possible with preservative uptakes of less than 3.7 kg/m^3 . Prolonged soaking in preservative solution is probably necessary if the required retentions are to be achieved with solutions of less than 18-20%.

Preservative uptake in the air dried and CCA/pressure treated samples (group EC) was relatively high at 512 litres/m^3 . Those samples with uptake below average generally contained heartwood or patches where the preservative had not completely penetrated (see Appendix I and Figure 26). This patchy penetration has been recorded previously in Poplar from other sources and may be associated with wood in a transition zone between the heartwood and sapwood (7).

Penetration tests for the dip/diffusion treatments of sawn timber are in Figures 2 - 21. After three weeks all of the samples in the pressure/diffusion group (EB) were completely penetrated (Figure 22).

After four weeks diffusion, penetration in all of the dip/diffusion groups was incomplete except for a few samples from the groups stacked in the laboratory (Figures 2 - 9). Penetration was complete in most of the laboratory stored samples after six weeks diffusion, but not in the samples stacked in cooler conditions outside (Figures 10 - 17). This shows the effect of temperature on diffusion rates and indicates that at temperatures below 20°C , diffusion times of more than six weeks for 50 mm thick wood will be necessary (2).

At the end of the eight week diffusion period there were still a few samples showing inadequate boron penetration, particularly in the two groups treated with a 12% solution (Figures 18 - 21). This is not surprising, considering the low uptakes and preservative retention figures from chemical analyses in Table 4.

The decision to include a double diffusion option was made after the results from the initial boron diffusion trials were largely completed. Normally double diffusion treatments involve soaking the wood in chemical solutions for several days (1). Dip treatments in copper are less likely to give good penetration in diffusion treatment particularly in the presence of boron (4). Diffusion of boron had been relatively successful suggesting that multiple dips may be adequate. Solution uptakes to give a copper retention about double that of the boron retention were required but not

achieved by the two dips. Either more dips, with a shorter interval between, or a soaking period of several days would be required to give the required uptake.

Copper penetration in the copper-sulphate/double diffusion group was incomplete after four weeks. Although there was some improvement after six weeks, there was still a large area in the centre of the samples which had not been penetrated by copper after eight weeks (see Figures 23-25). This confirms the view that much higher uptakes of the copper sulphate solution are required to give full penetration in a six to eight week diffusion period.

Results from chemical analyses of samples are summarised in Table 4. Full details are in Appendix I.

Table 4 - Summary of Results From Chemical Analyses of Sawn Timber

Treatment Group	Incomplete Penetration (No. of Samples)	Retention of H ₃ BO ₃ (g/100g of Oven Dry wood)	
		Cross Section	Core
AO.(10m/12%/11°)	1 (8 weeks)		0.13
AI (10m/12%/20°)	4 (6 weeks)	0.39	0.14
BO (2m/18%/11°)	1 (8 weeks)		0.19
BI (2m/18%/20°)	3 (6 weeks)	0.54	0.18
CO (2m/12%/11°)	4 (8 weeks)		
CI (2m/12%/20°)	5 (6 weeks)	0.32	0.09
DO (10m/18%/11°)	5 (8 weeks)		
DI (10m/18%/20°)	4 (6 weeks)	0.51	0.19
EB (pressure)	(3 weeks)	1.29	0.83
EC (CCA-T.A.E.)	NA	0.68	0.74

Core retentions in Table 4 show that the averages for the two groups treated with the 18% solution were relatively close to the target of 0.2% boric acid, although individual samples were as low as 0.14% and 0.10 % in the BI and DI groups respectively (see Appendix I). Slightly higher preservative uptake and/or a longer diffusion time may have been sufficient to produce results that would have met the New Zealand specification requirement.

The samples treated with 12% solution were well short of the specification requirement and unlikely to be improved greatly by either longer diffusion times or longer dipping times. Analytical results also indicate that there was little difference in uptakes between the ten minute dip groups and the two minute dip groups. If uptakes are to be raised significantly timber may need to be immersed in preservative for several hours or possibly days.

Boron diffusion did not appear to be prevented by heartwood but penetration was more variable in pieces containing heartwood. Although spot tests indicated that

there were areas of poor penetration adjacent to darker coloured heartwood in a few samples, other samples showed complete penetration into these areas. Analyses of cores from samples AO 9/1, BO 3/1 and BO 8/1, all containing at least 30% heartwood, showed retentions close to or above average for their groups.

Thickened solutions of boron have been used commercially in New Zealand for several years and enable radiata pine to be treated with cold solutions of about 10% boric acid (6). If heating of the treatment bath is not practicable then the use of cold thickened solutions of 12-15% boric acid should give core retentions of 0.2% in 50 mm thick timber after a diffusion period of 6-8 weeks.

Core retentions in the boron/pressure treated samples (group EB) were well above 0.2% and were probably influenced by partial drying of the logs during shipment. It may be possible to obtain satisfactory results with a lower solution strength or lower pressure during treatment but this would need to be tested on timber cut from freshly felled trees. With freshly cut radiata pine, solution strengths in the region of 5% are used because preservative uptakes are very much lower than those achieved with the Poplar in these tests.

The preservative retention achieved in the CCA/pressure treated samples (group EC), is midway between that required by the New Zealand H3 and H4 specifications for radiata pine. This should give reasonable protection to commodities used in exposed situations but out of ground contact. There was no significant difference in retention of preservative components between the outer 12 mm and the core. This suggests that higher solution strengths could be used if protection from higher decay hazards were required. However, cutting of timber after treatment is likely to expose pockets of untreated wood and should be avoided if the timber is used in moderate-high decay hazard situations.

Preservative Treatment of Roundwood

The roundwood samples were not given any extra preparation before treatment, except end sealing. Where cambium or inner bark had not been completely removed before shipment, it was left in place, although there was some possibility that it would influence treatment results. Full treatment results are in Appendix II and summarised in Table 5.

The initial dip treatment of the Group FA and FW samples resulted in only very small weight increases. This was mainly due to hand peeling of the samples which left a very smooth, almost shiny, surface. When preservative uptake figures were calculated it was obvious that insufficient preservative had remained on the samples for diffusion to be successful. Both sets of samples were given a second dip in the solution after 19 days in diffusion stack. Solution uptakes were similar to those achieved with the first dip, raising total calculated retentions to only 37% and 17% of the target retention of 3.7 kg/m³ for the FA and FW groups respectively.

Table 5 - Summary of Roundwood Preservative Treatment Results

Group Code	Pretreat. Condition	Treatment Type	Solution Strength (% H ₃ BO ₃)	Solution Uptake (litres/m ³)	Estimated Retention (kg/m ³)
FA	Ex ship	Dip (x2)/diffusion	18%	7.57	1.35
FW	Saturated	Dip (x2)/diffusion	18%	3.56	0.63
GB	Ex ship	Pressure/diffusion	2%	145	3.14
GH	Ex ship	H & C bath/diffusion	5%	191	9.03
GC (CCA)	Air dry	Pressure	1.6%	381	2.18

More dips or longer soaking times would have increased uptakes, particularly with the partly dry samples in group FA. The period between dips could also be reduced, anything from one to seven days being likely to give similar results. A debarking system which removed some wood and left the wood surface rough would also improve uptakes. However, without a prolonged total period immersed in the treatment solution, it is unlikely that simple dips in aqueous boron solutions would be sufficient to treat freshly cut or partly dried roundwood. Thickened solutions improve uptakes but boric acid concentrations would need to be higher than the 10-12% currently in commercial use for sawn timber in New Zealand.

The pressure treatment of the GB samples gave preservative uptakes higher than normally achieved with green sawn radiata pine. This was due to partial drying of the posts before treatment. Estimated retentions were close to those required for boron treatment of sawn hardwood timber in New Zealand.

It was anticipated that hot and cold bath treatment would give solution uptakes lower than those achieved with pressure treatment and the treatment solution strength was increased to 5% to compensate for this. Treatment results for group GH show that the uptakes were generally higher than for the pressure treated group, with one or two exceptions. This may have resulted from moisture content variation but may also have been influenced by the pressure treatment schedule used. The pressure treated roundwood was immersed in the solution before a vacuum was drawn, which may have resulted in surface absorption and subsequent swelling reducing the amount of air removed by the vacuum. This would produce the same effect as an empty cell process, where solution uptake is reduced because the air trapped in the wood expands when pressure is released and forces preservative solution out.

The high solution uptakes in the hot and cold bath treated roundwood indicated very high preservative retentions, well above those required for the New Zealand H1 specification.

The preservative uptake in the air dry and CCA treated samples (group GC) was lower than expected and varied considerably between samples. Samples with a moisture content close to 30% before treatment may have had core moisture contents above 30%, which would have affected preservative uptake. Inner bark and cambium on roundwood would also have affected preservative uptake and was particularly extensive on samples 6/1, 7/2, 11/2, 12/2, 14/1 and 15/4. With the exception of sample 15/4, the uptake in all of these samples was below average.

Spot tests of preservative distribution show irregular penetration patterns, observed in previous work with Poplar but also associated with inner bark and cambium left on the surface (see Figure 33). This variable distribution would make the roundwood unreliable when used in high decay hazard situations where it is cut to size after treatment.

Penetration in the roundwood samples is shown in Figures 27-33. For the pressure treated group (GB), penetration was incomplete in several samples after three weeks diffusion and they were held in diffusion stack for a further week (Figure 31). The hot and cold bath treated samples were completely penetrated within three weeks (Figure 32).

Boron penetration in the FA and FW samples was incomplete after six weeks diffusion. A further two weeks diffusion improved penetration only slightly. Preservative retentions were too low to give core loadings of 0.2% in the larger samples, regardless of diffusion time (Figures 27-30).

As indicated by preservative uptake figures in Table 5, boric acid retentions in the two roundwood dip/diffusion groups were below the New Zealand H1 specification. This confirms the view that dip/diffusion treatments are unlikely to succeed without prolonged soaking or some other method of increasing preservative uptakes substantially. There does not appear to be any barrier to diffusion provided preservative uptakes are adequate and there is sufficient moisture in the wood.

Table 6 - Summary of Preservative Retentions in Roundwood Samples

Treatment Group	Incomplete Penetration (No. of Samples)	Retention of H ₃ BO ₃ (g/100g of Oven Dry wood)	
		X-section	Core
FA	(8 weeks)		
FW	(8 weeks)		
GB	Nil (4 weeks)	0.79	0.32
GH	Nil (3 weeks)	2.70	1.60
GC	NA	0.51	0.39

Preservative retentions in the two roundwood groups treated with pressure and hot/cold bath were well above those required by the H1 specification. With the hot and cold bath treated group a lower solution strength could have been used, mainly because the posts were partly dry. Uptakes in freshly cut material would need to be tested to determine the solution strength to use for this type of treatment.

The patchy penetration observed in the group GC samples was reflected by variable preservative retentions. Generally, where there was relatively good penetration, the core retentions were similar to the cross-section retentions, indicating no screening of preservative elements. Total removal of bark and cambium would have improved preservative penetration, as would have a longer pressure period during treatment. Irregular distribution is likely to remain a problem and makes the end product unreliable in situations where it is exposed to a high decay hazard.

CONCLUSIONS

Poplar timber can be easily preservative treated for use in internal situations to protect it from insect attack. Preservative treatment to give protection against fungal decay is less reliable.

Freshly sawn Poplar timber was treated using a dip diffusion process with boron solutions. To achieve full penetration and core retentions above 0.2% within eight weeks, solutions of 18-20% and temperatures during diffusion of close to 20°C were necessary.

Thickened solutions of 12-15% boric acid should give similar preservative treatment results.

There was little difference in preservative uptake between groups immersed for two and ten minutes.

Dip diffusion treatments of roundwood were unsuccessful because the smooth surface of the wood reduced solution uptake. Prolonged soaking would be necessary to increase uptake to the point where diffusion would give a core retention of 0.2%.

An alternative process, pressure treatment of green roundwood with a 2% boron solution, followed by 4 weeks in diffusion stack gave good treatment results.

Similar results were achieved with hot and cold bath treatment using a 5% solution.

In both these cases partial drying before treatment improved preservative uptake. A lower solution strength would have given satisfactory results with the partly dry roundwood.

Pressure treatment of air dried sawn timber and roundwood with CCA solutions gave variable penetration. This was partly due to inadequate debarking of the roundwood but has also been recorded in Poplar timber from other sources.

Dip/diffusion treatments in copper sulphate solution, following boron diffusion treatment, resulted in limited copper penetration.

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FIGURE 1

Position of Sawn Timber Samples in Diffusion Stacks

GROUP AO

11-1	2-1	5-2	15-1
1-1	3-1	10-1	5-1
4-1	9-1	12-1	7-1
6-1	14-1	13-1	8-1

GROUP AI

13-1	5-2	6-1	15-1
9-1	10-1	3-1	12-1
11-1	1-1	4-1	7-1
2-1	14-1	8-1	5-1

GROUP BO

11-1	1-1	3-1	6-1
14-1	12-1	8-1	7-1
2-1	10-1	13-1	9-1
7-2	15-1	5-1	4-1

GROUP BI

1-1	12-1	8-2	4-1
6-1	7-1	14-1	1-2
2-1	5-1	10-1	13-1
9-1	3-1	15-1	11-1

GROUP CO

11-1	5-1	13-1	6-1
7-1	8-1	1-1	3-1
2-1	10-1	14-1	4-1
15-1	6-2	12-1	9-1

GROUP CI

11-1	5-1	7-1	13-1
1-1	3-1	8-1	6-1
14-1	2-1	4-1	10-1
5-2	12-1	15-1	9-1

GROUP DO

5-1	13-1	10-2	14-1
4-1	15-1	11-1	3-1
12-1	1-1	7-1	2-1
6-1	10-1	1-2	8-1

GROUP DI

14-2	15-1	11-1	2-1
3-1	4-1	8-1	10-1
7-2	13-1	6-1	5-1
14-1	12-1	7-1	1-1

FIGURE 2

PCV spot test results for Group AO samples (10 min. dip, 12% solution, cool diffusion) after four weeks diffusion. The line is the boundary of distinct colour change when the samples were tested.

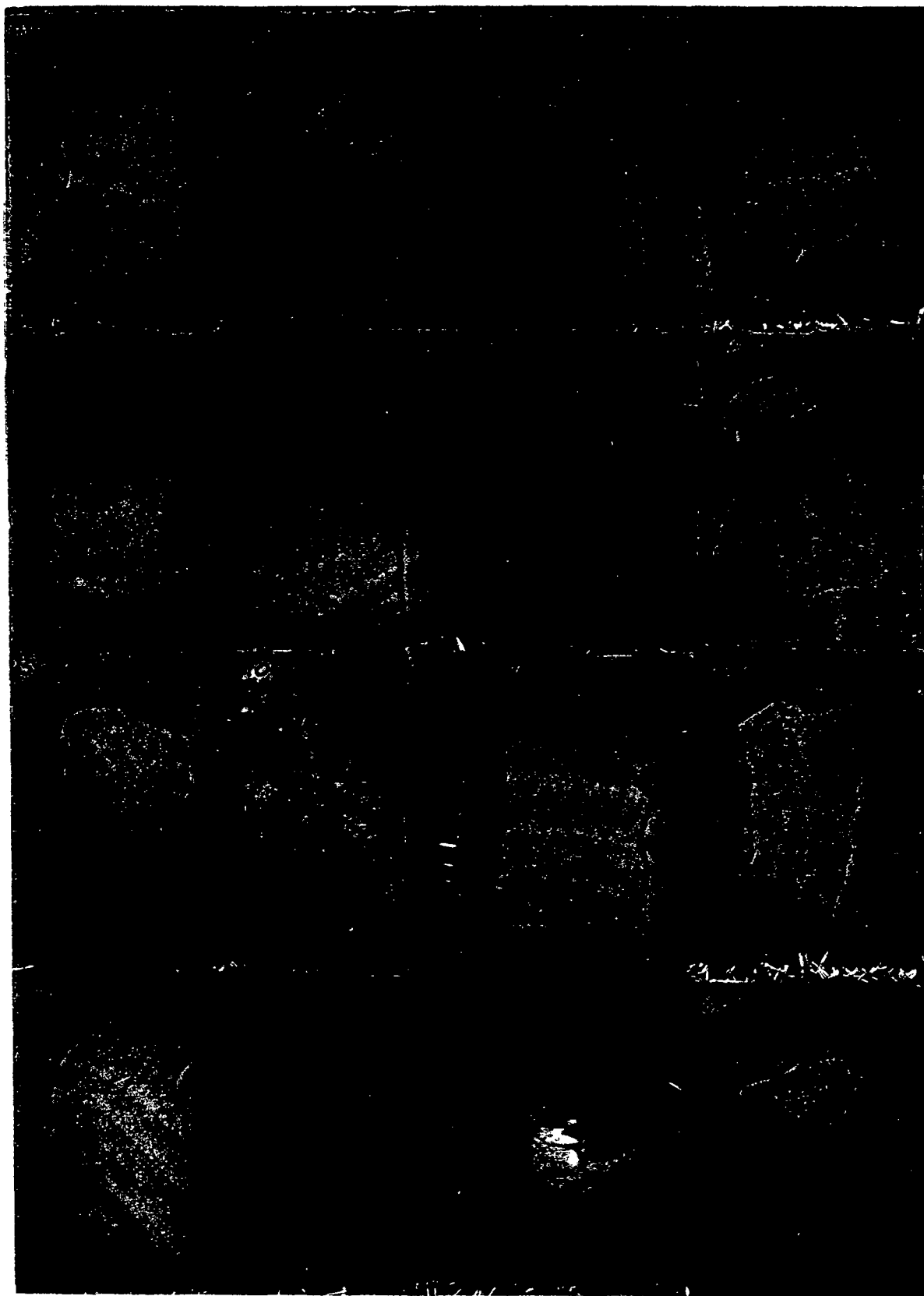


FIGURE 3

PCV spot test results for Group BO samples (2 min. dip, 18% solution, cool diffusion) after four weeks diffusion.

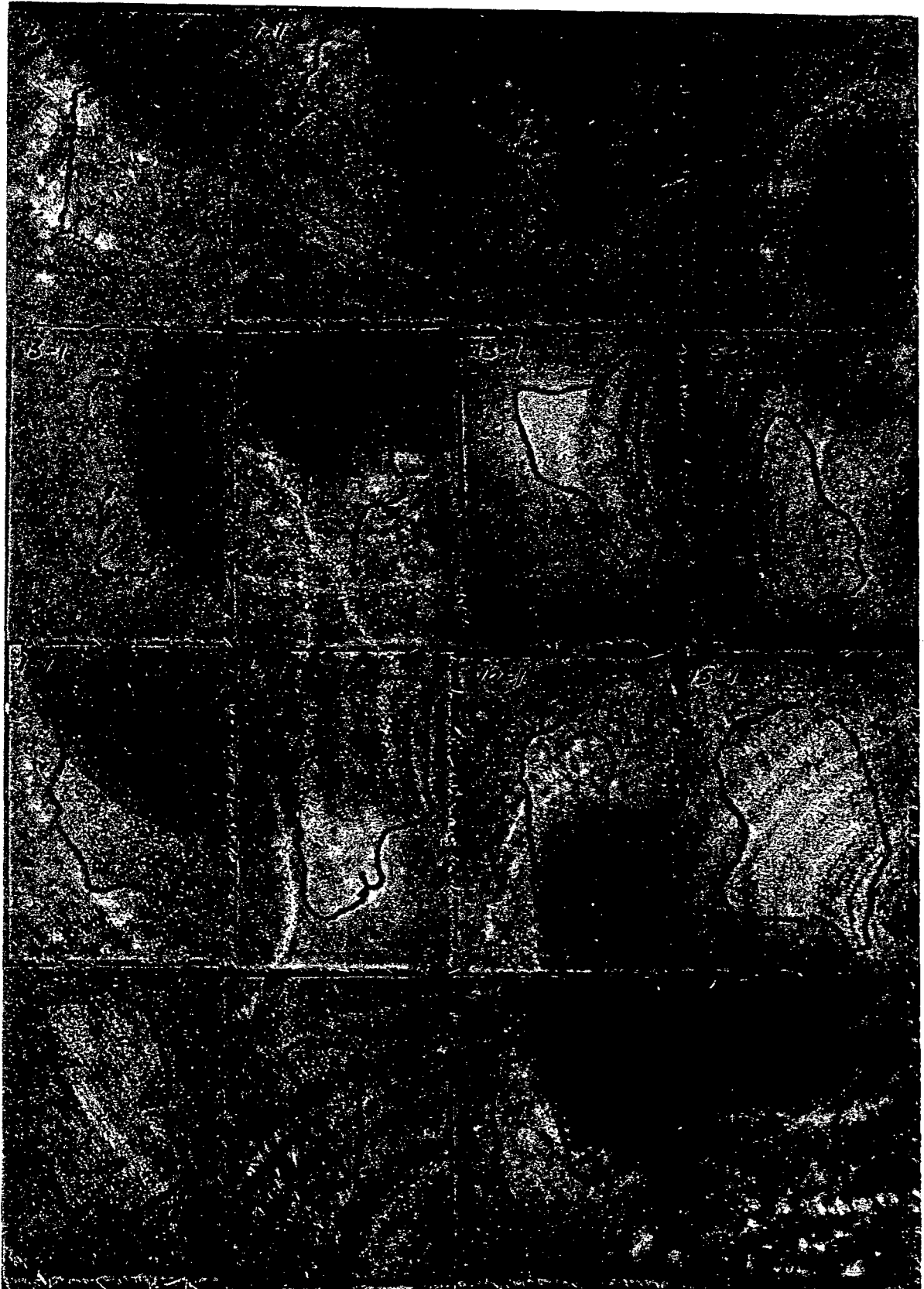


FIGURE 4

PCV spot test results for Group CO samples (2 min. dip, 12% solution, cool diffusion) after four weeks diffusion.

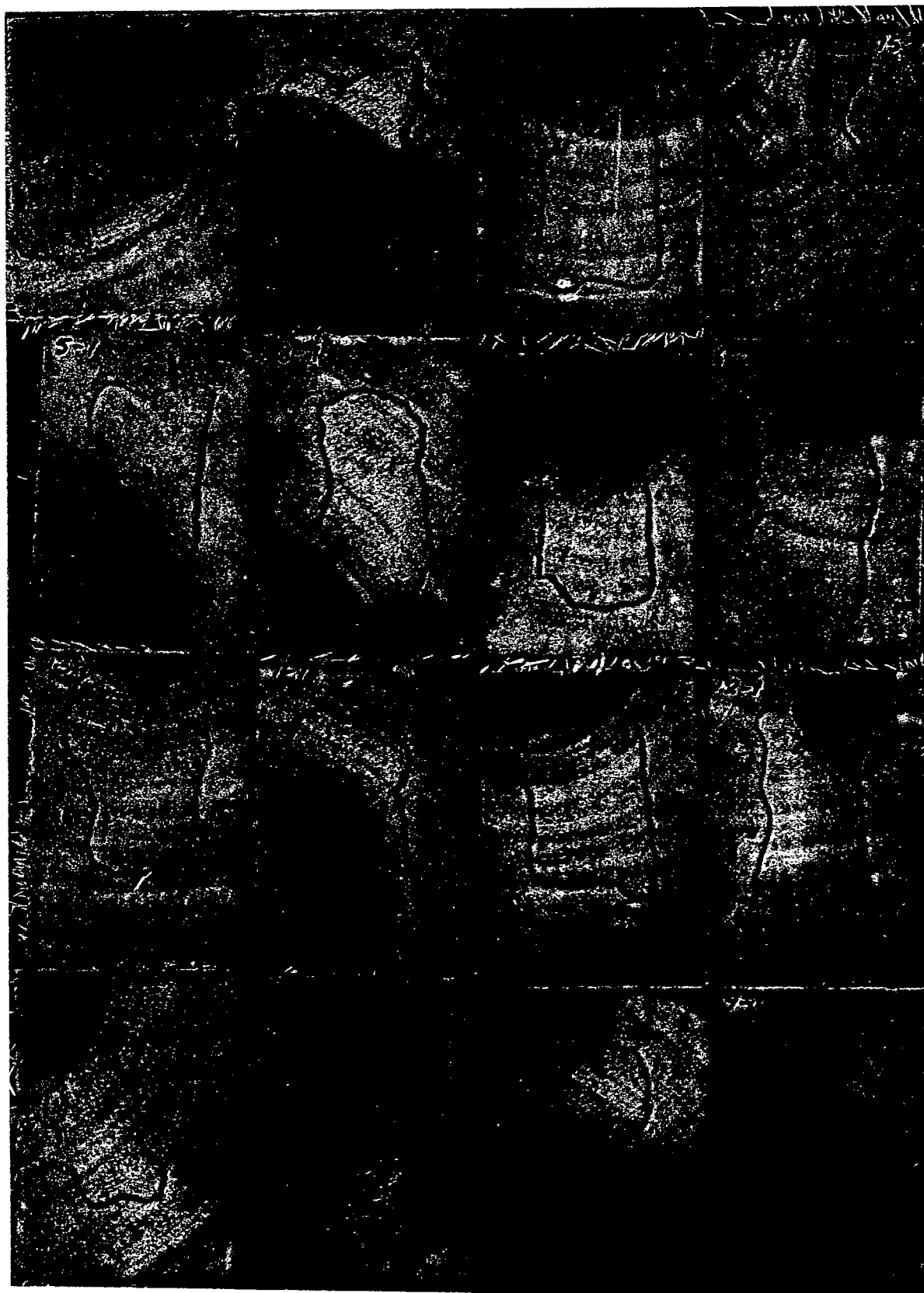


FIGURE 5

PCV spot test results for Group DO samples (10 min. dip, 18% solution, cool diffusion) after four weeks diffusion.

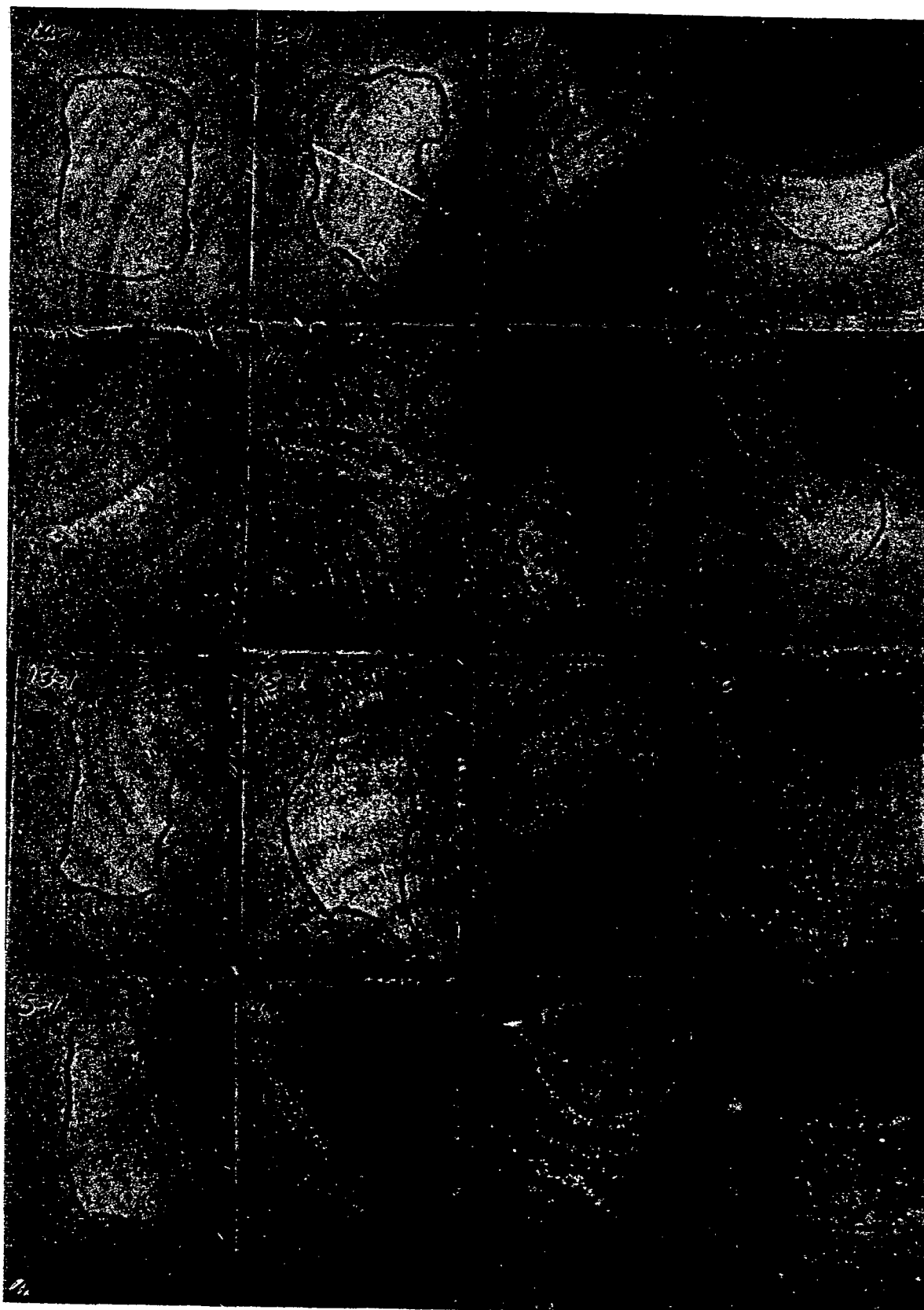


FIGURE 6

PCV spot test results for Group AI samples (10 min. dip, 12% solution, warm diffusion) after four weeks diffusion

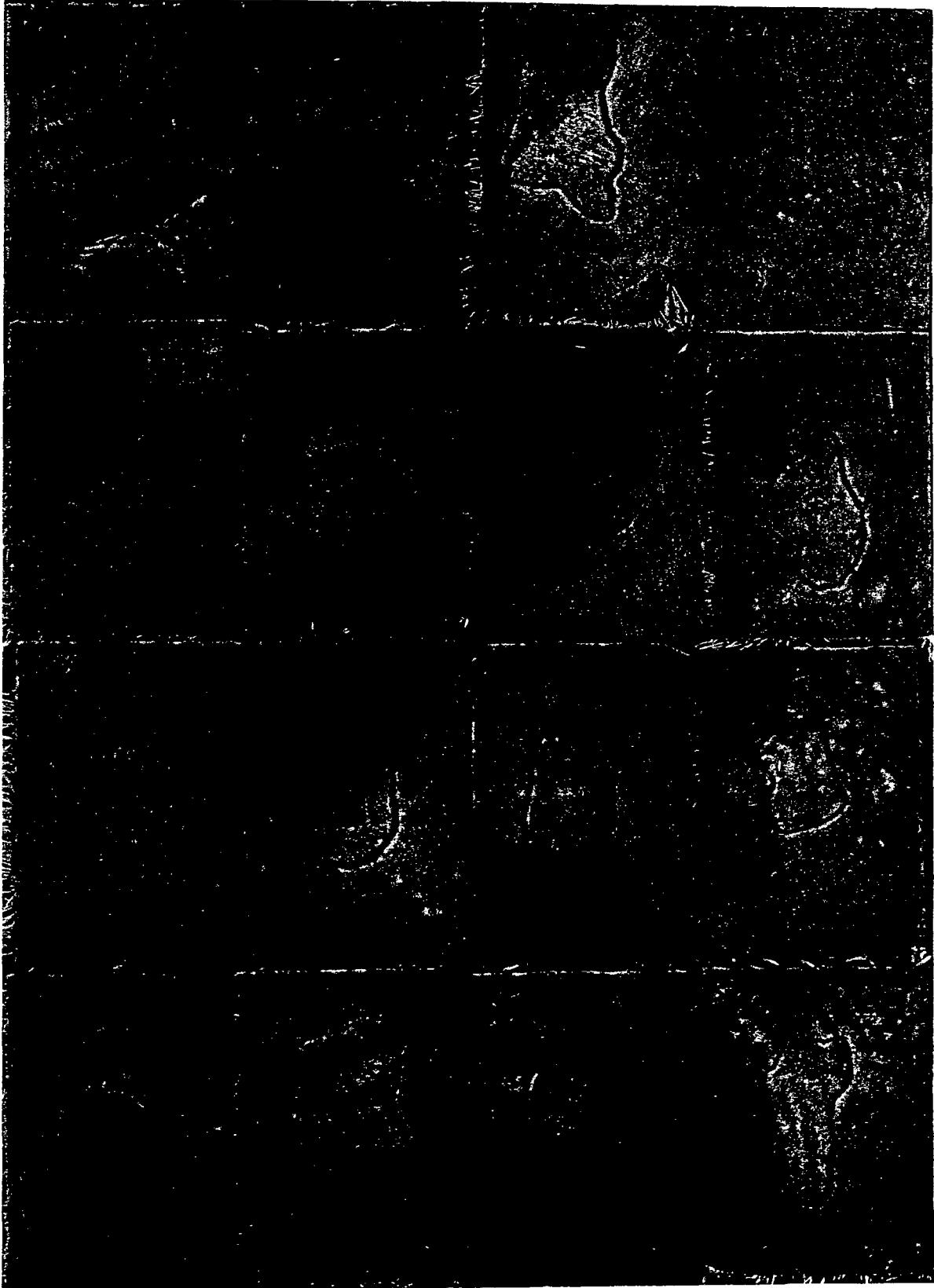


FIGURE 7

PCV spot test results for Group BI samples (2 min. dip, 18% solution, warm diffusion) after four weeks diffusion.



FIGURE 8

PCV spot test results for Group CI samples (2 min. dip, 12% solution, warm diffusion) after four weeks diffusion.

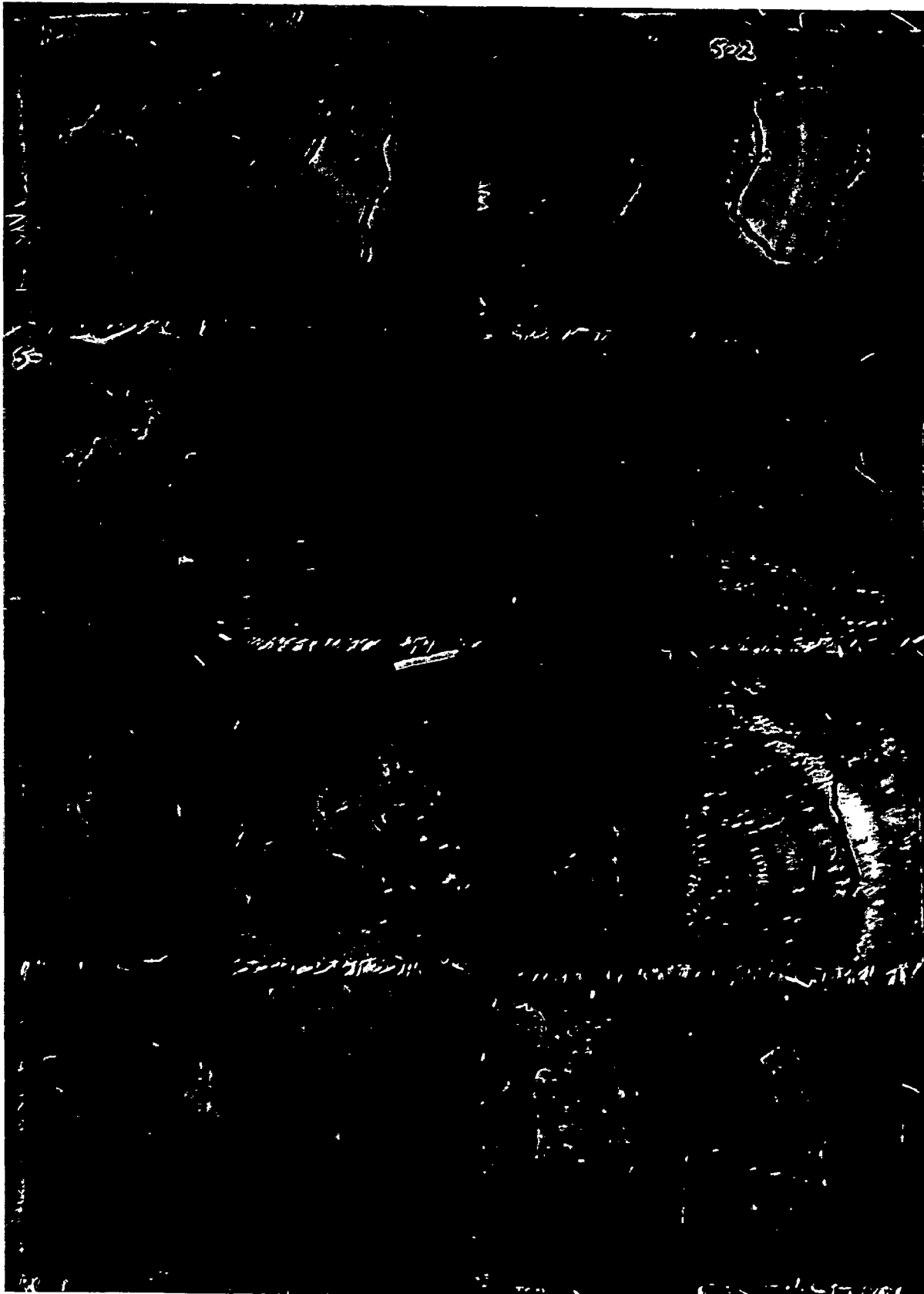


FIGURE 9

PCV spot test results for Group DI samples (10 min. dip, 18% solution, warm diffusion) after four weeks diffusion.

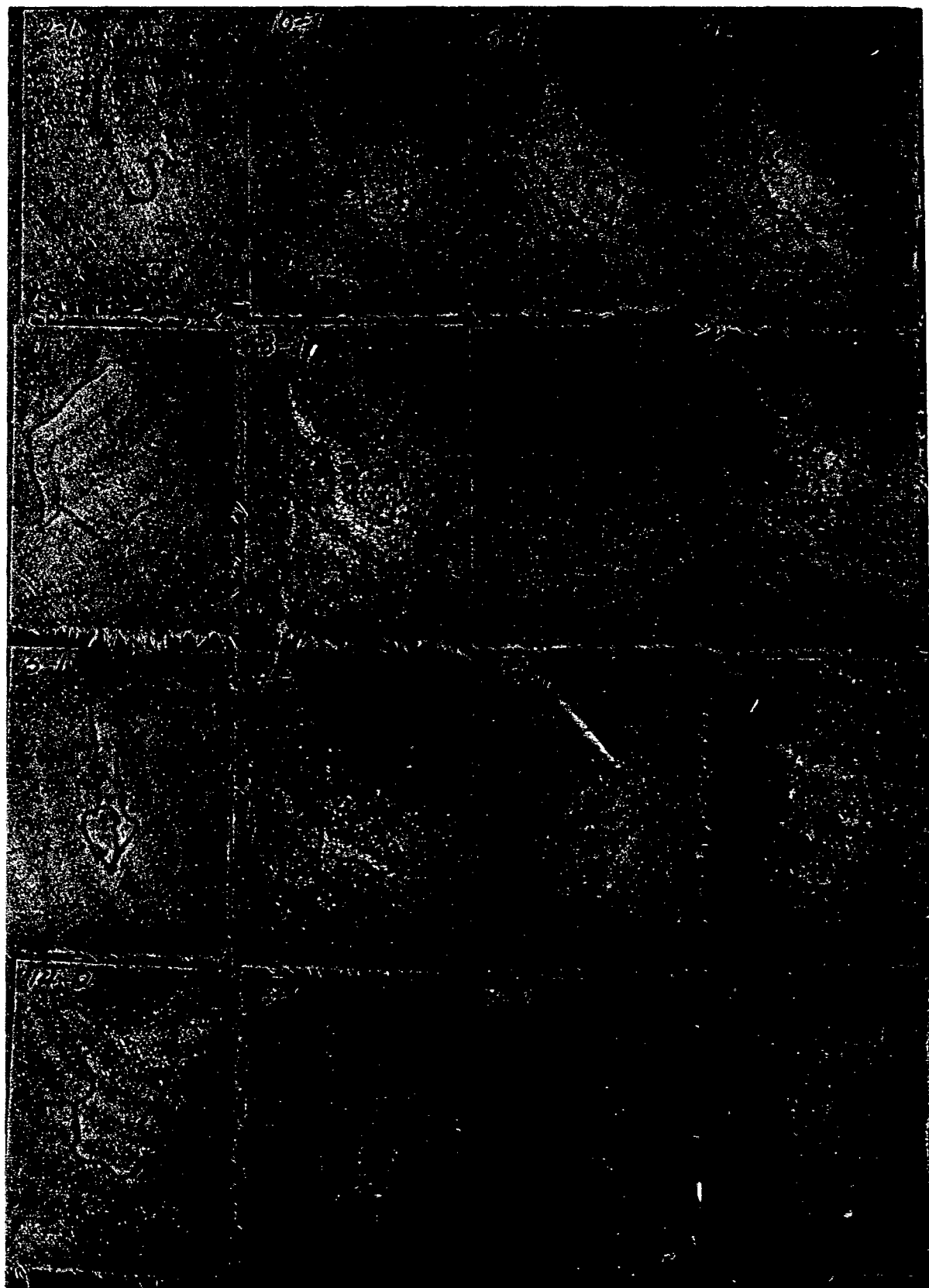


FIGURE 10

PCV spot test results for Group AO samples (10 min. dip, 12% solution, cool diffusion) after six weeks diffusion. The line is the boundary of distinct colour change when the samples were tested.

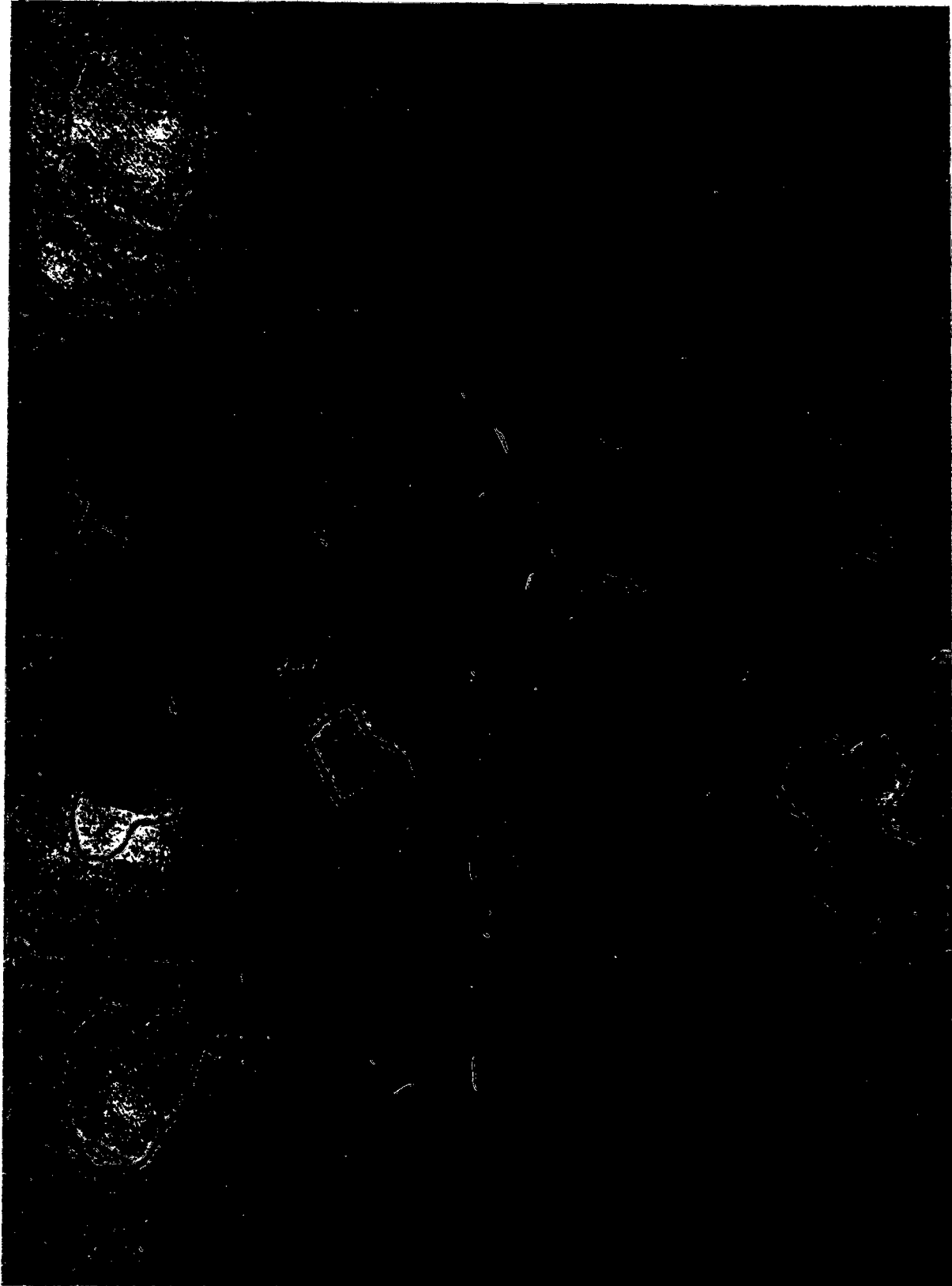


FIGURE 11

PCV spot test results for Group BO samples (2 min. dip, 18% solution, cool diffusion) after six weeks diffusion.



FIGURE 12

PCV spot test results for Group CO samples (2 min. dip, 12% solution, cool diffusion) after six weeks diffusion.



FIGURE 13

PCV spot test results for Group DO samples (10 min. dip, 18% solution, cool diffusion) after six weeks diffusion.

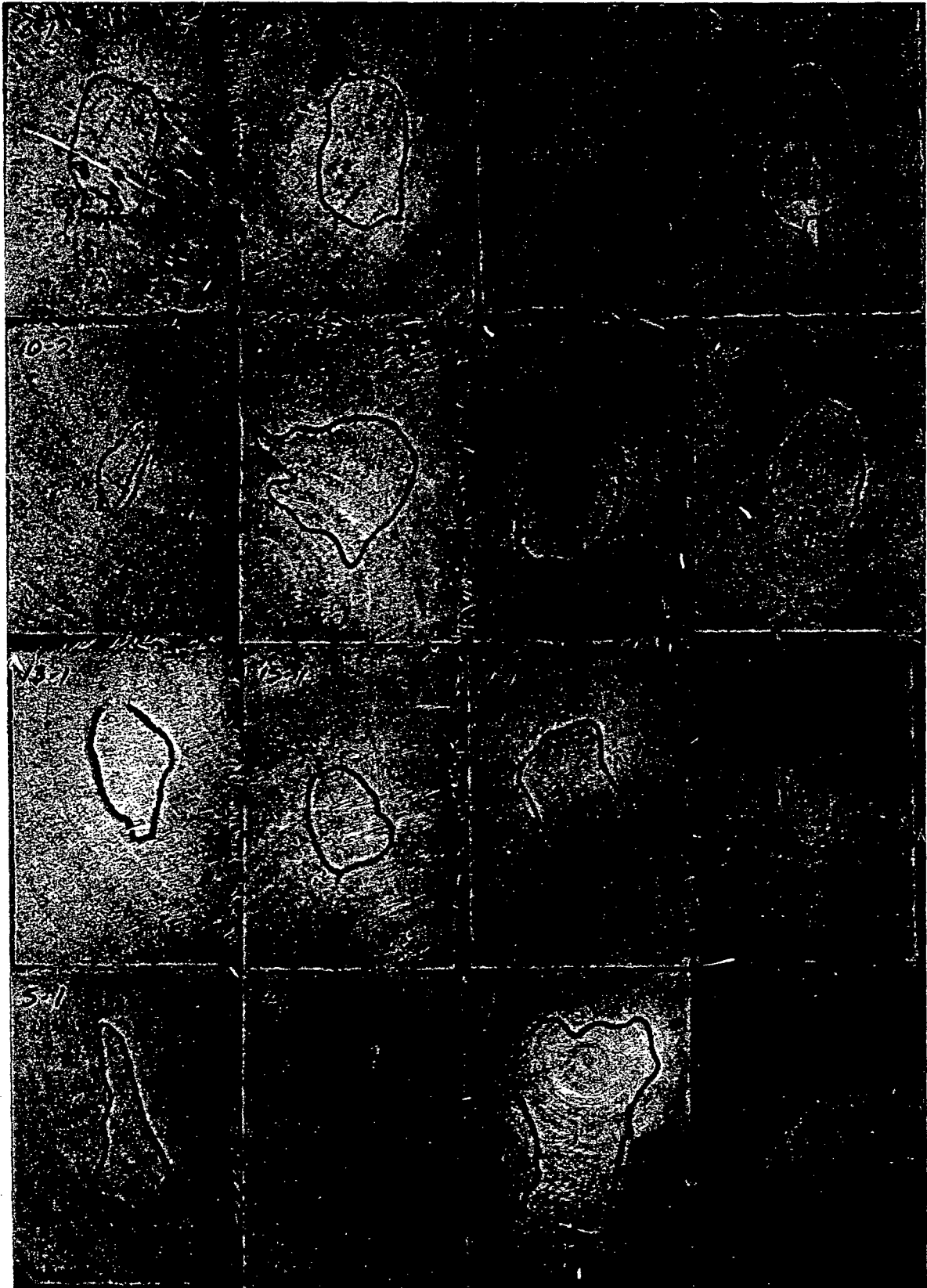


FIGURE 14

PCV spot test results for Group AI samples (10 min. dip, 12% solution, warm diffusion) after six weeks diffusion



FIGURE 15

PCV spot test results for Group BI samples (2 min. dip, 18% solution, warm diffusion) after six weeks diffusion.

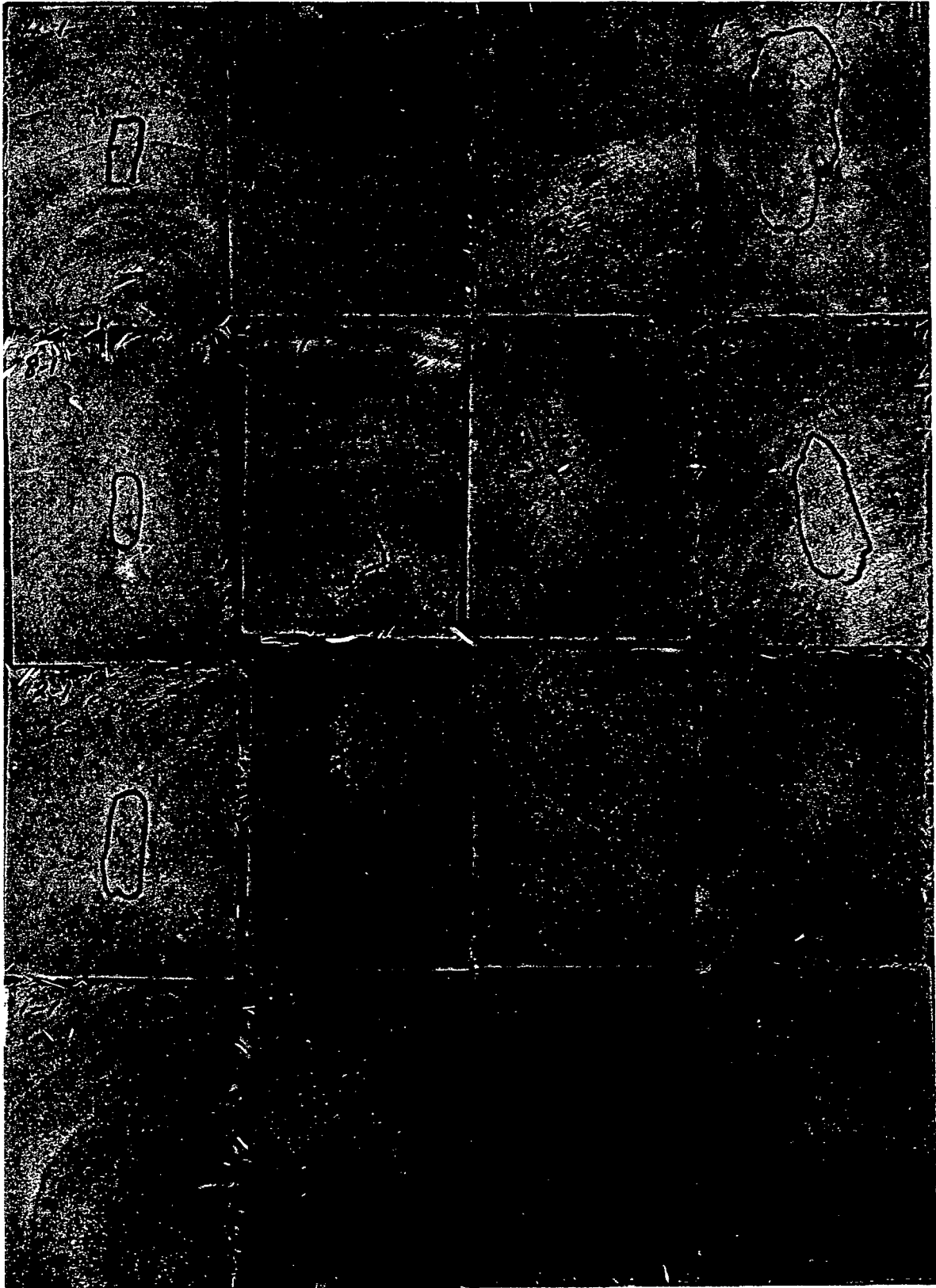


FIGURE 16

PCV spot test results for Group CI samples (2 min. dip, 12% solution, warm diffusion) after six weeks diffusion.

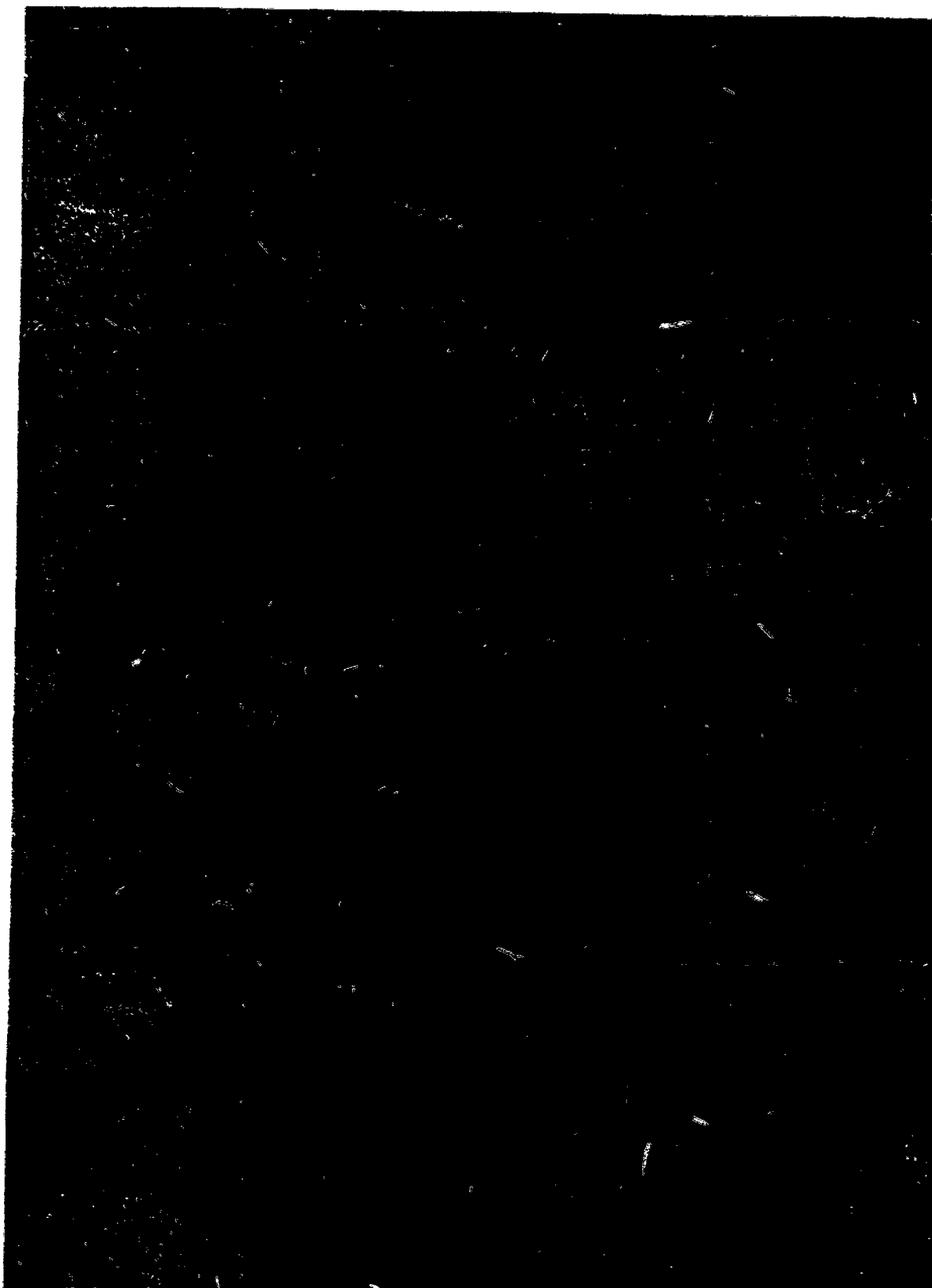


FIGURE 17

PCV spot test results for Group DI samples (10 min. dip, 18% solution, warm diffusion) after six weeks diffusion.



FIGURE 18

PCV spot test results for Group AO samples (10 min. dip, 12% solution, cool diffusion) after eight weeks diffusion. The line is the boundary of distinct colour change when the samples were tested.

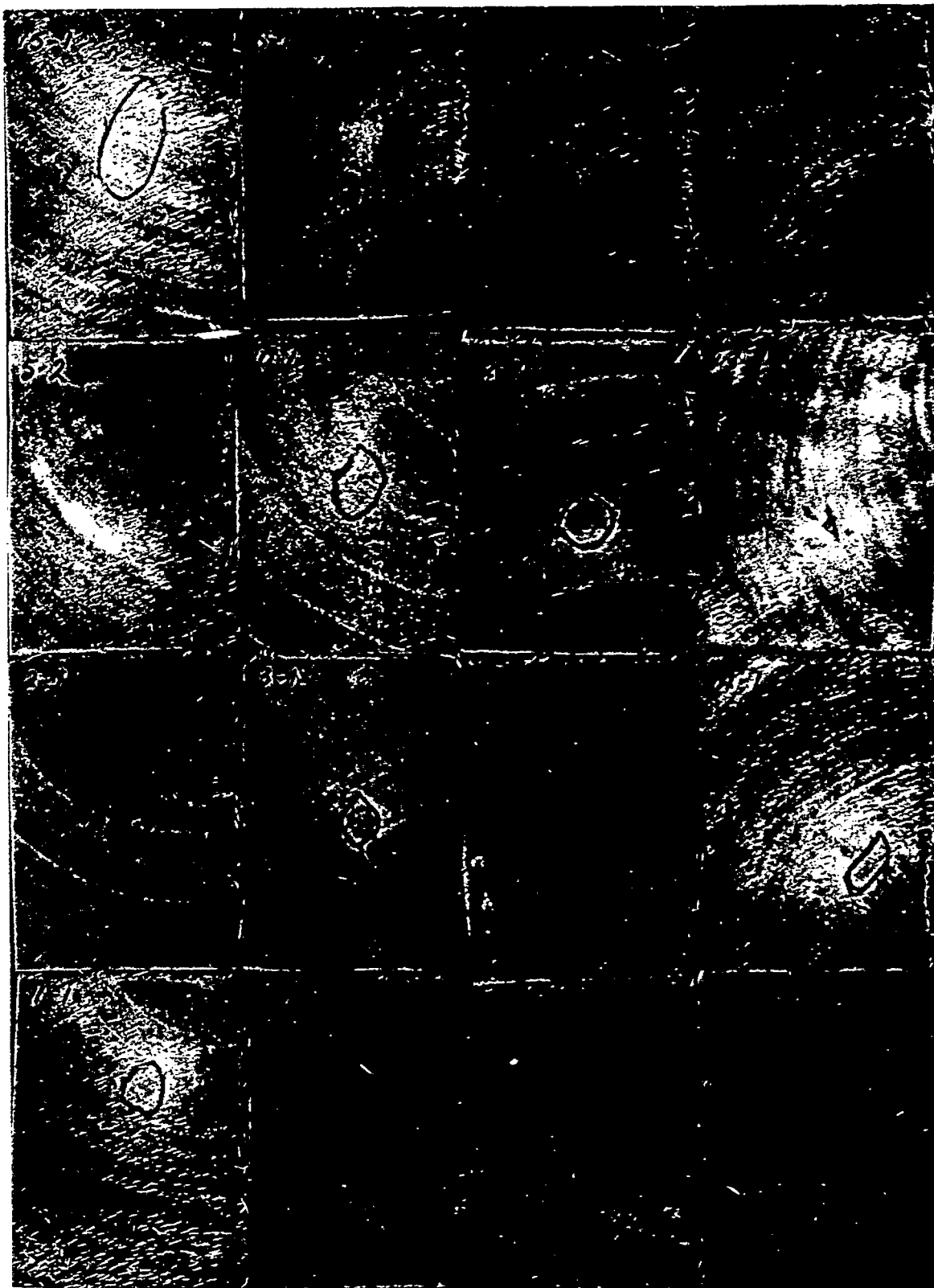


FIGURE 19

PCV spot test results for Group BO samples (2 min. dip, 18% solution, cool diffusion) after eight weeks diffusion.



FIGURE 20

PCV spot test results for Group CO samples (2 min. dip, 12% solution, cool diffusion) after eight weeks diffusion.

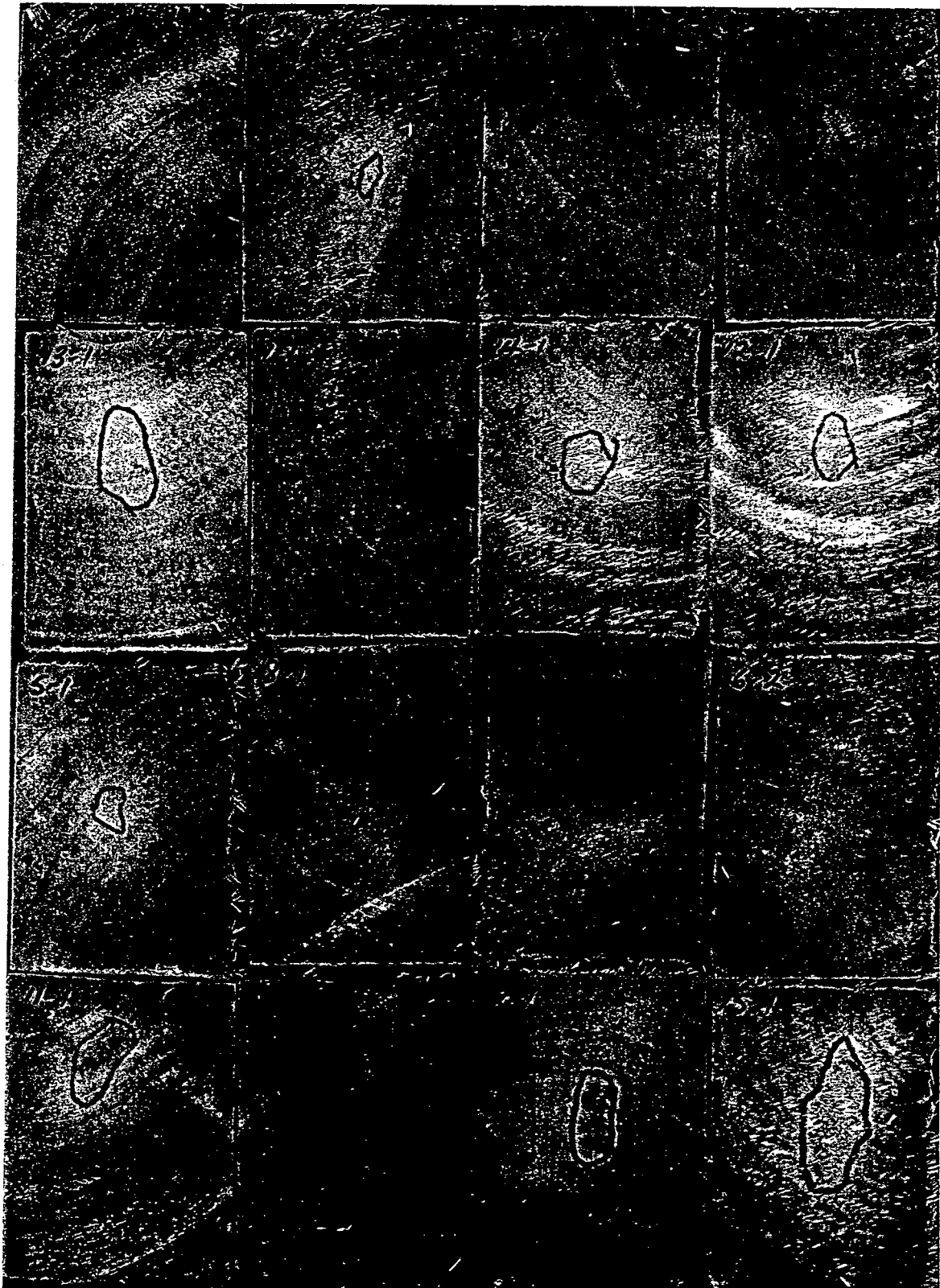


FIGURE 21

PCV spot test results for Group DO samples (10 min. dip, 18% solution, cool diffusion) after eight weeks diffusion.



FIGURE 22

PCV spot test results for Group EB samples (pressure treat with 2% solution, warm diffusion) after four weeks diffusion.

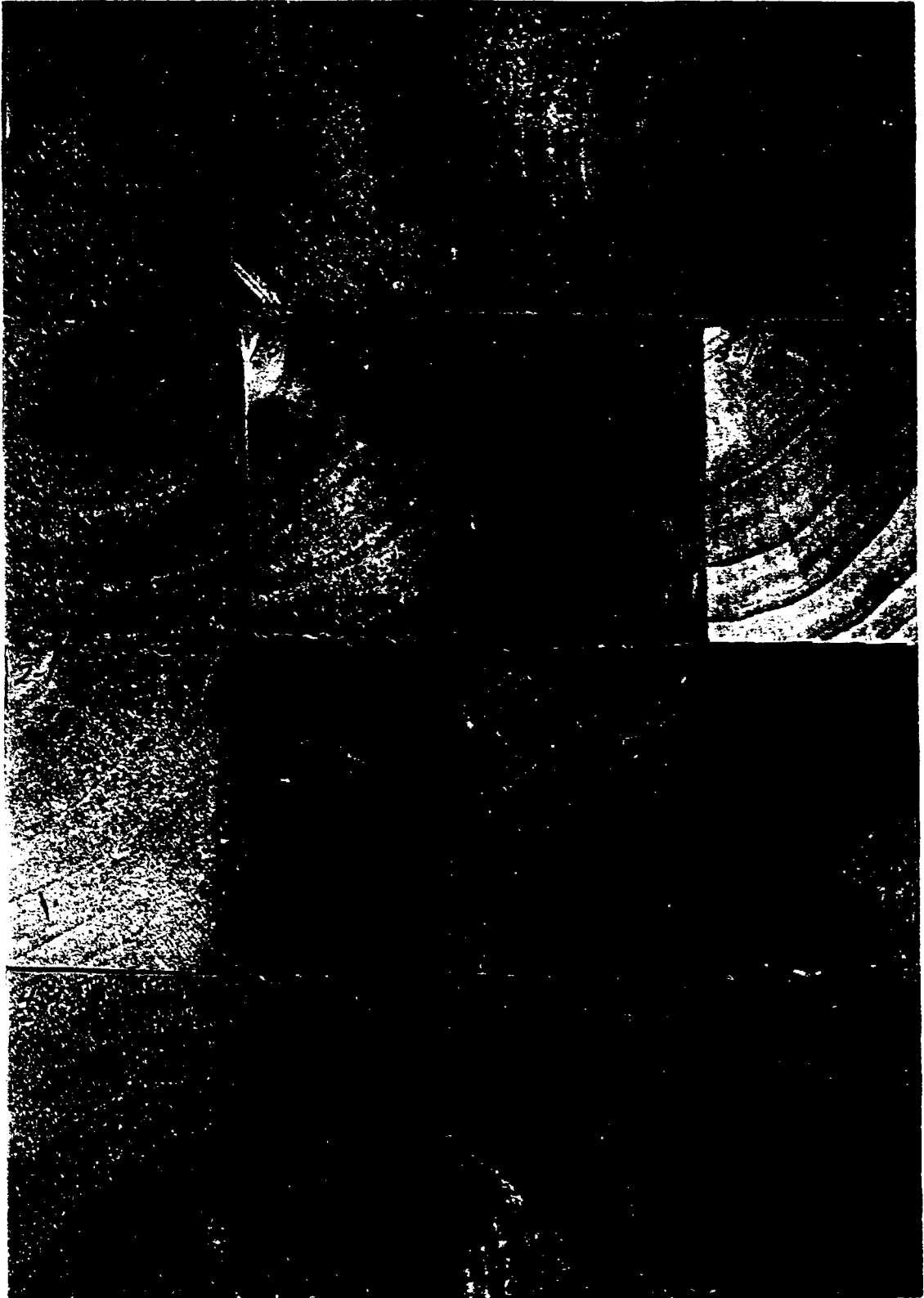


FIGURE 23

Rubeanic acid spot test results for Group EB samples (5 min. dip, 25% copper-sulphate solution, warm diffusion) after four weeks diffusion.



FIGURE 24

Rubeanic acid spot test results for Group EB samples (5 min. dip, 25% copper-sulphate solution, warm diffusion) after six weeks diffusion.

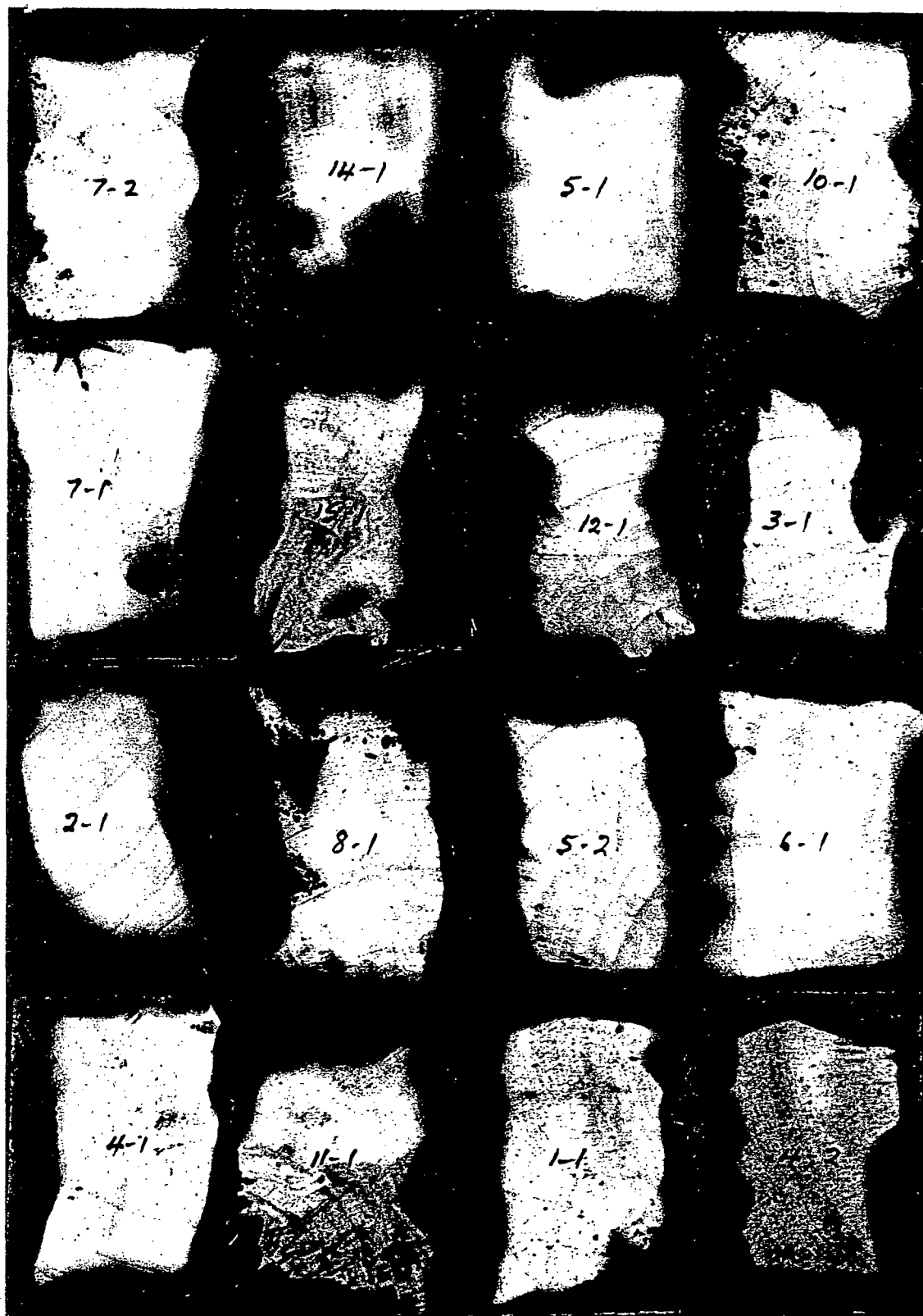


FIGURE 25

Rubeanic acid spot test results for Group EB samples (5 min. dip, 25% copper-sulphate solution, warm diffusion) after eight weeks diffusion.



FIGURE 26

Rubeanic acid spot test results for Group EC samples (air dry, pressure treat with 1.6% CCA solution). Samples are in numerical order from left to right with 1/1 at the bottom left and 15/2 at the top right



FIGURE 27

PCV spot test results for Group FA samples (5 minute dip in 18% solution, warm diffusion) after six weeks diffusion. Samples are in numerical order with 1 at the top left and 15 at the bottom right. (NZFRI CN315606 - J Barran)

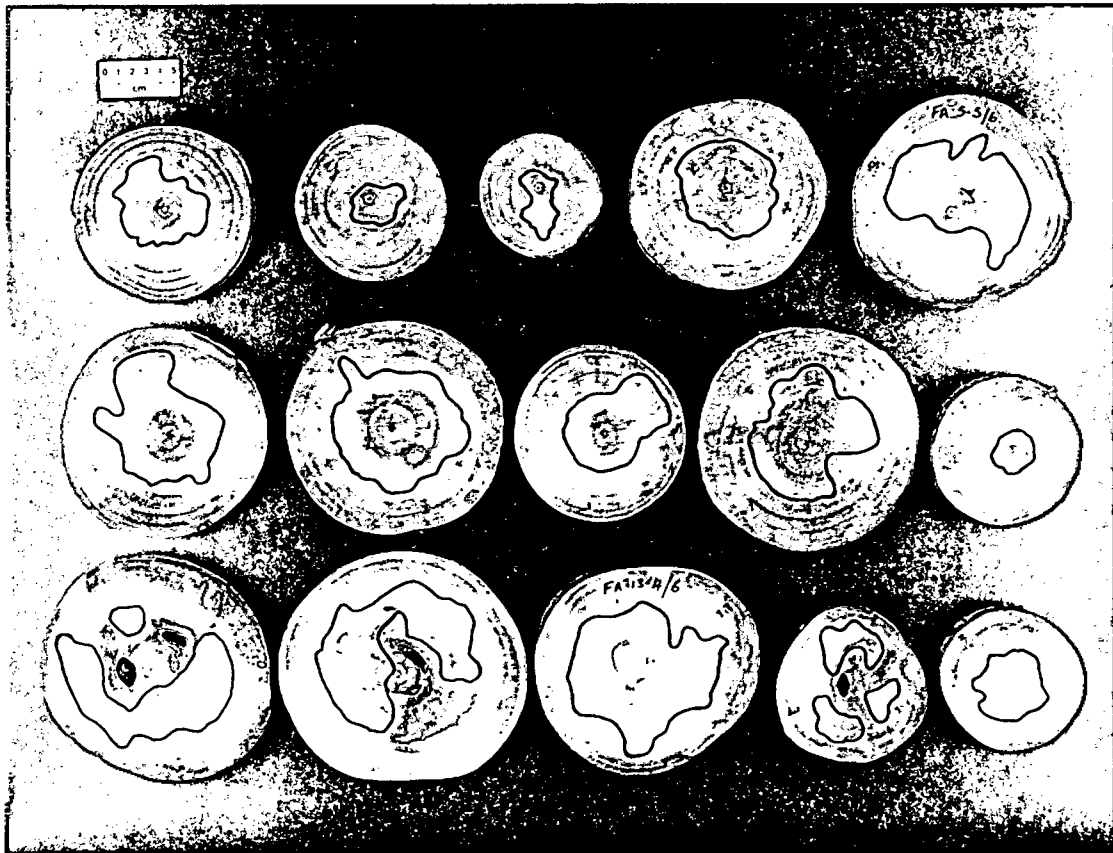


FIGURE 28

PCV spot test results for Group FA samples (5 minute dip in 18% solution, warm diffusion) after eight weeks diffusion. (NZFRI CN315602 - J. Barran)

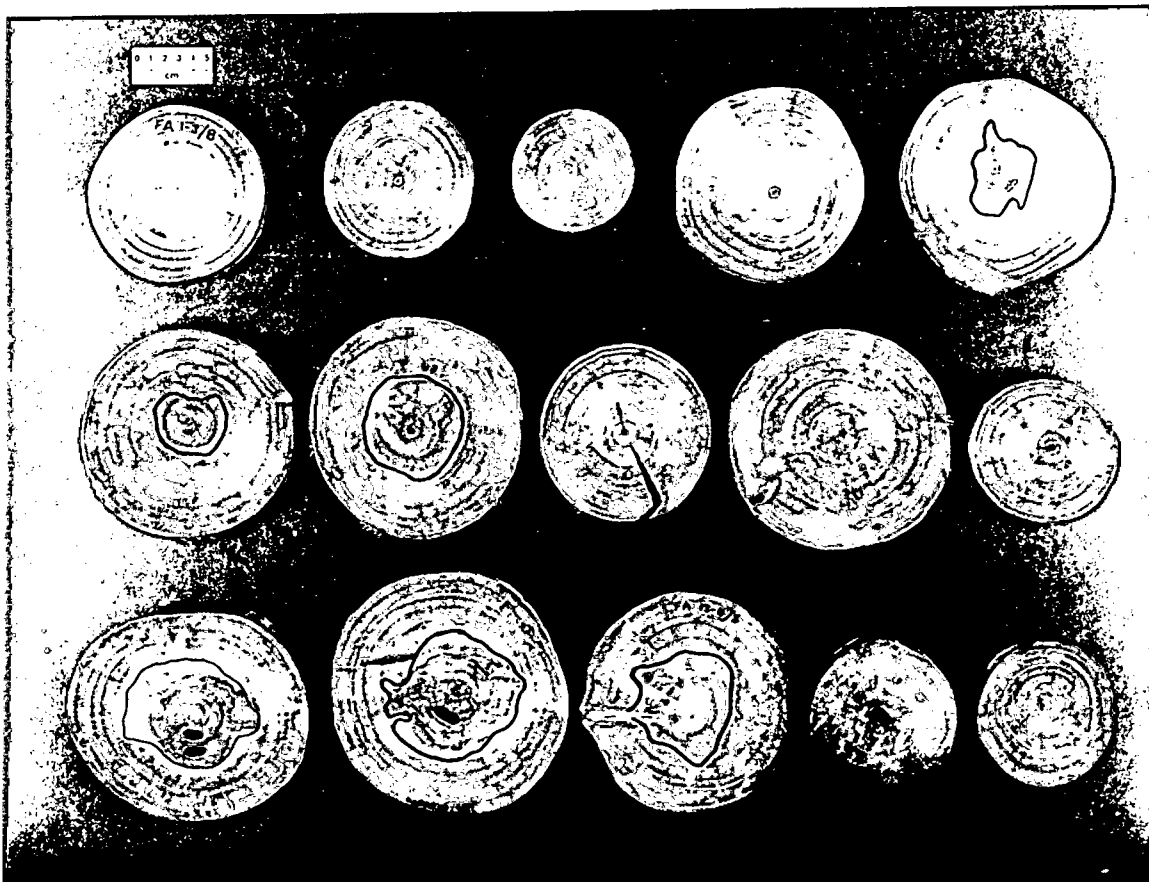


FIGURE 29

PCV spot test results for Group FW samples (Resaturated, 5 minute dip in 18% solution, warm diffusion) after six weeks diffusion. Samples are in numerical order with 1 at the top left. (NZFRI CN315603 - J Barran)

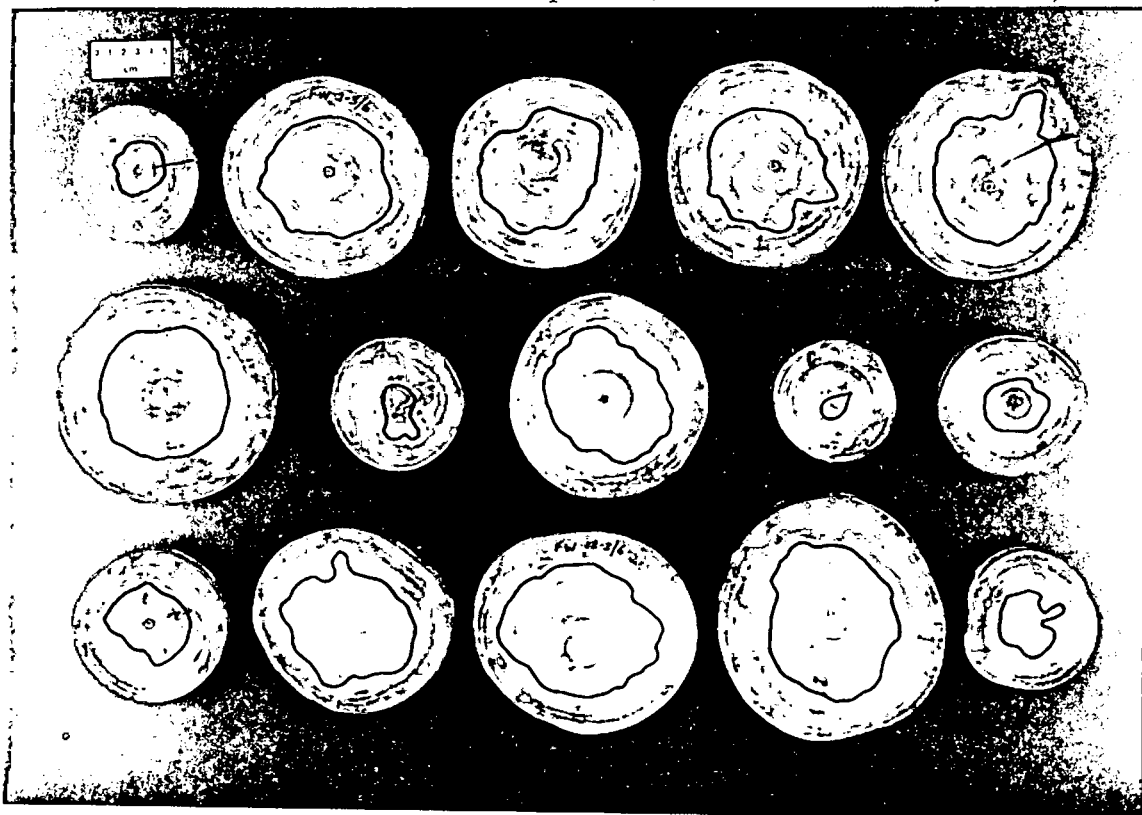


FIGURE 30

PCV spot test results for Group FW (Resaturated, 5 min. dip in 18% solution, warm diffusion) after eight weeks diffusion. (NZFRI CN315604 - J Barran)



FIGURE 31

PCV spot test results for Group GB samples (pressure treat with 2% solution, warm diffusion) after four weeks diffusion. Samples are in numerical order with 1 at the top left and 15 at the bottom right. (NZFRI CN315601 - J Barran)

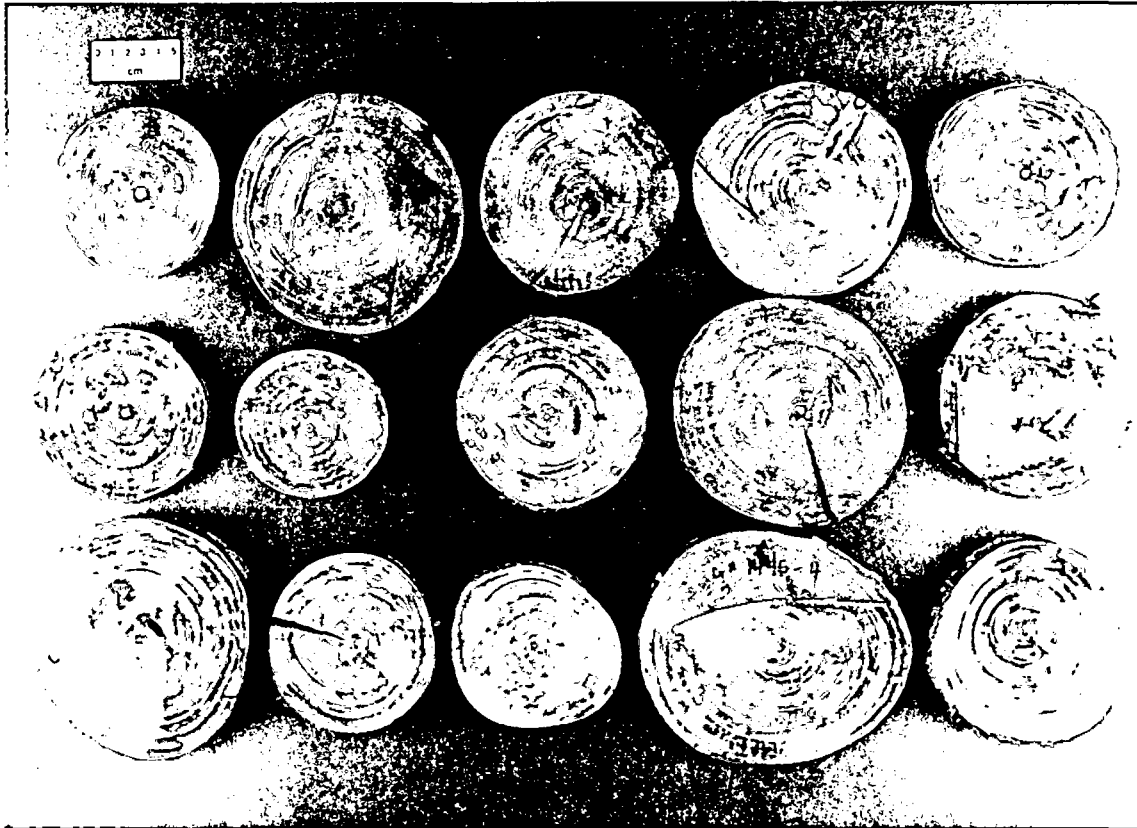


FIGURE 32

PCV spot test results for Group GH (hot and cold bath with 5% solution, warm diffusion) after four weeks diffusion. (NZFRI CN315606 - J Barran)

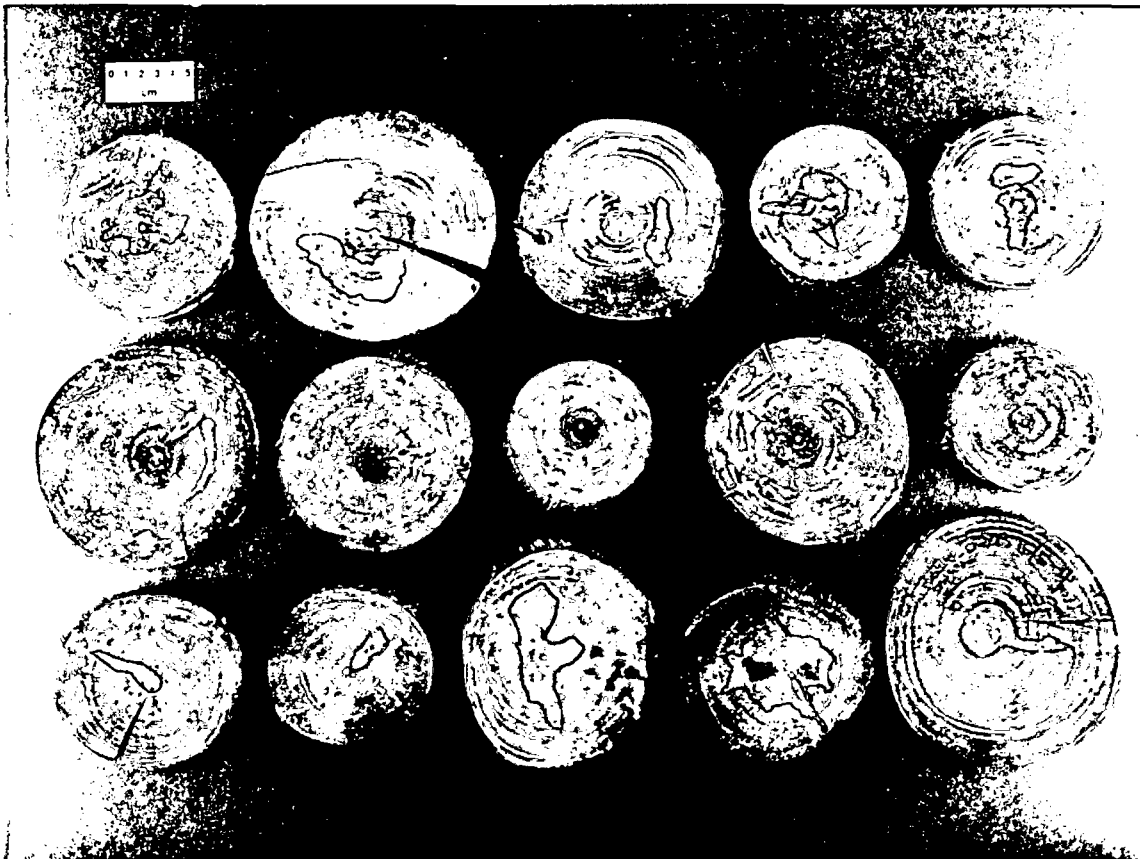


FIGURE 33

Rubeanic acid spot test results for Group GC samples (air dry, pressure treat with 1.6% CCA solution). Samples are in numerical order with 1 at the top left and 15 at the bottom right. (NZFRI CN315607 - J Barran)



APPENDIX I **Sawn Timber Treatment Details**

Sample Number	Weight Before (g)	Weight After (g)	Volume (litres)	Solution Uptake (l/m3)	Boric Acid Retention		
					Estimated (kg/m3)	X Section (g/100g of oven dry wood)	Core
Group AO -							
Ex ship, 10 minute dip in 12% Fbor solution, diffuse outside.							
AO 1-1	2559	2586	3.095	8.72	1.00		
AO 2-1	2592	2624	3.138	10.20	1.17		
AO 3-1	2771	2791	3.180	6.29	0.72		0.082
AO 4-1	2593	2620	3.095	8.72	1.00		
AO 5-1	2282	2309	3.078	8.77	1.01		0.111
AO 5-2	2683	2713	3.037	9.88	1.13		
AO 6-1	2226	2256	3.360	8.93	1.02		
AO 7-1	2083	2115	3.120	10.26	1.18		
AO 8-1	2321	2368	3.300	14.24	1.63		0.219
AO 9-1	2486	2518	3.240	9.88	1.13		0.186
AO 10-1	1856	1886	3.120	9.68	1.11		
AO 11-1	2829	2861	3.240	9.88	1.13		
AO 12-1	2576	2607	3.168	9.79	1.12		0.092
AO 13-1	2602	2642	3.240	12.35	1.41		
AO 14-1	2599	2645	3.138	14.66	1.68		
AO 15-1	2523	2560	3.222	11.55	1.32		0.063
Average				10.24	1.17		0.126

Group AI -							
Ex ship, 10 minute dip in 12% Fbor solution, diffuse inside.							
AI 1-1	2756	2788	3.300	9.70	1.11	0.376	
AI 2-1	2449	2478	3.240	8.95	1.03	0.396	
AI 3-1	2440	2477	2.880	12.85	1.47	0.361	0.204
AI 4-1	2453	2478	3.101	8.06	0.92	0.282	
AI 5-1	2395	2430	3.110	11.25	1.29	0.513	0.131
AI 5-2	2611	2644	3.037	10.87	1.25	0.306	
AI 6-1	2114	2146	3.326	9.62	1.10	0.366	
AI 7-1	2317	2346	3.326	8.72	1.00	0.433	
AI 8-1	1991	2022	2.995	10.35	1.19	0.402	0.083
AI 9-1	2545	2584	3.240	12.04	1.38	0.522	0.208
AI 10-1	2387	2427	3.180	12.58	1.44	0.472	
AI 11-1	2619	2643	3.120	7.69	0.88	0.340	
AI 12-1	2559	2595	3.095	11.63	1.33	0.386	0.144
AI 13-1	2670	2706	2.995	12.02	1.38	0.291	
AI 14-1	2321	2359	3.095	12.28	1.41	0.472	
AI 15-1	2868	2909	3.180	12.89	1.48	0.312	0.086
Average				10.72	1.23	0.389	0.143

APPENDIX I (Contd.)
Sawn Timber Treatment Details

Sample Number	Weight Before (g)	Weight After (g)	Volume (litres)	Solution Uptake (l/m3)	Boric Acid Retention		
					Estimated (kg/m3)	X Section (g/100g of oven dry wood)	Core
Group BO -							
Ex ship, 10 minute dip in 18% Fbor solution, diffuse outside.							
BO 1-1	2424	2448	3.180	7.55	1.35		
BO 2-1	2701	2728	3.078	8.77	1.57		
BO 3-1	2664	2746	3.197	25.65	4.60		0.170
BO 4-1	2382	2413	3.197	9.70	1.74		
BO 5-1	2523	2555	3.180	10.06	1.80		0.129
BO 6-1	2121	2150	3.154	9.20	1.65		
BO 7-1	2054	2087	3.078	10.72	1.92		
BO 7-2	2326	2356	3.300	9.09	1.63		
BO 8-1	2311	2347	3.180	11.32	2.03		0.332
BO 9-1	2160	2199	3.300	11.82	2.12		0.130
BO 10-1	1768	1799	3.019	10.27	1.84		
BO 11-1	3056	3089	3.120	10.58	1.90		
BO 12-1	2553	2588	3.060	11.44	2.05		0.195
BO 13-1	2702	2745	3.095	13.89	2.49		
BO 14-1	2653	2683	3.180	9.43	1.69		
BO 15-1	2540	2572	3.138	10.20	1.83		0.178
Average				11.23	2.01		0.189
Group BI - .							
Ex ship, 10 minute dip in 18% Fbor solution, diffuse inside							
BI 1-1	2444	2483	3.154	12.37	2.22	0.455	
BI 1-2	2646	2680	3.315	10.26	1.84	0.371	
BI 2-1	2504	2530	3.154	8.24	1.48	0.472	
BI 3-1	2586	2619	3.256	10.14	1.82	0.562	0.223
BI 4-1	2338	2369	3.101	10.00	1.79	0.442	
BI 5-1	2684	2719	3.120	11.22	2.01	0.619	0.170
BI 6-1	2014	2051	3.344	11.06	1.98	0.458	
BI 7-1	2407	2436	3.180	9.12	1.63	0.656	
BI 8-1	2436	2478	2.979	14.10	2.53	0.405	0.185
BI 9-1	2489	2522	3.344	9.87	1.77	0.692	0.187
BI 10-1	2013	2046	3.222	10.24	1.84	0.718	
BI 11-1	2881	2909	3.138	8.92	1.60	0.489	
BI 12-1	2388	2429	3.197	12.83	2.30	0.455	0.147
BI 13-1	2564	2624	3.078	19.49	3.49	0.838	
BI 14-1	2461	2498	3.078	12.02	2.15	0.524	
BI 15-1	2567	2602	3.256	10.75	1.93	0.421	0.140
Average				11.29	2.02	0.536	0.175

APPENDIX I (Contd.)
Sawn Timber Treatment Details

Sample Number	Weight Before (g)	Weight After (g)	Volume (litres)	Solution Uptake (l/m3)	Boric Acid Retention		
					Estimated (kg/m3)	X Section (g/100g of oven dry wood)	Core
Group CO -							
Ex ship, 2 minute dip in 12% Fbor solution, diffuse outside.							
CO 1-1	2499	2541	3.095	13.57	1.56		
CO 2-1	2444	2473	3.283	8.83	1.01		
CO 3-1	2690	2737	3.154	14.90	1.71		
CO 4-1	2712	2750	3.315	11.46	1.31		
CO 5-1	2562	2590	2.995	9.35	1.07		
CO 6-1	2027	2057	3.101	9.67	1.11		
CO 6-2	1953	1998	3.344	13.46	1.54		
CO 7-1	2414	2444	3.315	9.05	1.04		
CO 8-1	2284	2328	3.180	13.84	1.59		
CO 9-1	2059	2093	2.960	11.49	1.32		
CO 10-1	1947	1981	3.078	11.04	1.27		
CO 11-1	2930	2960	3.053	9.83	1.13		
CO 12-1	2827	2871	3.240	13.58	1.56		
CO 13-1	2622	2652	3.037	9.88	1.13		
CO 14-1	2587	2629	3.095	13.57	1.56		
CO 15-1	2318	2360	3.019	13.91	1.59		
Average				11.71	1.34		
Group CI -							
Ex ship, 2 minute dip in 12% Fbor solution, diffuse inside.							
CI 1-1	2810	2838	3.265	8.58	0.98	0.263	
CI 2-1	2536	2565	2.920	9.93	1.14	0.388	
CI 3-1	2358	2389	3.212	9.65	1.11	0.289	0.100
CI 4-1	2495	2526	3.078	10.07	1.15	0.286	
CI 5-1	2442	2475	3.138	10.52	1.21	0.235	0.067
CI 5-2	2488	2516	2.954	9.48	1.09	0.258	
CI 6-1	2132	2159	3.203	8.43	0.97	0.532	
CI 7-1	2092	2127	3.060	11.44	1.31	0.286	
CI 8-1	2360	2396	3.256	11.06	1.27	0.383	0.077
CI 9-1	2009	2044	2.920	11.99	1.37	0.447	0.147
CI 10-1	2005	2036	3.197	9.82	1.13	0.349	
CI 11-1	2799	2829	3.138	9.56	1.10	0.206	
CI 12-1	2630	2665	3.078	11.37	1.30	0.263	0.080
CI 13-1	2604	2648	3.095	14.22	1.63	0.401	
CI 14-1	2536	2571	3.344	10.47	1.20	0.235	
CI 15-1	2303	2331	3.019	9.27	1.06	0.293	0.086
Average				10.37	1.19	0.320	0.093

APPENDIX I (Contd.)
Sawn Timber Treatment Details

Sample Number	Weight Before (g)	Weight After (g)	Volume (litres)	Solution Uptake (l/m ³)	Estimated Boric Acid Retention (kg/m ³)	X Section (g/100g of oven dry wood)	Core
Group DO -							
Ex ship, 2 minute dip in 18% Fbor solution, diffuse outside.							
DO 1-1	2596	2623	3.120	8.65	1.55		
DO 1-2	2523	2563	3.315	12.07	2.16		
DO 2-1	2450	2477	2.995	9.01	1.62		
DO 3-1	2625	2655	3.256	9.21	1.65		
DO 4-1	2543	2573	3.078	9.75	1.75		
DO 5-1	2697	2724	3.120	8.65	1.55		
DO 6-1	2190	2222	3.326	9.62	1.72		
DO 7-1	2172	2204	3.180	10.06	1.80		
DO 8-1	2218	2250	3.037	10.54	1.89		
DO 10-1	1821	1849	3.180	8.81	1.58		
DO 10-2	2128	2160	3.222	9.93	1.78		
DO 11-1	3012	3044	3.120	10.26	1.84		
DO 12-1	2675	2705	3.197	9.38	1.68		
DO 13-1	2368	2400	3.060	10.46	1.87		
DO 14-1	2703	2735	3.329	9.61	1.72		
DO 15-1	2287	2315	3.000	9.33	1.67		
Average				9.14	1.64		
Group DI -							
Ex ship, 2 minute dip in 18% Fbor solution, diffuse inside.							
DI 1-1	2659	2685	3.095	8.40	1.51	0.451	
DI 2-1	2708	2748	3.154	12.68	2.27	0.673	
DI 3-1	2475	2495	3.101	6.49	1.16	0.459	0.123
DI 4-1	2594	2617	3.420	6.73	1.21	0.346	
DI 5-1	2437	2468	3.037	10.21	1.83	0.468	0.097
DI 6-1	2111	2142	3.265	9.50	1.70	0.547	
DI 7-1	2183	2216	3.138	10.52	1.88	0.732	
DI 7-2	1901	1932	3.120	9.94	1.78	0.463	
DI 8-1	1967	2002	3.240	10.80	1.94	0.682	0.296
DI 10-1	2301	2327	3.162	8.22	1.47	0.422	0.219
DI 11-1	2670	2704	3.095	10.98	1.97	0.501	
DI 12-1	2678	2719	3.222	12.72	2.28	0.523	0.109
DI 13-1	2613	2645	3.197	10.01	1.79	0.409	
DI 14-1	2583	2614	3.197	9.70	1.74	0.407	
DI 14-2	2447	2478	3.078	10.07	1.80	0.460	
DI 15-1	2444	2471	2.901	9.31	1.67	0.574	0.313
Average				9.77	1.75	0.507	0.193

APPENDIX I (Contd.)
Sawn Timber Treatment Details

Sample Number	Weight Before (g)	Weight After (g)	Volume (litres)	Solution Uptake (l/m3)	Boric Acid Retention		
					Estimated (kg/m3)	X Section (g/100g of oven dry wood)	Core
Group EB -							
Ex Ship, pressure treat with 2.2% Fbor solution, diffuse inside							
EB 1-1	2718	3354	3.120	204	4.42	1.118	
EB 2-1	2273	2908	3.000	213	4.62	1.026	0.545
EB 3-1	2626	3275	2.978	218	4.73	1.574	
EB 4-1	2431	3278	3.162	268	5.81	1.280	0.827
EB 4-2	2608	3374	3.222	238	5.16	1.222	
EB 5-1	2400	3280	3.138	280	6.09	1.357	0.486
EB 5-2	2547	3273	3.078	236	5.12	1.068	
EB 6-1	1664	2707	3.222	324	7.02	1.881	1.402
EB 7-1	2231	2940	3.256	218	4.73	1.510	
EB 7-2	2057	2805	3.078	243	5.27	0.972	
EB 8-1	2458	3201	3.222	231	5.00	1.143	
EB 10-1	2066	2879	3.120	261	5.65	1.776	
EB 11-1	2892	3370	3.120	153	3.32	0.677	
EB 12-1	2375	3226	3.019	282	6.12	1.422	0.839
EB 14-1	2493	3268	3.154	246	5.33	1.308	0.871
EB 15-1	2606	3343	3.138	235	5.10	1.247	
Average				241	5.22	1.286	0.828

APPENDIX I (Contd.)
Sawn Timber Treatment Details

Sample Number	Weight Before (g)	Weight After (g)	Volume (litres)	Solution Uptake (l/m ³)	CCA (Active Elements) Estimated (kg/m ³)	Retention X Section (g/100g of oven dry wood)	Retention Core
Group EC - Air dry, pressure treat with 1.6% CCA solution.							
EC 1-1	1316	3076	3.037	580	3.63	0.806	0.804
EC 2-1	1585	3225	3.120	526	3.30	0.724	
EC 2-2	1366	3026	3.197	519	3.26	0.706	
EC 3-1	1366	3092	3.067	563	3.53	0.698	
EC 4-1	1452	3207	3.120	563	3.53	0.555	0.694
EC 5-1	1566	3332	3.315	533	3.34	0.458	0.675
EC 6-1	1050	2613	3.154	496	3.11	0.649	0.780
EC 7-1	1132	2886	3.344	525	3.29	0.607	
EC 8-1	1503	3046	3.180	485	3.04	0.860	0.776
EC 10-1	1148	2886	3.240	536	3.36	0.892	
EC 10-2	1530	2938	3.180	443	2.78	0.914	
EC 11-1	1127	2662	3.120	492	3.08	0.546	
EC 12-1	1460	3197	3.154	551	3.45	0.717	0.729
EC 14-1	1464	2969	3.120	482	3.02	0.606	
EC 15-1	1775	3025	3.203	390	2.45	0.530	
EC 15-2	1540	3180	3.265	502	3.15	0.675	
Average				512	3.21	0.684	0.743

Sample Number	Volume (Litres)	Solution Uptake (l/m ³)			Copper Retention	
		First Dip	Second Dip	Total	Estimated (kg/m ³)	X-Section (g/100g)
Group EB - Ex boron diffusion, double dip in 25% Copper Sulphate						
EB 1-1	1.75	7.4	13.1	20.6	1.38	
EB 2-1	1.95	9.2	6.7	15.9	1.07	
EB 3-1	1.90	6.8	12.1	18.9	1.27	
EB 4-1	2.03	10.9	12.3	23.2	1.56	
EB 4-2	2.05	4.9	9.8	14.6	0.99	
EB 5-1	2.01	6.0	8.0	13.9	0.94	
EB 5-2	1.97	7.6	8.1	15.8	1.06	
EB 6-1	2.07	9.2	7.7	16.9	1.14	
EB 7-1	2.13	6.6	11.7	18.3	1.23	
EB 7-2	2.01	5.5	7.5	12.9	0.87	
EB 8-1	1.97	9.6	9.1	18.8	1.27	
EB 10-1	2.04	5.4	8.8	14.2	0.96	
EB 11-1	2.02	7.9	12.4	20.3	1.37	
EB 12-1	1.96	6.1	12.2	18.3	1.24	
EB 14-1	2.05	7.8	11.7	19.5	1.31	
EB 15-1	2.05	8.3	12.7	21.0	1.41	
Average		7.5	10.3	17.7	1.19	

APPENDIX II

Roundwood Treatment Details

Sample Number	Average Diameter (mm)	Moisture	First Dip		2nd Dip	Total		Boric Acid Retention X Section Core (g/100g of OD wood)
		Content % Before Treatment	Solution Uptake (l/m3)	Estimated Retention (kg/m3)	Solution Uptake (l/m3)	Estimated Retention (kg/m3)		

Group FA - Ex ship, 5 minute dip in 18% Fbor solution, diffuse inside.

FA 1-3	127	68.4	0.80	0.14	3.88	0.84		
FA 2-1	114	46.9	2.73	0.48	4.47	1.29		
FA 3-5	92	44.0	3.85	0.68	5.78	1.72		
FA 4-3	139	66.4	1.96	0.34	2.86	0.86		
FA 5-5	153	62.4	2.41	0.42	2.28	0.83		
FA 6-4	155	55.6	2.26	0.40	1.53	0.67		
FA 7-5	159	78.7	2.26	0.40	3.07	0.95		
FA 8-4	128	65.4	3.68	0.65	4.06	1.38		
FA 9-5	161	80.0	1.92	0.34	2.41	0.77		
FA 10-2	109	61.3	2.92	0.51	2.39	0.94		
FA 11-4	168	92.7	4.98	0.88	3.69	1.54		
FA 12-3	180	86.9	5.79	1.02	4.82	1.89		
FA 13-4	154	75.1	0.92	0.16	3.03	0.71		
FA 14-3	105	66.9	11.83	2.08	12.69	4.37		
FA 15-1	105	59.6	4.07	0.72	4.21	1.47		

Average		67.4	3.49	0.61	4.08	1.35		
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Group FW - Resaturated, 5 minute dip in 18% Fbor solution, diffuse inside.

FW 1-4	148	150.0	8.78	1.55	1.24	1.77		
FW 2-3	149	150.1	1.23	0.22	1.89	0.56		
FW 3-1	144	138.2	0.93	0.16	0.85	0.32		
FW 4-1	100	165.1	1.89	0.33	2.99	0.87		
FW 5-4	149	132.2	1.29	0.23	1.29	0.46		
FW 6-5	163	157.9	0.65	0.12	1.07	0.31		
FW 7-4	96	195.5	1.87	0.33	1.87	0.66		
FW 8-1	146	174.1	1.40	0.25	0.66	0.37		
FW 9-1	93	166.4	2.01	0.35	2.01	0.72		
FW 10-3	101	167.8	1.24	0.22	1.09	0.41		
FW 11-5	111	147.2	1.55	0.27	1.81	0.60		
FW 12-1	142	132.2	1.04	0.18	1.60	0.47		
FW 13-3	158	155.8	1.39	0.25	1.39	0.50		
FW 14-4	173	157.4	1.41	0.25	1.77	0.57		
FW 15-2	100	149.7	2.09	0.37	3.05	0.92		

Average		156.0	1.92	0.34	1.64	0.63		
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APPENDIX II (Contd.)
Roundwood Treatment Details

Sample Number	Average Diameter (mm)	Moisture Content % Before Treatment	Weight Before Treatment (g)	Weight After Treatment (g)	Solution Uptake (l/m ³)	Estimated Retention (kg/m ³)	Boric Acid Retention X Section (g/100g of OD wood)	Core
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Group GB - Ex ship, Pressure treated with 2.2% Fbor solution, diffuse inside.

GB 1-1	117		4937	5893	113	2.457	0.556	
GB 2-5	159		11092	12661	98	2.122	0.399	
GB 3-2	135		7909	9833	168	3.637	0.820	
GB 4-2	105		4202	5114	128	2.787	0.526	
GB 5-2	112		4708	5817	142	3.081	0.718	
GB 6-3	145		7377	9183	136	2.952	0.479	0.390
GB 7-1	130		5349	7338	184	3.990	1.040	
GB 8-3	99		3759	4834	172	3.727	0.759	
GB 9-2	133		6131	8120	181	3.937	1.270	0.474
GB 10-4	96		3391	4380	168	3.651	1.310	
GB 11-1	122		5814	7128	140	3.047	1.040	
GB 12-5	111		4860	6180	171	3.719	0.880	
GB 13-5	141		9011	10626	124	2.691	0.804	0.326
GB 14-2	123		6170	6961	83	1.792	0.556	0.209
GB 15-5	168		13334	16238	161	3.492	0.602	0.220
Average					145	3.139	0.784	0.324

Group GH - Ex ship, Hot & Cold Bath treatment in 5.0% Fbor solution, diffuse inside.

GH 1-2	112	38.3	4656	5188	67	3.2	0.64	
GH 2-4	153	71.4	10507	12842	157	7.4	2.07	2.17
GH 3-3	129	60.3	7157	7791	60	2.8	1.04	
GH 4-5	143	75.3	9593	11421	140	6.6	1.27	0.42
GH 5-3	124	41.1	5979	8189	229	10.8	2.12	
GH 6-2	117	68.7	4864	6719	216	10.2	3.99	
GH 7-3	101	57.3	3533	5262	266	12.5	4.21	
GH 8-5	123	65.6	5481	7649	224	10.6	4.48	
GH 9-4	146	70.2	7166	9598	182	8.6	1.87	1.27
GH 10-1	129	62.3	5853	7683	173	8.2	2.66	
GH 11-3	155	86.3	11415	13792	156	7.4	2.10	2.54
GH 12-3	117	68.2	5656	7810	249	11.7	3.35	
GH 13-2	113	56.3	5050	7723	330	15.6	6.16	
GH 14-5	164	89.2	11978	15402	204	9.6	2.06	1.60
GH 15-3	132	62.8	7386	9748	216	10.2	2.55	
Average		64.9			191	9.0	2.70	1.60

APPENDIX II (Contd.)
Roundwood Treatment Details

Sample Number	Average Diameter (mm)	Moisture Content % Before Treatment	Weight Before Treatment (g)	Weight After Treatment (g)	Solution Uptake (l/m3)	Estimated Retention T.A.E (kg/m3)	T.A.E. Retention X Section Core (g/100g of OD wood)	
Group GC - Air dry, Pressure treated with 1.6% CCA solution.								
GC 1-5	153	27.0	7719	13807	418	2.39	0.651	0.520
GC 2-2	110	18.0	3758	7448	484	2.77	0.612	
GC 3-4	128	19.3	5252	9323	400	2.29	0.461	
GC 4-4	148	27.6	7345	14188	491	2.81	0.556	0.511
GC 5-1	116	16.5	4079	8487	531	3.03	0.641	
GC 6-1	114	20.1	3533	6101	310	1.77	0.626	
GC 7-2	123	20.5	4032	6528	258	1.48	0.358	
GC 8-2	93	19.4	2467	4238	325	1.86	0.509	
GC 9-3	137	22.1	5029	9984	418	2.39	0.490	0.395
GC 10-5	136	26.4	5132	8682	304	1.74	0.519	
GC 11-2	138	23.2	6730	10404	298	1.70	0.398	
GC 12-2	152	31.2	8483	13228	327	1.87	0.344	0.155
GC 13-1	92	25.7	3028	5369	431	2.46	0.555	
GC 14-1	145	19.4	6524	10634	304	1.74	0.530	
GC 15-4	146	24.4	6965	12599	424	2.42	0.378	0.342
Average		22.7			381	2.18	0.509	0.385