RECORD
of the
1989 ANNUAL CONVENTION
of the
BRITISH WOOD PRESERVING ASSOCIATION

Cambridge
July 4th-7th, 1989

Issued by the
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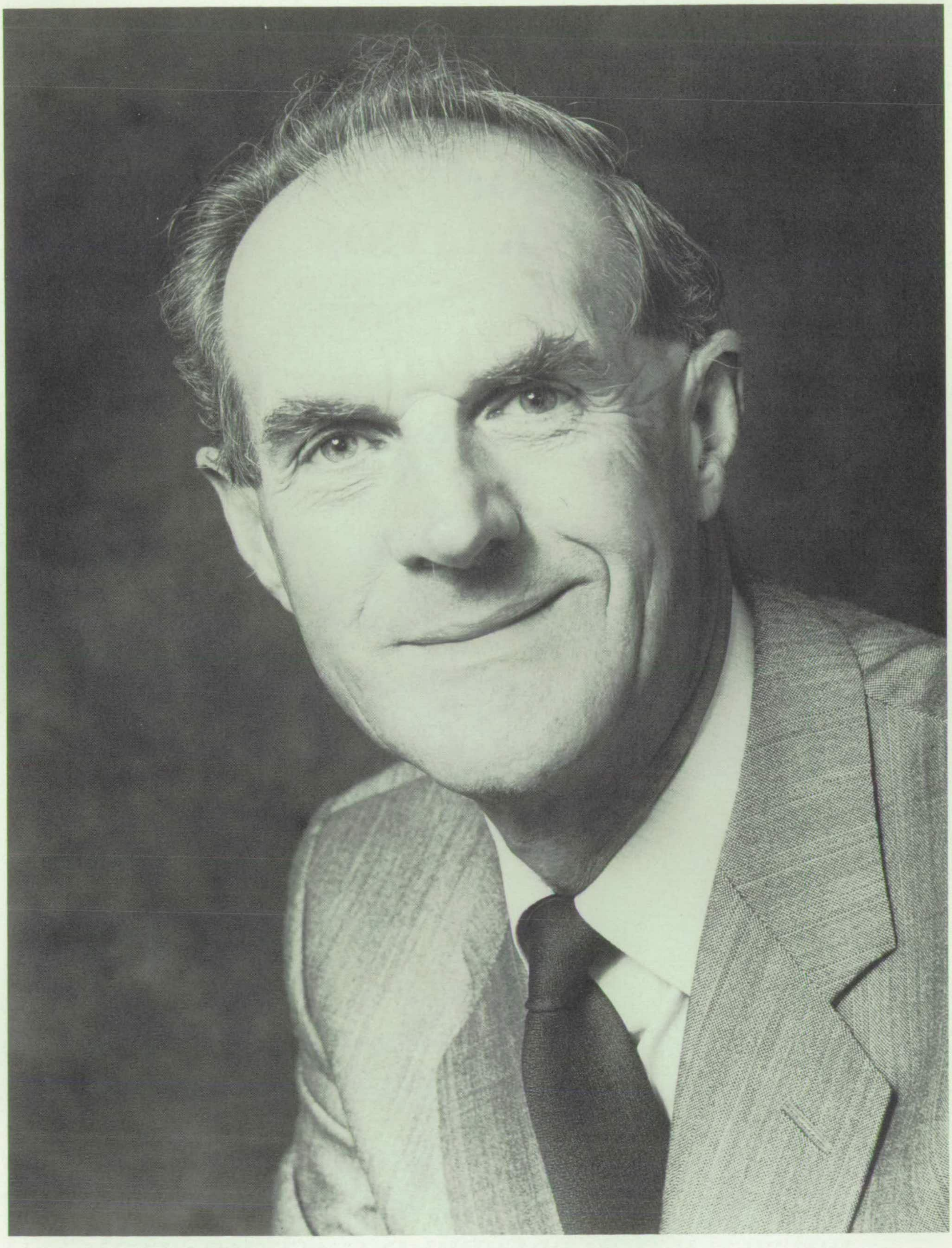

E. A. Hilditch
President of the British Wood Preserving Association

The British Wood Preserving Association

BUILDING NO. 6, THE OFFICE VILLAGE, 4 ROMFORD ROAD,
STRATFORD, LONDON E15 4EA

BRITISH WOOD PRESERVING ASSOCIATION

The British Wood Preserving Association is a scientific and advisory association.

It is a body which collects information on the preservation and fireproofing of timber and the methods of applying preservatives and fire retardants; it sponsors scientific research into the use of preservatives and fire retardants, and makes available to all enquirers the results of its researches by the publication of leaflets, a technical advice service and specialist lectures. It is completely impartial in its outlook and in the advice it gives. Among other objects it aims at making known the advantages of using preserved timber in the interests of the consumer and the national economy.

MEMBERSHIP: Amongst the members are

Learned societies and research bodies at home and overseas.
Architects, surveyors, builders, etc.
Manufacturers of all types of preservatives and fire retardants.
Users of timber.
Firms operating all forms of treating plant.
Specialists in the remedial and curative treatment of timber *in situ*.
Manufacturers of plant.

COMMITTEES

In the working of its committees close liaison is maintained with Government Departments, as well as with the principal consuming industries.

On the Council there are representatives of learned societies, scientific bodies, principal consumers, architects and consultants, as well as manufacturers and those who specialise in preservative treatment of timber.

Other Committees deal with technical matters, finance, membership and environmental problems.

On several of these Committees there are representatives of the nationalised industries, consuming industries, and organisations such as Princes Risborough Laboratory, T.R.A.D.A. and the Health and Safety Executive.

SERVICES

It offers a free advisory service on all problems connected with timber preservation.
It publishes a technical manual, issues leaflets dealing with practical problems and the latest developments in research.
It holds an Annual Convention at which specialist papers are presented by experts from all over the world.
It publishes in book form a Record of the Annual Convention containing copies of the papers, etc.
It issues free of charge to all members a News Sheet.
It maintains a panel of lecturers whose services are available on request.
It organises exhibitions to show the value of preservation.
It arranges visits to the works of manufacturers and treaters.
It represents the industry on a number of international committees connected with timber preservation.

FINANCES

It should be appreciated that the Association depends entirely on subscriptions and special contributions from its members. This, of course, enables it to remain completely independent and at the same time to maintain its impartial and scientific approach to all problems.

CONTENTS

OPENING ADDRESS BY THE PRESIDENT MR. E. A. HILDITCH

THE PRESIDENT: Good morning, Ladies and Gentlemen. We will start the Convention on time on the basis of those who have missed two or three minutes will not have missed much.

I open this Convention with two apologies: first, that the papers from last year's Convention have only just been circulated and, secondly, the papers for this year's Convention have not been pre-circulated. I am not going to offer you any string of excuses. Both are wrong. It is the President's responsibility to chase the office and it is the responsibility of the office to chase the authors. All three, I regret, are at fault. I do hope, however, you managed to read all the papers last night. One particular feature of this Convention is that the sessions are for amplification, illustration and discussion. Papers should have been read beforehand. I do hope that authors of the future will accept that papers must reach the office some time in May for pre-circulation. With all the work which goes into preparing papers, this is something that authors should give proper attention to.

Since the 1988 Convention the wood preserving industry has been subject to unprecedented media attack on the question of health and the environment. The industry was not ready to respond to this, and yet it should have been. The offensive parallels that in Germany a few years ago. As I have said, the industry was not ready and no-one can be very happy about the response. It is my view that at least one of the reasons why we were not able to respond, but not the only one, was that our technological basis was not deep enough and not sound enough. I believe that to survive in future years the industry, as a whole, must learn to look at research and development for it is only with a sound and unquestionable basis of knowledge that we will be able to resist the pressures that are now bearing in on us. In providing a forum for discussion of these matters this Convention, which I also hope will motivate future research, is a shining light. We must ensure that it continues and indeed, grows to achieve greater things.

Turning to another aspect of the future, the long debated amalgamation with the British Chemical Damp-Course Association draws nigh. Plans are well laid and the meeting of this Association to approve this amalgamation will occur later this month. I say to you, please, if you are in any way able to, come along. It is important, whatever decision is taken, it is, and is seen to be, in accordance with the will of the majority of the members of this Association.

We have at this Convention something like 190 members in total. This is a good average, being a few above those who attended last year, and we have, of course, the usual large contingent from overseas. The numbers attending the Dinner will be down a little. Perhaps this suggest that we are due for a little more work and a little less play and it depends on your frame of mind whether this is good or bad.

Ladies and Gentlemen, the 1989 Annual Convention is now open.

PERFORMANCE OF METAL FASTENERS IN C.C.A. TREATED TIMBER

by J. N. Cross, G. Bailey, G. A. M. Sussex‡, M. J. Schofield*

Capcis/Umist
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1. Introduction

Metal fasteners are widely used for joining timber. Mild steel and galvanised mild steel are the most common materials employed and over the last few years doubt has been raised regarding the integrity of some joints made with these metals, such as those used in roof trusses[1-4]. The concern centred around the possibility of enhanced corrosion of the fasteners when copper-chromium-arsenic (C.C.A.) preservatives were used to treat the timber.

Evidence of enhanced corrosion was based on observations of the corrosivity of fresh (un-fixed) C.C.A. treated timber and treated timber exposed to very humid environments. However, timbers are rarely used in such conditions. A minimum fixation time is specified within which freshly treated timber should not be used, during which most of the preservative salts become fixed. The moisture content of timber in very humid environments is 22 per cent and upwards, tending to be greater in treated than untreated timber. Roof trusses experience much lower moisture contents of, perhaps, 10-18 per cent. Timber and other building materials such as plaster are at great risk of deterioration when their moisture contents exceed approximately 22 per cent.

In view of these observations, a need was identified for the corrosion rate determination of metal fasteners in contact with treated timber at 'realistic' moisture contents i.e. typical of those found in service[5]. In this range, 10-22 per cent moisture content, the electrical conductivity of timber is too low to enable conventional (d.c.) corrosion measurement and monitoring techniques, such as polarisation resistance, to be used. However, UMIST have developed and are using electrochemical noise and impedance techniques which are applicable to low conductivity media.

A collaborative research project was therefore instigated at CAPCIS, funded by the Department of the Environment (through the Building Research Establishment) and two industrial sponsors, Hickson World Timber Limited and Rentokil Limited. The main objective of the project was to determine, using modern electrochemical corrosion monitoring techniques, the corrosion performance of metal fasteners in C.C.A. treated timber with particular emphasis on normal timber moisture contents.

This paper presents the essential findings of the investigation, while the full results are to be published by the Building Research Establishment.

2. Practical Work

In January 1986, a two-year experimental programme was initiated involving the exposure of timber blocks (dimensions 20 cm x 10 cm x 2·5 cm) in which various metals were embedded. The blocks were exposed in artifical laboratory and natural roof space environments. The variables which were studied included:-

(i) Timber type (a) Baltic Redwood – *Pinus Sylvestris*
(b) European Spruce – *Picea Abies*

(ii) Treatment type (a) C.C.A. salt formulation – Tanalith C
(b) C.C.A. oxide formulation – Celcure A

(iii) Laboratory temperature – 10°, 25° and 35°C
(iv) Relative humidity – 87% to 100%
(v) Timber moisture content – 17% to 26%
(vi) Metals – Mild steel, zinc electroplated steel, galvanised steel, stainless steel (type 304) and an aluminium alloy (B.S. 6063)

Site exposures were made at four locations in the North West of England (Liverpool, Flixton, Sale and Ramsbottom); these were chosen to represent the spectrum of roof design, usage pattern and hence micro-climates present in dwelling houses. The measured moisture contents of timber samples were from 10 per cent to 18·5 per cent.

The corrosion monitoring techniques used to determine corrosion rates and corrosion mechanisms for the various metals embedded in timber were electrochemical impedance (E.I.M.), zero resistance ammetry (Z.R.A.) and electrochemical noise (E.C.N.). Information relating to these techniques can be found in refs 6 to 11. The high resistivity of dry and medium-moisture content timber precluded the use of conventional corrosion monitoring techniques such as linear polarisation resistance measurement (L.P.R.M.). A novel electrode configuration was developed to allow monitoring in the timber; the 'comb electrode' as shown in Figure 1. The monitoring instrumentation is shown schematically in Figure 2.

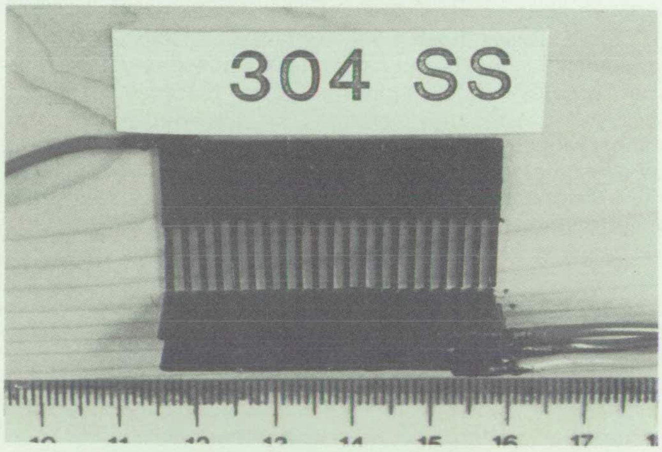

Fig. 1. CAPCIS comb electrodes. A three electrode arrangement is inserted in the timber.

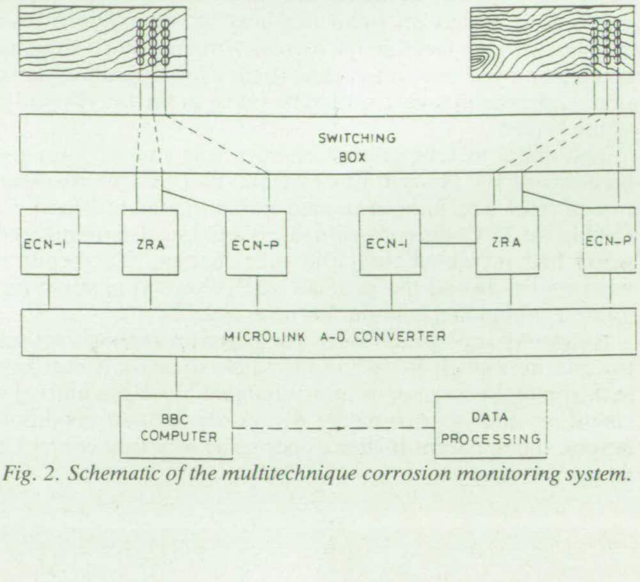

Fig. 2. Schematic of the multitechnique corrosion monitoring system.

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* CORTEST Laboratories Limited, 23 Sheperd Street, Sheffield S3 7BA, U.K.

3. Results and Discussion

Selected results are presented here to illustrate the most important effects that were observed, although additional confirmatory and proving experiments were conducted. Most of the experiments were carried out using untreated and salt formulation C.C.A. treated timbers.

3.1 The Effect of Moisture Content

Table 1 illustrates the strong dependence of corrosion rate of mild steel on timber moisture content.

The data indicate that there exists a 'critical' moisture content below which the rate of corrosion is negligible, and above which the rate of corrosion increases measurably in both treated and untreated timber, especially the former. This effect can probably be explained by the increase in conductivity of the timber at higher moisture contents, enabling corrosion by acetic acid and/or differential aeration to proceed. In treated timber, the presence of hygroscopic salts of sodium sulphate are believed to further increase the conductivity.

3.2 Differences Between Metals

Table 2 compares the typical corrosion rates obtained after approximately one years' exposure at high moisture content in treated (30 per cent M.C.) and untreated (24·5 per cent M.C.) redwood. The data for electroplated zinc were determined using pressure saturated timber after five months exposure (sodium sulphate saturated untreated timber and distilled water saturated treated timber).

The results confirm that more corrosion resistant materials such as stainless steel can be used in very damp timber, both treated and untreated.

3.3 Site Exposure Testing

Continuous temperature and relative humidity recording, coupled with periodic moisture content determination was undertaken at the four exposure sites. The average monthly temperatures ranged from 5°C to 17°C, the average monthly relative humidities ranged from 55 per cent to 85 per cent and the moisture contents ranged from 10 per cent to 14·5 per cent for the untreated timber and from 12·5 per cent to 18·5 per cent for the treated timber.

Corrosion monitoring was carried out on mild steel, zinc electroplated steel and aluminium electrodes embedded in treated and untreated redwood. Corrosion rates were generally immeasurably low, the highest rate indicated being some 0·02μm/yr for zinc electroplated steel in treated timber. The results of corrosion monitoring under service conditions are in accordance with those obtained in the laboratory studies.

3.4 General

A number of additional experiments were carried out, the results of which are summarised below. Some of these experiments were based on small numbers of observations; this, coupled with the fact that the corrosion monitoring techniques being employed were often close to their lower limits of detection, demands that care should be taken in the interpretation of the results.

The effect of temperature on corrosion rate at a relative humidity of 100 per cent was variable. At 10°C, the corrosion rate of mild steel in both treated and untreated redwood was similar. At 25°C, the corrosion rate of mild steel in treated redwood had increased fifty fold over that at 10°C, while in untreated redwood the increase at 25°C was very slight (see Table 1, right hand column, for rates at 25°C).

Redwood and spruce were compared in their corrosivity towards mild steel. Redwood was found to be more corrosive than spruce by a factor of approximately 5½ in the untreated condition and approximately 8½ in the treated condition, despite the apparent higher (3 per cent) moisture content of the spruce samples.

At moisture contents of approximately 30 per cent and 26 per cent respectively, salt formulation C.C.A. treatment (loading of 14·5 kg/m^3) was found to be some five times more corrosive towards mild steel than oxide formulation C.C.A. treatment (loading of 5·2 kg/m^3).

In treated redwood of approximately 26 per cent moisture content, the corrosion rate of mild steel combs sampling along the grain was approximately 50 per cent greater than combs sampling across the grain, this probably being due to increased ionic conductivity along the grain.

TABLE 1
Corrosion rate of mild steel (μm/year)

	Moisture Content/Temperature		
	17%/35°C	*21%/25°C*	*24·5%/25°C*
Untreated Redwood	1	18	26
	19%/35°C	*26%/25°C*	*30%/25°C*
Treated Redwood	2	250	500

(i) The corrosion rates were estimated by electrochemical impedance measurements and checked by visual examination.
(ii) The moisture contents were determined by moisture meter. The values for treated redwood are not corrected for the effect of salts.
(iii) Preservative loading was 14·5 kg/m^3, after fixing.

TABLE 2
Materials and estimated general corrosion rates (μm/yr) at 25°C and with high moisture contents

	Untreated redwood (24·5% M.C.)	*Treated redwood (30% M.C.)*
Mild steel	26	500
Electroplated zinc(ii)	39	88
Galvanised steel(iii)	13	43
Stainless steel	0·22	0.26
Aluminium(iv)	0·36	4·7

(i) The corrosion rates were estimated by electrochemical impedance measurements and checked by visual examination.
(ii) The zinc coating had corroded away completely (15-30 μm) from the underlying steel in both treated and untreated redwood. Attack to the steel was very slight in the sodium sulphate saturated untreated timber and in the range 15-30 μm in the distilled water saturated treated timber.
(iii) The zinc coating had corroded away completely from the nail plate surfaces in contact with the treated timber and localised attack of the mild steel had progressed to estimated depths of up to 100 μm (0·1 mm). There was evidence of slight zinc corrosion on the contact surfaces of the nail plate in untreated timber.
(iv) Pitting attack had progressed to a depth of approximately 10 μm (0.01 mm) on combs in untreated timber and approximately 50 μm (0.05mm) on combs in treated timber. Furthermore, intergranular corrosion had occurred to the extent of approximately 500 μm (0.5 mm) on combs in the treated timber.

4. Conclusions

The essential conclusion of this two year research programme is that at normal moisture contents i.e. below approximately 19 per cent, the corrosion rates of mild steel, electroplated/galvanised steel, aluminium alloy and stainless steel are extremely low in both C.C.A. treated and untreated timbers. Corrosion rates of several microns per year are low enough to be ignored. At moisture contents of approximately 26 per cent, rates of some 0·2 mm/yr are experienced by steel and zinc (in the form of galvanising and zinc electroplate) in treated timber. At very high moisture contents of approximately 30 per cent, steel in treated timber corrodes at up to 0·5 mm/yr. Stainless steel (type 304) and aluminium alloy (B.S. 6063) exhibited negligibly low corrosion rates under all test conditions except for pitting and severe intergranular corrosion of the aluminium in treated timber at very high moisture levels.

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ACKNOWLEDGEMENTS

The authors wish to thank the sponsors of this research programme, carried out at CAPCIS-UMIST, for permission to publish the work.

DISCUSSION ON PAPER 1

Chairman: The President

THE PRESIDENT: Perhaps Jeff Cross would like to join us on the platform. We have 15 minutes or so for questions. Can I start the ball rolling? How did you measure the moisture content in the wood?

DR. BAILEY: There were three methods essentially. One was the T.R.A.D.A. charts which give indications of moisture content versus relative humidity at a given temperature. The other technique was to weigh oven dry pre-weighed blocks of timber, giving the direct moisture content. The third way was to use a commercial moisture meter.

THE PRESIDENT: Was this a resistance meter?

MR. CROSS: Yes, it was.

THE PRESIDENT: Was the calibration for salt treated wood?

MR. CROSS: No, we just used a calibration for untreated wood.

THE PRESIDENT: Did the results of the moisture meter reading on the treated timber correlate with the oven dry treated wood on the same timber?

MR. CROSS: Yes, they were fairly close.

MR. D. SCUTT (Fosroc Ltd.): I have a small criticism, I am afraid. It relates to the method of exposing timber on site. I am sure the method used was very good to represent the moisture content of those timbers in a similar position, in other words, the ceiling rafters, the ceiling joists. If, in fact, you go into a roof space in the winter, in a centrally heated house, occupied by a fairly normal family, with correct building practice, in fact, you ought not to get much condensation but, in actual practise, very frequently you will find roof spaces are not as well ventilated as they ought to be. In cold weather, when you can have snow on the roof or frost on the roof, in a fairly modern house, which has felt underneath the tile battens, you will frequently find quite a high level of condensation on the underside of that felt.

This clearly can affect the moisture content of the rafters of the roof, not as a result of raised humidity but as a result of actual liquid water. So I am a little bit critical of that method of assessing moisture content.

DR. G. BAILEY: How would you suggest that we ought to do it?

MR. D. SCUTT: Well, you have got to have your blocks fixed in a similar position to the rafters in a roof where they are, in fact, in contact with the felt on the underside of the tile battens and, of course, this only applies in the winter when you have high levels of heating in the house and moisture vapour, and a cold surface on the outside. So it does not apply throughout the year, but in the winter period, which can be fairly extended, you can get this phenomenon. I mean, I have seen this on a number of occasions. I have actually seen an instance – on one occasion only – where decay had occurred in rafters for exactly that reason.

DR. JOHN MORGAN (B.R.E.): It may seem surprising to the speakers that although I come from B.R.E. this is the first sight I have had of this work and I must congratulate the authors in filling in a lot of information we did not have in the past.

My question to them is, has anything which they have done contradicted any of the sort of simple wisdom that was developed from our earlier experiments three or four years ago?

DR. G. BAILEY: No, it has not, but it has filled in a useful range of the midground moisture content. A lot of the early work that was done was done for very natural reasons, for reasons of accelerated testing at very high moisture contents, but that data is not really applicable to the practical situation we are in in the vast majority of instances. The work carried out at UMIST concentrated on the mid-range of 14 to 20 per cent moisture content, which is the common usage range for trussed roofs.

DR. D. S. BELFORD (Private Member): I compliment the authors on a most interesting paper. It certainly does give rise to increased confidence, I think, as you rightly say in your concluding remarks. You have given us, with some precision, relative rates of corrosion under different conditions in different substrates, but of course the proof of the pudding is in the eating and what people are really concerned about is the strength of the fastening. Have you done, or do you plan to do, any work on correlating the degree and extent of corrosion with strength?

DR. BAILEY: Not presently, no. As I said, the work is now essentially concluded. I think it should be said, though, that the corrosion rates which were measured under practical conditions i.e. medium moisture contents, were so low, so very low – of the order of 0·01 of a micrometer per year – that the extent of iron salts and hydroxides diffusing into the timber would be so small as not to result in any degradation or loss of strength.

DR. BELFORD: That, perhaps, should be emphasised, I think.

MR. J. DAVID (Catomance): I think if we could guarantee that the moisture content would be contained at very low levels there would be very little argument for wood preservation. So that we have a practical problem, which is that wood preservation is there because of high water content potential. Therefore, perhaps one of the things we could learn from corrosion might be that it is an indication there is high water content and therefore a need to repair the building; a useful thing, which you cannot do just by looking at a piece of timber.

My question comes back to very early work at what used to be called the Manchester College of Science and Technology, which is now glorified as "UMIST", on the oxidation of cellulose in the presence of sulphur dioxide. I wondered if you had looked at the SO_2 content of your atmosphere at any time.

DR. BAILEY: We have not. That was not really part of the work that we undertook.

DR. JOHN MORGAN (B.R.E.): If I may be permitted another question, Chairman. One of the things which I did notice and which stuck out in my mind about the results was this low corrosion rate of aluminium, which is something which has always been a matter for question. Are you able to comment on the limits of that in terms of the purity. I believe you used aluminium alloy in this case.

DR. BAILEY: Yes. It was an aluminium-magnesium-silicon alloy, which has an inherently fairly good track record against corrosion. I think it is possible, looking at some work that was carried out in the past, that fairly high copper containing alloys have been used, and they have suffered intergranular corrosion, not necessarily as a result of the timber preservative treatment, but more as a result of the metallurgy of these alloys which are more prone to intergranular corrosion, even at medium moisture contents.

DR. D. G. ANDERSON (Hicksons): It was, in fact, a nail grade alloy that was used?

DR. BAILEY: It was.

THE PRESIDENT: Can I get in another question, partly for some members of the audience. I think you have shown about a 20 per cent moisture content threshold between corrosion and no-corrosion, which is, of course, also more or less the threshold between decay and no decay. I think you hinted in your paper this might have some implications on the mobility of water in wood. We still seem to have a level well below fibre saturation point. Would you like to comment on that, or would anybody else like to comment on that. It seemed to me to be more than coincidence.

DR. BAILEY: No, we did not really investigate the relationship between corrosion and decay.

DR. A. BRAVERY (B.R.E.): Well, since you have put me on the spot, I just wonder whether it needs any one in this corner here to remind the audience that free water arises in a wood structure above fibre saturation point and through the mid-20's one is in a situation where the structure is beginning to become, as it were, saturated ready for free water to develop. So it seems to be in line with the simple relationship, which I have always accepted, that the wetter it gets the more likely there is to be corrosion, the more free water the more risk of corrosion, and the same is true, in a sense, for fungal development because the water is not available to the fungus until it gets close to and then above fibre saturation.

THE PRESIDENT: It may be that the term is not sufficiently complete, but it did seem to me from the results that we are not having a gradual and progressive increase but we do have a threshold.

DR. BAILEY: That is right. There is a sharp take up in corrosion rate.

DR. BRAVERY: It would be a mistake to assume that there is a sharp threshold for fungi just because we have all got used to 20 per cent or thereabouts as a rule of thumb. It depends on which literature you read. Even from our establishment it varies and you will see 20 per cent and 22 per cent. Many of you will know more recently when we tried to rationalise it we got a rather more complex series of ranges which we tried to relate more accurately to the critical phases of fungal development. Although it is a narrow range it is not actually a step in fungal terms.

DR. D. G. ANDERSON (Hicksons): Can I just make a brief comment. I think the important part of the work that Geoff has undertaken is that it has illustrated very clearly this point of discontinuity below 20 per cent moisture content, and it is one of the dangers when establishing accelerated tests that you can fall into, by not making an investigation of this type which attempts to determine the way in which the weight and the property you are examining changes with time and temperature and humidity and any other factor. I think it is one of the important things that it showed us: the dangers of rushing into accelerated testing without fully understanding mechanisms. That is a very important part of the work.

THE PRESIDENT: It remains for me to thank, and inviting you to thank in the usual manner, the two authors who are present today for presenting the paper and indeed, *in absentia*, their two colleagues. *(Applause)*.

B.W.P.A. ANNUAL CONVENTION 1989

TWENTY-FIVE YEARS OF JOINERY TREATMENTS

by D. A. Lewis and D. Aston
Hickson Timber Products Ltd.

1.0 Introduction

During 1964, the first of the current double-vacuum type plants was introduced in the United Kingdom. This paper reviews the treatment of industrial joinery with organic solvent preservatives over the past 25 years using these plants.

By bringing together the various strands of standards, specifications, processes, equipment, market requirements, market growth as well as developments in other countries, we seek to demonstrate how the needs of joinery manufacturers and their customers have been met by the Wood Preservation Industry. Such a review emphasises the importance of double-vacuum treatments in ensuring continuing confidence in joinery.

2.0 The Problem

2.1 Incidence of Decay

Doubts over the long term performance of exterior softwood joinery were raised during the early 1960's when, contrary to previous experience, instances of decay were to be found in the opening lights of windows less than 10 years of age. Such concerns led to the issue of B.R.E. Digest 73 (Building Research Station 1966). Further studies on the incidence of decay in joinery demonstrated the importance of good design and the potential extent of the problem without an efficient, effective preservation system (Savory and Carey 1979).

Tack (1966) reported a survey of local authority dwellings which had been built since 1919. From the buildings examined, Tack found that 26 per cent showed some form of biodeterioration with 11·8 per cent having decay and 22 per cent showing insect attack.

A more detailed survey (Beech and Newman 1975), concerning Scottish housing, concluded that the preservation of non durable species against decay is economically justified for all exterior timber components particularly for windows and external door frames although soffits, fascias and weatherboards were also affected. Approximately 26 per cent of the houses surveyed possessed at least one window frame which was showing decay, with the overall incidence of decayed windows being almost 9 per cent: it was also suggested that over 50 per cent of the decayed window frames required repair or replacement.

Furthermore, the Beech and Newman survey found that approximately 20 per cent of the homes showed decay in their external doors (11·0 per cent of all doors were affected): the extent of decay found in the survey suggested that over 40 per cent of the defective frames examined required major repair or replacement.

The issue of decaying external joinery is not confined to the United Kingdom. Henningsson (1977) noted that in Sweden there was an increasing incidence of decay being reported from around 1963. In 1974 the S.A.B.O. investigation was undertaken in Sweden which suggested that the overall level of decay in window joinery was 1 per cent although the incidence was much higher in buildings which were less than 7 years old at the time of survey.

Studies conducted in Denmark mirrored the Swedish situation (Harsmen 1966, 72, 86 cited by Henningsson). Borsholt (1981) noted that there had been significant problems during the early 1970's of untreated frames decaying within 3 to 8 years: during 1978 insurance claims for decaying windows reached almost £2 million.

Soane (1978) detailed an examination of more than 2,000 external doors (age 2 to 18 years). 38 per cent were found to contain decay but the incidence was more than 60 per cent at some sites where the doors were only in the 6 to 8 year age bracket. Carey (1980) reported a 1973 postal survey to local authority maintenance departments where the respondents agreed that the amount of decay in external doors was such that preservative pre-treatment would be desirable.

In her own study, Carey concluded that observations on joinery after 7 to 10 years service, provide a 'depressingly monotonous' picture of water penetration and decay at sites which had not received preservative treatment prior to installation.

2.2 Contributory Factors to the Decay Problem

The previous section not only points out the potential for problems in untreated joinery but also the conclusions from several studies that there was a significant increase in the incidence of decay starting from the early 1960's. Many reasons have been submitted but, as in most situations, it is due to a complex of interacting factors:-

- increasing proportion and usage of non-durable sapwood in Baltic redwood timber.
- changing design and construction of windows (i.e. the E.J.M.A. Standard Casement window).
- sectional sizes becoming smaller; condensation channels removed etc.
- architectural fashions with cills embedded in brickwork; windows flush with external brickwork; 'tight skin building' systems.
- increase in local authority repainting intervals.
- inadequate on-site storage of treatment units.

Most of the above factors and problems with decay imply moisture access into the susceptible areas. Tack (1968), in one of the earliest studies, suggested that a moisture content of more than 21 per cent was sufficient to initiate and sustain decay. He found that 66 per cent of the frames examined could be considered as being at risk from decay by virtue of their moisture content. It should also be noted that a quarter of the windows had decayed within 14 years from installation. Experiments at P.R.L. (Baker *et al* 1975) in the 'window test hut' showed that even in Summer, the moisture content of bottom joints could be above 20 per cent and, thereby, susceptible to decay.

2.3 Organisms Responsible

In examining the extent and causes of decay, attention has also been directed to the organisms responsible as this could impact upon the chemicals used in pre-treatment products.

Numerous decay inducing Basidiomycetes have been isolated from window and door joinery including: *Phellinus contiguus, Dacrymyces deliquescens, Lenzites trabea* and *L. sepiara, Poria contigua, Coriolus versicolor, Gloephyllum sepiarium* and *G. trabeum, Poria calcea.* More recently decay of untreated cladding in Norway has been caused by *Dacrymyces stillatus*; perhaps an academic point until one realises that more than 600 claims have been made and the problem has also been identified in Sweden. This outbreak was unexpected in Norway as *D. stillatus* is considered slow growing and requires warm temperatures. However, the past two winters in Norway have been very mild thus allowing such colonisation and decay to occur.

Henningsson and Kaarik (1982) commented that the principle decay fungi have a rather high temperature for optimal growth and a pronounced tolerance to variations in wood moisture content.

Carey (1983) found that joinery underwent a colonisation process with bacteria - - - -> blue staining fungi - - - -> 'soft rot' type fungi - - - -> basidiomycetes. Such work highlights the complexity of an apparently simple 'decay' process and should be appreciated when introducing new active ingredients into wood preservative formulations and in their evaluation.

3.0 The Answer

3.1 Light Organic Solvent Preservatives

Early attempts at the pre-treatment of joinery to a higher standard than that obtained with immersion were carried out with vacuum-pressure impregnation using waterbased F.C.A.P. formulations, the timber then being kiln dried and machined after treatment. Indeed such a system, but utilising C.C.A. or C.C. preservatives, is currently carried out in Finland. Obviously such a scheme has disadvantages such as grain raising and the need for post-treatment drying and fixation. A natural evolution was to utilise light organic solvent preservatives which had been previously been used for immersion and deluge, but incorporated with treatment process technology of waterbased systems to obtain improved performance.

3.1.1. *Active Ingredients*

Section 2 highlighted the obvious need for the pretreatment of joinery although Light Organic Solvent Preservatives were not unknown and products based on metallic naphthenates and naphtholenes had been used for brush, dip and spray applications. During the late 1950's American experience with pentachlorophenol (P.C.P.) was introduced into the U.K. with the addition of organochlorine contact insecticides.

The 'norm' was accepted as 5 per cent w/w P.C.P. although this required the addition of an antibloom agent to produce a stable formulation and prevent 'blooming' on the timber surface. By the late 1960's an alternative fungicide, tributyltin oxide (T.B.T.O.) was introduced, originally at 0·5 per cent w/w in the treatment solution, but eventually settling at 1 per cent w/w which was expected to give equivalent performance to 5 per cent w/w P.C.P. One supplier sought and obtained a patent on T.B.T.O./P.C.P. mixtures.

Since the 1960's organotins such as tributyltin oxide and naphthenate have become the major fungicides used for joinery. Despite questions raised about its permanence and stability (Henshaw *et al* 1978; Jermer *et al* 1985) the recorded failures of T.B.T.O. treated timber are remarkably few. As Imsgard *et al* (1984) state, window joinery when correctly treated and used will give excellent service despite a potential for degradation or evaporation of T.B.T.O. Similar problems are faced by other active ingredients.

However, recent years have seen an increased activity in the development and utilisation of active ingredients for L.O.S.P.s. The synthetic pyrethroids cypermethrin and, in particular, permethrin have been accepted as alternatives to the organo-chlorine insecticides. The effectiveness and permanence of permethrin is such that it can be used at 0·1 per cent w/w as opposed to 0·5 per cent w/w for organochlorines.

Such a change, however, means the selection of a new fungicide due to incompatibility between T.B.T.O. and the synthetic pyrethroid is necessary.

One such alternative in use is tributyltin phosphate (T.B.T.P.) whilst another is acypetacs-zinc. Both are supplied for double-vacuum treatments and leading companies provide a range of formulations to meet the particular needs of their customers.

Other fungicides such as T.C.M.B.T., isothiazolones, I.P.B.C. and quaternary amines have been promoted but the path to approval and acceptance by the treating industry is long, arduous and expensive. P.C.P. and T.B.T.O. have given excellent service over the past 25 years and still remain highly cost effective and the 'benchmarks' for alternatives.

3.1.2. *Additives and Ancillary Properties*

Light organic solvent preservatives have become so well established, not only because they can prevent biodeterioration, but also due to the flexibility they allow in terms of ingredients. Additives may be incorporated to impart properties to the treated timber, which enable it to meet specific market requirements. However, as Sheard (1981) points out, such changes to formulations must be made with care so that other properties or the biological effectiveness of formulations and timber are not adversely affected.

It has long been recognised that water repellent additives could be included in L.O.S.P.s and the benefits have been amply demonstrated by Levi, Lewis and Gildon (1970). Aliphatic hydrocarbon resins and paraffin waxes were originally introduced to give joinery items a 'shower resistance' capability during storage and exposure 'on site'. The presence of water repellents has made a positive contribution to improving the longevity of subsequently applied surface coatings by markedly reducing the degree of movement in joinery timbers subjected to cycles of wetting and drying. However, as Taylor and Pearce (1979) point out, problems in terms of solution penetration may occur if the resin content exceeds specific levels. Once more the formulation is a fine balance between conflicting demands which preservative manufacturers must meet.

Since the early days of L.O.S.P.s much work on water repellents has been conducted, as exemplified by the studies of Banks and Carragher (1984) and Voulgaridis and Banks (1983).

Varying types or grades of solvent have been introduced with higher rates of evaporation: this is particularly important in the processing of joinery components where the 'dwell time' between treatment and further work must be as short as is practically possible particularly for assembly and basecoat application.

3.1.3. *Coloured Treatments*

With an increased awareness of L.O.S.P.'s versatility and associated advances in materials technology, an obvious extension is the introduction of coloured treatments which allow colour and preservation to take place at the same time i.e. a 'one-shot' process. In order to arrive at such a product, many technical problems must be overcome particularly in terms of utilising pigments that prevent uneven colour on the timber and agglomeration in the storage tank. Once these are solved, many possibilities of exploitation are available. Due to the particle size of pigments, at concentrations required, there may be a reduction in penetration over unpigmented solutions: however, this reduction can be overcome, to some extent, by the use of more severe cycles. Results have shown that the application of a short 1 kgf. cm^{-2} pressure period will give similar penetrations to those achieved using a three minute immersion with an unpigmented solution. For example CEDASOL was introduced in 1980 to meet a specific market niche for a 'one-shot' colour preservative process and has been successfully used for the treatment of leisure buildings because the manufacturer wished to avoid further application of a stain following treatment with standard VACSOL.

Thus we can see that the typical organic solvent preservative used in double-vacuum treatments must be a master of many roles with fungicide(s), insecticide(s), water repellents, pigments, dyes, marker systems. Today there is probably the widest range of L.O.S.P. formulations available than at any other time. This reflects a clear economic need to treat timber, an appreciation of particular hazards and risks and a requirement to meet customers demands.

3.2. The Equipment

The earliest attempts at producing a joinery treatment system for batch processing which improved upon immersion or deluge treatments, consisted of a large rectangular tank sunk into the ground. A cage, containing fabricated frames was lowered into the tank, a lid placed over and a vacuum pulled, resulting in a solution uptake of '¼ gallon per cubic foot'. The first of the units was installed by Hickson around 1959 at Harvey & Co. Ltd. in Cornwall and a second at Magnet Joinery in 1961/2. Reports from eye witnesses recall an alarming tendency for the tank walls to flex under vacuum plus there was a large void volume in the tank because made up frames were treated. However, despite these problems the importance of these early plants should not be forgotten or underestimated as providing the basis for further developments.

The next stage was to bring the plants above ground with vessel entry at one end and the production of cylindrical plants to withstand the vacuum and low pressure cycles. Added to this was the concept of treating components for a more efficient utilisation of vessel space. What we would term the first of the current 'VAC VAC' type plants in the U.K. was installed at H. C. Janes with Boulton and Paul and Austins of East Ham following quickly.

Typical cylinder sizes ranged from 3 ft. 6 in. diameter × 25 ft. to 6 ft. 0 in. diameter × 25 ft. and the larger plants were fitted with an option for diluting concentrates at the works. However, these early double-vacuum plants did not have vacuum capability storage vessels and experience from early installations in Denmark during the late 1960's indicated that this could result in an inconsistency of uptake through a pack. Consequently this was modified on the next generation of plants.

Obviously additional safety factors were necessary such as the use of copper linkages for all steel elements thereby preventing a build up of static electricity.

Control mechanisms evolved from 'manual' to remote with pneumatic valves from a central console and finally to an 'automated' system where, after closing the door, an operator has only to push a single button to initiate a pre-determined treatment cycle.

Considerable changes have also taken place in the process control systems of double-vacuum plants. Scroll cards operating switches on a camshaft may still be used to control pumps, valves etc. However, on new plants this has been superseded by solid state technology and programmable logic controllers, thus improving efficiency, ease of use, maintenance and flexibility. Plant control processing can be easily changed by directly altering the programme or by the use of a ROM cartridge to reprogramme the plant operation. These systems, along with computerisation, lend themselves admirably to digital output for graphics and data transmission using the latest information transfer devices.

Square or rectangular cross-section plants were introduced as they presented advantages in terms of vessel capacity utilisation and reduced solution stock-holding requirements. Subsequently vessels of 2·1 kgf. cm^{-2} (2 bar) capability were introduced for the treatment of European whitewood.

In recent years, the development of small plants, for example 0·5 m. cross section and 5·0 m. long, have brought double-vacuum treatment into the domain of the small joinery manufacturers wishing to exceed minimum N.H.B.C. standards and treat to requisite British Standards.

Legislation such as the Control of Pollution Act (1974), Health and Safety at Work Act (1974) and the Control of Pesticides Regulations (1986) have resulted in the preservation industry, in co-operation with the Health and Safety Executive, publishing a 'Code of Practice for the Safe Design and Operation of Treatment Plants'. Highlighted is the need for correct bunding, safety devices, covering of the plant and associated covered storage areas for freshly treated timber.

Timber treatment plant installations now call for more than just the mere provision of double vacuum-plants equipment. Planning applications, civil engineering requirements, the need for operator training and associated quality control mean that the preservative manufacturer must be able to supply the complete, professional package to both existing and new customers.

3.3 The Process

Dip treatments, although in use prior to the introduction of double-vacuum plants, were not considered ideal because the end results were difficult to control with absorptions and penetrations not always being considered adequate.

The 'hole in the ground' tanks pulled an initial vacuum of 25 in. Hg for 30 minutes. This became known as the 'double-vacuum' process and the registered trade mark 'VAC-VAC' became associated with the treatment plant and resultant timber.

By the mid 1960's this relatively severe cycle, with absorptions of '¼ gallon per cubic foot', had been modified to give a level of penetration which led to the concept of a 'protective envelope' of preservative in pre-machined joinery components and made up frames. This modified cycle became known as the 'Redwood cycle' outline below:

TABLE 1
'Redwood' Double-Vacuum Cycle

Stage	*Vacuum/Pressure*	*Time*
Initial vacuum	− 0·33 bar	3 minutes
Soak	atmospheric pressure	3 minutes
Final vacuum	− 0·67 bar	20 minutes

Such a cycle described in Table 1 gave typical absorptions of 20 to 24· l. m^{-3} (0·12–0·15 gall. ft^{-3}) in joinery components. It also reduced the dwell time between treatments and priming, this being increasingly important in volume joinery manufacturing units.

In such a 'Redwood' cycle the pressure vessel containing the timber is evacuated to a predetermined vacuum and this is held for a specified time. With the vacuum pump still running, the vessel is flooded with preservative so that some preservative is immediately taken up by the evacuated timber cells. With the vacuum pump off, the vessel is ventilated so that atmospheric pressure forces more preservative into the wood. Residual air in the wood is now at atmospheric pressure.

The vessel is emptied of preservative, the vent is closed and a vacuum is again applied. The difference in pressure between the interior of the wood and the space around it causes air to escape from the wood and in doing so it expels preservative from the wood cells, leaving them coated, but not flooded.

The recovered preservative is pumped back to storage, measured and a nett absorption is determined. Residual air in the timber is again at a low pressure so that, when the vessel is vented to atmosphere, preservative on the surface is driven back into the timber leaving it in a touch dry state.

During the early 1970's the proportion of 'Whitewood' (*Picea sp*) used in U.K. joinery began to increase. These species are well known for their low durability and resistance to preservative treatment. Morgan (1975) examined the possibility of spruce for joinery and raised questions on heartwood durability but also noted that due to its different moisture relations from those of redwood, it may be an acceptable timber for external joinery. However, 'redwood' treatment cycles were not appropriate for spruce and new schedules were progressively developed, amid much debate, to obtain adequate preservative penetrations and uptakes. The initial hold pressure was 1 kgf. cm^{-2} until the introduction of plants capable of a 2·1 kgf. cm^{-2} (2 bar) cycle. Such cycles allow a standard of treatment to be consistently achieved which is difficult with immersion techniques.

The introduction of Hemlock into external doors and its potential for decay (see section 2.1) led to the development of a further cycle. An increasing use of non-durable hardwoods required another addition to double-vacuum schedules.

Thus it can be said that the industry has responded to demands of new species and end uses (i.e. termite treatments) with process cycle modifications such that the B.W.P.A. Manual (B.W.P.A. 1986) now list seven double-vacuum/low-pressure treatment schedules.

It should be noted that the U.K. differs fundamentally from many other countries by specifying the *Process* with which to treat joinery rather than defining in detail, the requisite loadings and penetration (*Results type* specification) to be achieved.

4.0 THE SUCCESS

The Western European Institute for Wood Preservation (W.E.I. 1989) recently published a compilation of statistics which placed the annual volume of timber treated with Light Organic Solvent Preservatives at 1,150,000 m^{-3} of which the U.K. treated 78 per cent. This shows the success and significant impact dpuble-vacuum treatments have had over the past 25 years particularly as the W.E.I. estimate shows that L.O.S.P.'s account for 20 per cent of the total treated wood volume in Europe.

4.1 **Benefits**

The obvious benefits to a joinery manufacturer in using L.O.S.P.'s, applied by double-vacuum, are in the improvement of durability and quality thereby giving his customers confidence in the use of wood. However, other benefits, less immediately obvious, make the organic solvent products and double-vacuum process eminently suited to the rapid production of joinery:-

- rapid treatment of joinery to a level which exceeds that given in many national standards and specifications.
- treatment of components ensures that the high risk joints and end grain zones are well treated.
- with double-vacuum treated Baltic redwood, components are ready for assembly immediately after it leaves the plant as it is 'touch dry' due to the application of a final vacuum.
- treatment does not change the dimensions of wood and therefore, assembly of components may take place immediately without further machining.
- timbers are readily glued and overpainted.
- improved control and consistency of treatment with double-vacuum plants.
- with enclosed double-vacuum plants there is improved site hygiene and ability to reduce organic solvent emissions.
- better control of uptake in over-absorbent timbers using double-vacuum plants.
- the compact nature of double-vacuum plants makes them viable where space is restricted.
- stock in progress is significantly reduced.
- timber remains competitive in terms of durability over other materials such as U.P.V.C.

Such advantages are available to all manufacturers and hence the significant use of L.O.S.P.'s not only for external joinery but also truss-rafters, internal joinery, timber frame housing components, joists etc.

4.2 **The United Kingdom**

Shaw (1982) suggested that approximately 90 per cent of softwood windows and doors are pre-treated with organic solvent preservatives by double-vacuum or time controlled immersion processes. This figure is now probably higher with the specifications to treat certain hardwood species and the introduction of plants, such as the MINIVAC range, for the smaller joinery producers.

The success of double-vacuum treatments can be put into perspective when one considers that, in 1987 and 1988, Government estimates put the number of wooden windows sold in the United Kingdom at approximately 4·5 million and 5·0 million respectively: these unit sales represent a nett sales value of £202 million in 1987 and £226 million for 1988. There can be little doubt that the external timber joinery market would not be this size if the problems of the 1960's and early 1970's outlined in Section 2.0 had been allowed to continue.

To illustrate the significant impact in terms of units treated, with all industrial applied L.O.S.P.'s, further analysis of U.K. production figures would suggest that at least 30 million window frames have been treated with HICKSON VACSOL alone since the introduction of double-vacuum treatments 25 years ago. Smith, at the 1981 B.W.P.A. Convention, estimated that since the N.H.B.C. introduced requirements for the treatment of doors in 1975, more than 3·5 million had been treated with VACSOL.

Despite the hazards and risks, particularly those associated with external joinery, there have been very few substantiated failures in the U.K. Lewis (1981) examined windows at three local authority sites, with ages from 5 to 14 years, covering a range of designs and paint conditions. Decay was absent despite a close inspection of the vulnerable bottom joint areas: compare this with studies carried out by Tack and Beech and Newman on local authority housing.

Bravery, Dobbs, Laidlaw and Miller (1981) noted that of three instances of decay in treated joinery which they had examined, poor design contributed significantly by allowing gross water penetration into the joints. Furthermore, in one instance, pre-infected timber had been used and in another machining of the joints after treatment and failure to treat some components were also contributory factors. Mention was also made of decay in three 2 x G hemlock doors. However, closer study showed that glue in the centre and lower rail joints had entirely failed; water penetration was aided by voids in the centre rail joints and back filling putty failures by the 'dry' insertion of plywood panels.

In addition, the preservative had been entirely removed at critical points by subsequent machining of dowel holes. Preservative had also been lost when horns were removed and the rail machined on site. Another site with treated doors made to an adequate specification were sound.

The observations above highlight that treatment with organic solvent preservatives must be used in conjunction with, not replace, good design and workmanship procedures both in the factory and on-site: preservation must be regarded as an adjunct to good practice if confidence in the durability of treated joinery is to be maintained.

4.3 **Nordic Countries**

The Nordic countries have also been at the fore front in using organic solvent products for joinery treatments since Centrum Vinduer (Denmark) first carried out treatments in 1963. Stueland Trevarefabrikk A/S (Norway), S. P. Snickerier, Elite Group and Modulfonster (Sweden) are all major joinery manufacturers relying upon double vacuum/low pressure treatments to gain consumer confidence with certain companies offering performance guarantees on their products.

Recent figures for L.O.S.P. treatments, published by the Nordisk Trebeskyttelserad (N.T.R. 1988) are shown in Table 2.

TABLE 2
Volume of Timber Treated with L.O.S.P. 1987

Country	*Volume Treated* m^{-3}
Denmark	41,200
Finland	1,300
Norway	39,600
Sweden	28,200

Once more, a bald statement of treated volumes belies the number of units. Borsholt (1981) and Jensen and Imsgaard (1982) noted that since the introduction of double vacuum treatment into Denmark more than 3-5 million window frames had been treated and only 3 incidents of decay were found. All 3 cases were manufactured prior to adoption of the Nordic Classification system by joinery producers.

4.4 **Other Market Areas**
From the U.K., double-vacuum treatments have spread to many countries including Malaysia, New Zealand, Australia, (the first plant installed in 1970), Bulgaria, Italy, Greece, Portugal, Spain, Singapore and the Middle East.

5.0 The Standards
In reviewing the growth of joinery treatments with light organic solvent preservatives, a discussion on the requisite standards is essential as it indicates the technical developments and market acceptance of, for example, the double-vacuum process. However, it must also be noted that such standards usually formalise the good practice and systems that innovative and responsible companies have introduced.

The web of Standards and specifications in the U.K. is generally complex, primarily because of the number of involved authorities. It is also interesting to note that different standards of treatment are required in various countries; perhaps because there are not any universally applied guidelines although this may well change with the technical harmonisation process underway within Europe. We still need to ensure that in any such harmonisation process the higher standards of treatment are maintained.

5.1 **United Kingdom**
As pioneers of double-vacuum treatments in the U.K., to replace immersion, Hickson introduced the first 'VAC VAC' plant during 1964. Further impetus was given to the process in particular and treatment in general by the introduction of Technical Note 24 from Forest Products Research Laboratory in 1967 with a revision following in 1968.

Further revisions took place over the years which raised the concentration of T.B.T.O. in formulations to 1 per cent w/w; drew the distinction of improved treatment with a double-vacuum process compared to a controlled 1 to 3 minute immersion and, in general became more useful to the preservation industry and specifiers. Eventually it 'linked' with schedules in B.S. 5589:1978 to suggest a preservative penetration of at least 3 mm laterally and 40 mm longitudinally in the sapwood.

Alas, a good friend passed away in 1985 when 'Technical Note 24' was superseded by various British Standards.

In 1969 the then National House Builders Registration Council (later renamed the National House Builders Council) made preservative treatment mandatory for external joinery timber of houses constructed by its member companies. This was extended in 1975, to include external softwood flush doors. It should be noted that the original treatment level was a minimum period of 1 minute immersion later increased to 3 minutes. Whilst working closely with the N.H.B.C., the preservation industry, has to accept treatment standards that are lower than it would perhaps like, although solace can be derived from the fact that N.H.B.C. specifications are acknowledged as the minimum required. In reality builders/specifiers usually adopt much higher standards.

The British Woodwork Manufacturers Association, in 1967, approved the preservation of window frames with the minimum treatment level being a 1 minute immersion.

The Property Services Agency made, in 1971, the treatment of external joinery mandatory and during the late 1960's and early 1970's various local authorities, such as the G.L.C., were developing specifications as well as an appreciation of the benefits to be derived from double-vacuum treatments.

Perhaps one can say that the treatment of joinery became part of the 'establishment' when British Standards (i.e. B.S. 5589 and B.S. 1186) incorporated L.O.S.P.'s and with specific standards such as B.S. 5707 part 1: 1979 and B.S. 5707 part 3: 1980. British Standard B.S. 1186: 1986 was important because it also recognised the necessity to treat selected hardwood species, particularly *Shoreas* if used for windows etc. Not before time, considering the problems encountered in Holland with untreated hardwoods (Hanson 1983).

Throughout the past 25 years, the leading role played by the B.W.P.A. should not be forgotten or underestimated in developing standards and specifications to improve the quality of preservative treatments. B.W.P.A. input is still significant given the revisions of British Standards and harmonisation activities within Europe.

Despite the battery of Standards in place and the potential for decay, it is perhaps salutary to note that preservation of timber in buildings is not mandatory and so it is even more important to ensure that products and services meet the needs of a very critical market place.

5.2 **Nordic Countries**
Within Sweden, Denmark, Norway and Finland, the standards for joinery double-vacuum treatments differ in two main ways. Firstly, they are 'results orientated' contrary to the U.K.'s 'process specification'. Secondly, Class B standards call for a minimum penetration and preservative loading of the outer 10 mm lateral sapwood as opposed to the United Kingdom's 3 mm. (Nordic Wood Preservation Council 1980). This has obvious implications for post-treatment handling due to the significantly increased solution uptakes to meet the penetration criteria. In Scandinavia plants may be using 30 to 50 l/m^{-3}.

More recently, there has been much discussion in the Nordic Countries, with a view to changing the above standards (in operation since 1976) to a level similar to that attained in the U.K. Essentially, the new 'Class B' (N.W.P.C. 1989) proposal places greater emphasis on longitudinal penetration with a specified loading to be achieved 45-50 mm from the end grain. Cycles to meet such a standard will probably result in lateral penetrations of 3-5 mm and significantly reduced solvent absorptions which will undoubtedly have beneficial effects on post-treatment handling operations.

5.3 **Other Countries**
In Australia, treatment specifications are of the 'results' type and have been particularly influenced by the relevent regulations in Queensland and New South Wales, which require full sapwood and some heartwood penetration. Greaves (1984) summarises the chronological development of Standards in Australia.

In Malaysia a draft L.O.S.P. standard has recently been issued, whilst in Italy (Gambetta, Orlandi and Cockcroft 1985) there are not any regulations nor mandatory treatment specifications for external joinery although double-vacuum treatments are covered by U.N.I. C.L. Mandatory treatment for non-durable species was introduced for Netherlands state subsidised housing in 1971 although the main emphasis is still on immersion treatments even for spruce (Bergers, Cockcroft and de Jong 1985).

The development of the standards and specifications are important particularly as part of the marketing effort of reputable preservative companies was, and still is, aimed at gaining specifications for which customers may tender.

6.0 The Trends
Increasing controls on the operation of treatment plants with regard to environmental protection will play a significant role in directing the development of plants and design layouts. The Code of Practice for the Safe Design and Operation of Treatment Plants addresses areas regarding plant design, civil engineering and the prevention of pollution to water courses.

'Zero pollution' installations are now being developed where any potential run off or liquid escape is contained. In the future, solvent emissions will also have to be controlled.

Health and Safety considerations have been to the fore in recent years and this will continue. The Control of Substances Hazardous to Health Regulations 1988 are an example. The use of solvent in the work place is being reviewed in Scandinavia where, fortunately, drying units for organic solvent treated joinery are already in use; these were originally installed as a necessity due to their standards requiring high solvent uptakes. Drying schedules vary from 24 to 48 hours at temperatures in the range of 25°C-40°C: manufacturers seek to remove 50 per cent of the solvent with the above time to allow further processing. However, companies are re-examining the efficiency of their drying units with the possibility of introducing solvent recovery/recycling systems. Such recovery units using oil, activated charcoal, ion exchange resins etc., have been considered and each have their own recovery efficiencies which, in turn, are dependent upon the removal efficiencies of the 'drying' unit. High capital costs, low solvent prices and relatively poor recovery rates have prevented wide spread use of such equipment.

The search for new active ingredients, as mentioned earlier, will continue but confidence will be slow to build particularly as some suppliers are underwriting product performance guarantees with T.B.T.O. treated windows for 25 to 30 years. Product innovation should not be discouraged but the benefits must be demonstrable on the basis of long term service life. Concern should be expressed over the promotion of products as 'environmentally safe': as was once said 'there are no safe chemicals only safe ways of using them'. In this context, we should note that increased use of double-vacuum treatments for joinery will reduce the future requirement for both remedial and D.I.Y. products. With pre-treated timber the final consumer (i.e. home owner) rarely comes into contact with the timber and does not come into contact with the chemicals – an important consideration. Training of plant operators will emphasise the need for both plant and personal hygiene. Improved guidelines will be prepared for those who handle the treated timber, such as joiners. Whilst these may be considered as educational matters, it is essential that preservative manufacturers supply such information and assistance.

During the 1970's and increasingly in the 1980's the market for 'wood care' products has grown dramatically. This has led to a number of superficially applied products claiming wood preservation/protection properties.

Wood protection, in the mind of many consumers, is readily confused with preservation and it is important that, wherever possible, the distinction in application technology and performance is made. The Health and Safety Executive is closely examining the definitions used in the descriptions of such products.

Factory finishing offers future scope for further developments and competitiveness of the joinery industry. There are significant hurdles to overcome in the form of current building practice, window design, wood quality and coatings technology before such schemes see widespread use in the U.K. If manufacturers supply semi or fully finished windows, double-vacuum treatments are still regarded as a necessity to meet the anticipated joinery service life (not the surface coatings life) expected by specifiers British Standards and the public: confidence to offer such a system is derived from the 20 years experience gained by L.O.S.P. treatments.

7.0 Conclusion

This paper has demonstrated how the wood preservation industry by the adaptation and development of technology and recognition of the requirements of the market place has helped save and now win back to timber the greater share of the industrial joinery market. Untreated wooden windows still fail prematurely and competitor materials, despite their own problems, will try to take market share. Joinery producers are making advances in design but preservative manufacturers must assist by continuing to promote and develop product-process combinations such as L.O.S.P. and double-vacuum treatments. As Chenery (1989) states, the customer's needs must be understood and satisfied.

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DISCUSSION ON PAPER 2

Chairman: Mr. L. B. Woodhouse

THE CHAIRMAN: I understand from Dr. D. A. Lewis that Dr. Aston has arrived to answer all the difficult questions! May I have the first question, please?

MR. P. D. NORTH (Timberwise Consultants): Dr. Lewis is to be congratulated on a thoroughly professional and most enjoyable review, unashamedly commercial and none the worse for it. But I think one of the aspects of rot in external joinery that he side-stepped quite neatly is the way that we interfere with the wetting and drying cycle. In the same way as I believe that plastic wall coatings have destroyed more brickwork than the weather has, I think that some of the oil paints that we use now are destroying almost more joinery than non-treatment is or bad design.

I say this because about 16 years ago I replaced, on a short-term basis, some timber frames in an outbuilding, which were installed with purely grey primer. I never got around to painting them and they had not rotted in any degree when I sold the building about two years ago. On the other hand, about 13 years ago I installed a number of new timber frames in an extension of ours which were scrupulously and continually painted but they rotted comprehensively within 10 years. I wonder if you had any comments to make on this.

THE CHAIRMAN: A difficult question!

DR. LEWIS: The decay of timber is a complex equation: the wood substrate, the organisms and surface coatings. If you have alkyd gloss paints which allow sufficient water ingress through cracks etc. to allow decay how is that moisture going to escape? Attempts have been made to resolve this situation by developing 'breather paints'. However, such problems may also be prevented by utilising coatings which will not allow water ingress in the first instance. How far we are from such products which can be applied by, for example, the householder, is another question.

MR. NORTH: I think there is a lot of ignorance in the public domain. People think that if you keep the moisture out that is all that is required but, in fact, we do need to allow the moisture that is already in the timber, or that gets into it from other sources, such as other parts of the timber which are not painted, to be removed and most of these paints do not allow the timber to 'breathe'.

DR. LEWIS: I also think a lot of emphasis is given to external water ingress and yet there is a significant role played by condensation, for example: the householder rarely pays attention to that, apart from may be putting a cloth at the bottom of the window every now and then.

THE CHAIRMAN: Does anyone want to protect the Paint Industry? Dr. Miller?

DR. E. R. MILLER (B.R.E.): Well, not really. However, I would not entirely agree with the questioner. It seems to me that the issue of the role of permeability in paint remains still relatively unclear. Certainly the evidence that we have accumulated over a number of years is that if you compare a so-called tight system, an alkyd oil paint, with a more permeable system over a fairly long period of time, then the levels of moisture content that are reached do not differ very significantly. I still feel that the essence is that if you have sapwood and you allow it to get wet, then it is going to be at risk from decay and you are therefore dependent entirely on the preservative, and we have seen the excellent work that the preservation industry has done. But if you make the hazard sufficiently severe, it is not going to be adequate. I still think that the basic argument of keeping the wood dry is the right one, and the hope that we can somehow use designs which permit excessive uptake of water and then somehow rely on a surface coating which is going to allow the wood to breathe, I think, is a forlorn hope.

MR. E. PEARCE (Fosroc Ltd.): You have shown quite clearly the extent to which double vacuum technology has been used in the U.K. and has also made inroads into the Scandinavian countries. Can you give any reason why it has not gone beyond those frontiers into other parts of Europe.

DR. LEWIS: I think one is education. It is a necessity of such technology that decay is a problem. I think perhaps in many other countries timber rot is replaced; concrete, plastic, aluminium is used in its place. But I think, for example, what we have seen in Turkey, and the progress in Turkey, means that eventually countries will begin to see the benefits of not just double vacuum treatment but preservation as a whole, because of the economic restraints imposed upon them by timber having to be replaced. We have seen the inroads into New Zealand, Australia and Malaysia which, again, are examples of this.

DR. ASTON: I should like to add to that in the sense that there are technical reasons why, perhaps, and also the commercial business development, or perhaps the lack of business development; the relationship of British companies who have been involved in the development of double vacuum processing and whether or not they have actually had commercial operations in the territories to any great extent.

I think also a point we have to make is that, in a sense, we are involved in a selling exercise, convincing people of the reasons why they should adopt this type of process technology. Perhaps in some of those countries this has not been quite as effective and as extensive as it could be.

DR. D. J. DICKINSON (Imperial College): Could an additional factor be that the double vacuum systems seem to have taken off where the more permeable pines have come to be the major joinery timber. In countries where Norway spruce, for instance, is used extensively different systems have proved adequate with the less permeable material.

D. LEWIS: It was interesting that in the previous paper there was not a significant difference in equilibrium moisture contents between Spruce and Pine after exposure to water vapour.

So, with water vapour, we may also arrive at moisture content levels which will support decay.

DR. DICKINSON: It is going to be liquid water through end grain primarily in joinery, is it not?

DR. LEWIS: Primarily, but not necessarily. You could be talking about trussed roof rafters, for example, or any other sheltered components where moisture vapour will have a role to play. I think perhaps Neils Burgers might like to comment.

DR. N. BURGERS (W.E.I.): Yes. I do not think the dipping system, for instance, that we used in Holland for Spruce was adequate because the preservative does not penetrate the timber. Another important factor is the structure of the industry. If there are many small firms then they cannot pay for the rather expensive double vacuum process and it is then too much trouble to have a few plants here and there to receive joinery. Another reason is the price standard in a country. If the contractor who buys from the joinery industry presses down the price all the time, what does the joinery industry care about supplying a more expensive product if it does not get paid for it?

It is a big problem but I think we have come to the conclusion in Holland, or we have played with the idea – I do not know whether we have accepted it – that may be impregnation is not necessary. If you use timber that is really dry, down to 10 per cent, if you have very fine machining, exact machining with great precision and if you have the modern type of glues with end grain sealing and then put a coat of paint on in the factory using modern paints which last 8 to 10 years without damage, then you can ask yourselves whether with Spruce the preservation that we have done up to now is relevant. So if we do not find a more penetrating way by some kind of diffusion, which is practically the only way you can protect Spruce, we may question whether it is not money thrown away.

DR. ASTON: I think, as we tried to demonstrate, there has to be a combination of all these things to optimise the use of that particular raw material.

DR. BURGERS: Yes.

DR. L. E. LEIGHTLEY (Rohm & haas, U.S.A.): I should like to congratulate you on your paper. What I would like to ask is something directed towards your future products. What do you think the future holds for organic based solvents with the introduction of aqueous based systems?

DR. LEWIS: The formulation of aqueous based systems, as you know from your experience with antisapstains, is not the problem. The problem is with treatment cycles to ensure that very close tolerance dimension joinery is not distorted by swelling. Then there is a drying consideration, because you are still going to be putting in 25 to 30 litres of water. So one then has to look to the ancillary technology to come of sufficient age before that approach is viable. But no doubt there are drying manufacturers, for example, who are working on such systems.

DR. ASTON: Certainly in our discussions with joinery companies, when we have mentioned the words "waterborne" or "aqueous" then immediately they think of all the grain that is going to be raised and the potential problems that are going to occur. I think it will take quite a technical exercise to be able to convince them that it is possible to use a water based system. I think people start off from something of a position of prejudice to some extent.

MR. G. EWBANK (Rentokil Ltd.): Thank you very much again, both of you, for a very professional paper. Can I address my question to David Aston. It is about something you and I have both been concerned about recently. On your figures, David, 25 million litres or thereabouts of solvent evaporate into the atmosphere per year. Both of us have had concern expressed to us about this and have been asked is this a problem, with environmental issues being such a high priority, at the moment, and how can the industry cope with it. Would you like to comment on that?

DR. ASTON: Thank you for raising the point, Gordon. Yes, it is of significant interest, particularly to the U.K. wood preservation industry, in the sense that we have a government which is taking a much more positive attitude in relation to the "Green" issues. Regrettably, timber treatment plants are sitting ducks as far as the bureaucrats are concerned. Treatment plants do not get up, they do not run around and so they can be legislated for and they can be licensed.

The discussions to which Gordon Ewbank is referring, relate to those that we are having with Her Majesty's Inspectorate of Pollution. What we are trying to articulate is an argument which says, "Why pick on our industry when every day X millions tins of paint are opened and solvent is dissipated into the atmosphere." We are arguing that why should we, as an industry, be faced with the possibility of having to go through a licensing system and so on and end up having to pay levies on the solvents that we use, whereas the person who is using paints with these solvents gets away without paying anything. It is early days in terms of the discussions, although one does rather get the impression that we are not going to have a very favourable response when the Government can see our industry as a means of generating revenue.

DR. N. BURGERS (W.E.I.): I think the paint industry is in an easier situation because they are using water based paints more and more and they do not have that problem.

DR. ASTON: Accepting that, I think we are in a situation where technology is available to remove solvent or mitigate the amount of solvent which is removed. Effort has been expended in the past in terms of trying to recover that solvent and, as David has mentioned, the relative economics of that are questionable. But certainly the technology is there to remove or reduce the amount of solvent, first of all, in terms of the workplace, which is what the Health and Safety legislation is concentrating on, but now in terms of the emission of solvent into the wider environment as a whole. So we have a delicate balance to maintain in terms of the way in which we, as an industry, are going to approach this matter.

MR. A. BUIJS (Holland): In Holland we have a quality certification system for window frames and in order to get a certificate, the window frame can be preserved only locally by means of a dry pin containing bifluoride. When the wood becomes moist later in service, active ingredient will diffuse into the wood. That is the only way that we may preserve window frames. What is your opinion about that?

DR. LEWIS: I think it is perhaps a fairly simplistic approach to water dynamics in a window frame. I mentioned earlier about the potential for decay and I am sure people could cite decay occurring in the centre of windows, where the condensation problem has been quite severe. I think we also have a continuing debate as to whether coated window joinery represents a leaching hazard. If you are going to get water in it will redistribute the chemical or cause removal of the active ingredients. I think that this factor and your proposal must be looked at, in practice, over the 30 years or 40 years service that people are expecting from their windows or door joinery. So perhaps in certain specific instances there is a role for the type of system you have mentioned. Given the wider context in which windows are used, for which windows are designed and the conditions with which they come into contact, then I would perhaps doubt the long-term validity of such a system, with just discrete entry points of the preservative.

THE CHAIRMAN: We have just about reached the end of our time. I would like to congratulate the authors, as so many of you have already done, on a well presented and well prepared paper. Thank you very much. *(Applause)*.

B.W.P.A. ANNUAL CONVENTION 1989

A NEW GENERATION OF WATER-REPELLENT FINISHES WITH A DOUBLE BARRIER AGAINST MOISTURE ABSORPTION

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Summary

A new type of surface coating and impregnant for wood is described which is characterised by high water repellency and excellent resistance to moisture and weathering.

These new, unique products owe their water repellency to the use of a *double-barrier system* against water absorption consisting of *migrating* and *non-migrating* hydrophobic components.

The migrating components are dispersed as true molecular solutions in the surface film and act as a reservoir for hydrophobic materials to replenish areas where the water repellency is reduced due to exposure to water and natural weathering, while the non-migrating components are dispersed as submicroscopic particles in the same film to provide a permanent water-repellent barrier.

Results from laboratory tests and natural exposure to weathering in three different climatic zones, Norway, Kenya and South Africa, confirm that with respect to water repellency and durability the surface coatings and impregnants based on the double-barrier system are superior to conventional and traditional products.

Key Words
Wood
Water repellency
Hydrophobic material
Weathering resistance
Double barrier against moisture
Surface coatings
Preservatives.

Introduction

It is generally accepted that variations in the moisture content of wood exposed to natural weathering is more detrimental to the durability of wood and wooden products than any other single factor including oxidation and photochemical processes.

A considerable amount of research has therefore been carried out internationally to develop water-repellent products that will retard and as far as possible prevent the absorption of water.

Our first research in this field was published already in 1961 in Norway (1) at the same time Miniutti presented his pioneering work in the Forest Products Journal in the U.S.A. (9).

Since then we have continued our research on water-repellent wood preservatives, primers and surface coatings under widely different climatic conditions in Norway, Germany, Greece, Kenya and South Africa.

Of special importance was a research project lasting several years comparing the effect of cold and hot climatic conditions on the durability of different surface coatings for wood (7).

Some of the water repellents we evaluated during the various research projects were developed into commercial products to be manufactured in South Africa, England, Sweden and Norway.

During this period we tested a large number of commercial products from Norway, Sweden, Denmark, Holland, England and the U.S.A., and came to the conclusion that the composition of the available products on the international market was in principle basically the same. They all belonged to the same generation of water-repellent products, incorporating the same type of components in their recipes.

Their performance in preventing water absorption therefore varied only within narrow limits, and no single product was found to be inherently different from the others. Further progress in this field was therefore only possible if a new generation of water repellents was developed relying on radically new principles for reducing water absorption.

The result of these attempts, representing a departure from the conventional approach, is described in the following.

Theoretical

From our research on the durability of wood under different environment conditions, we came to the conclusion that in most cases the wood structure failed due to the destruction of the embedding matrix on a microscopic and submicroscopic level (3) (5) (6) (8).

Although oxidation, hydrolysis, depolymerisation and photochemical processes are of importance, the wood structure, especially the middle lamella and the matrix between the microfibrils, are ultimately destroyed by mechanical stresses set up by the absorption and desorption of water.

Under constant humidity conditions, whether wet or dry, the gross structural characteristics of wood can be remarkably stable. Indeed, *Quercus robur* from a Viking ship left in moist soil for 1,100 years, and *Acacia nilotica* kept inside the dry air of an Egyptian pyramid for 4,400 years have been found to be almost identical to new wood (3).

As long as microbiological decay is prevented by biocides or other means, it is of little importance whether the wood is wet or dry as long as the moisture content is *constant*.

The main function of a water repellent is therefore to reduce the *variation* in the moisture content of wood by providing a barrier for water transmission in any direction.

Conventional methods

A material is water repellent or hydrophobic when its contact angle with water is higher than 90° (Fig. 1), which is the minimum value for preventing capillary penetration into a porous solid.

The film-forming polymers normally used, such as drying oils, alkyds and polyacrylates, have contact angles with water from 30°-70°, and are therefore not hydrophobic materials.

The conventional film-forming polymers allow water in liquid and vapour form to pass through a coating in the form of capillary penetration or true molecular diffusion depending on the moisture gradient of the system.

To make a surface coating water repellent, the film deposited from a solution of polymers must be modified with a hydrophobic material.

The performance of a combination of film-forming polymers and hydrophobic materials depends on several factors. The main one being the incompatibility of the two types of materials used which is accentuated by the limited number of hydrophobic materials available.

Shortcomings of conventional methods

There are very few materials with a contact angle with water higher than 90° and in practice, commercial products rely entirely on the use of paraffin waxes and in a few cases on silicone oils.

Unfortunately, paraffin waxes have very little affinity for the surface coating into which they are incorporated, and form no bonds with the surface of the wood.

The result is that the molecules of the paraffin waxes are dis-

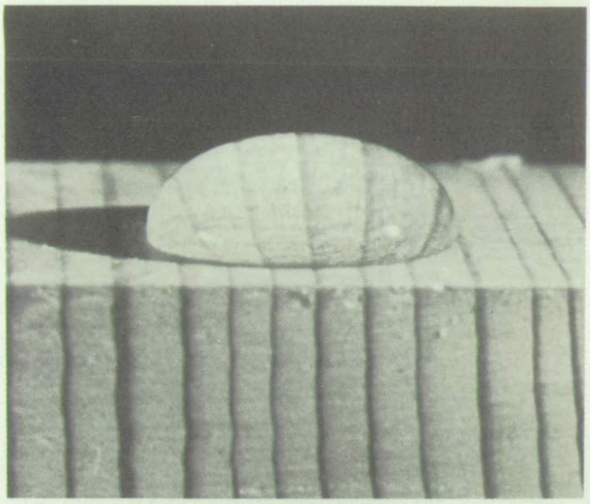
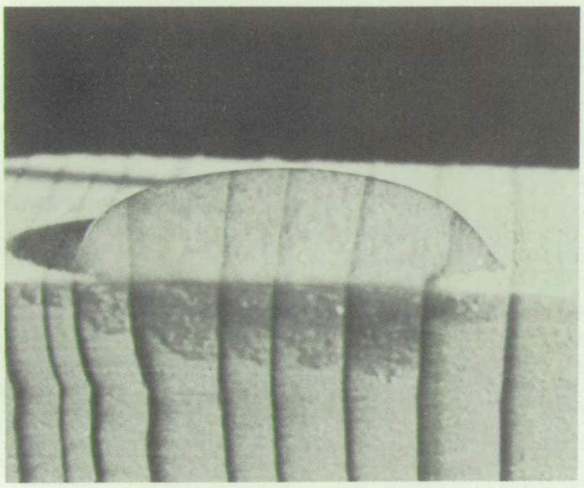


Fig. 1.
A water-solid contact angle above 90° prevents spreading of water.



A water-solid contact angle below 90° supports wetting and spreading of water.

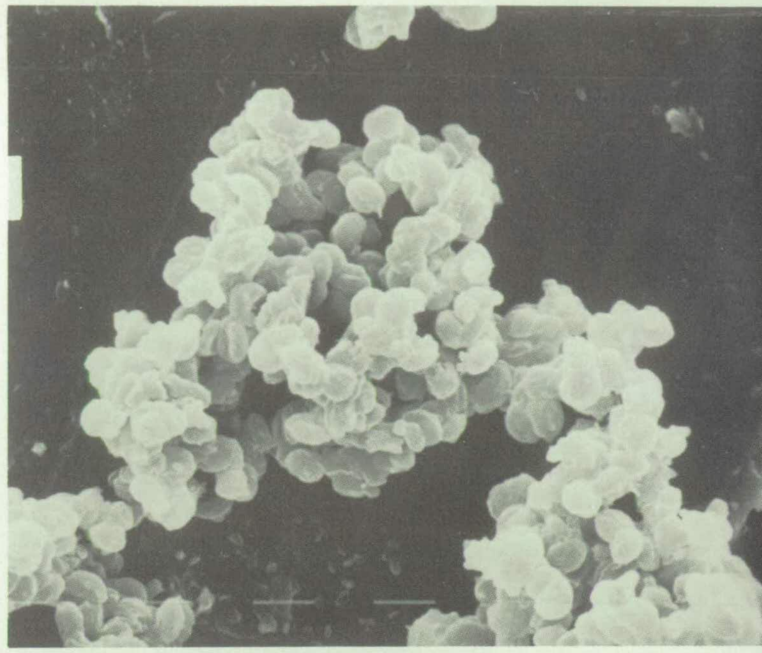


Fig. 2.

Non-migrating particles. Magnification 800× SEM micrograph. White marker = 10 μm.

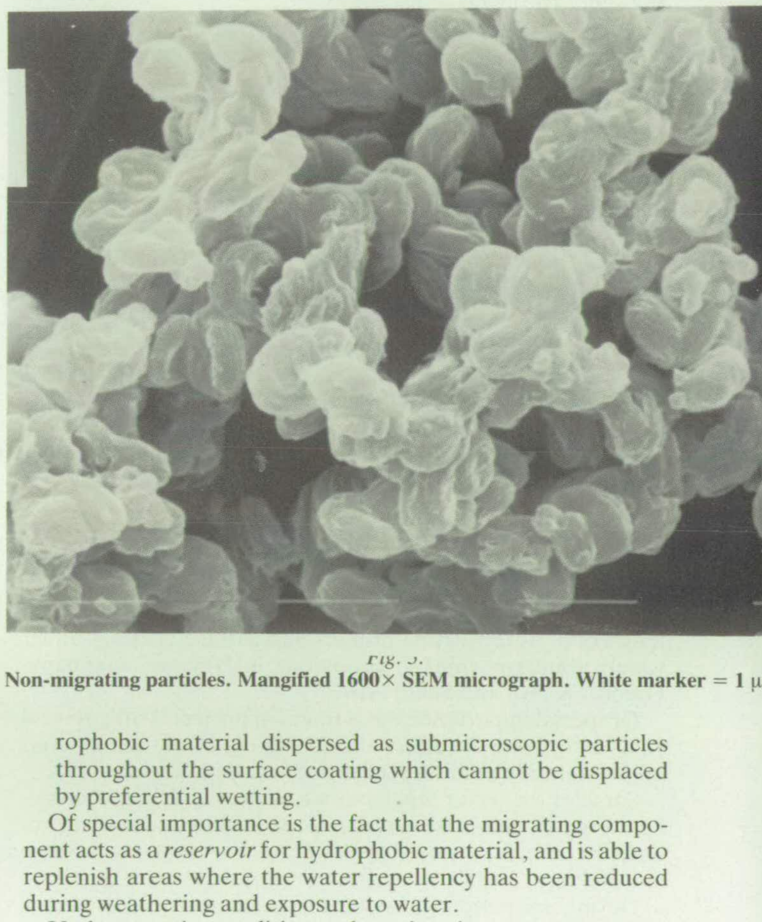


Fig. 3.
Non-migrating particles. Mangified 1600× SEM micrograph. White marker = 1 μm

placed from the surface of the coating by a process we have called preferential wetting (2) (4).

Preferential wetting takes place each time the surface coating or impregnant is in contact with liquid water, with the inevitable result that the system is eventually depleted of its water-repellent components.

The double-barrier system

To overcome this problem inherent to all water repellents depending on paraffin waxes, we have introduced *two* hydrophobic barriers against moisture absorption instead of the conventional one.

The components of the two barriers are of different composition and perform different functions, each supporting the other in a true *synergetic* system.

The two types of hydrophobic material used in the double-barrier system are referred to as the migrating and non-migrating components. They are characterised by the following properties:

1. *The migrating component* consists of a linear hydrophobic polymer in a true molecular dispersion in the filmformer of the surface coating.

   The migrating component can distribute itself uniformly through the surface coating, diffuse into the substrate, e.g. wood, and constantly replenish the water-repellent material on the surface, lost due to weathering and erosion.
2. *The non-migrating component* consists of a dense hydrophobic material dispersed as submicroscopic particles throughout the surface coating which cannot be displaced by preferential wetting.

Of special importance is the fact that the migrating component acts as a *reservoir* for hydrophobic material, and is able to replenish areas where the water repellency has been reduced during weathering and exposure to water.

Under certain conditions, the migrating component can even diffuse into the porous substrate, e.g. wood, and render the coating-substrate interphase water repellent.

The non-migrating component, however, is so firmly embedded in the surface film that it will remain there during the whole service life of the coating.

The total effect of the self-repairing property of the migrating component and the permanency of the non-migrating component is an improved resistance to water which lasts much longer than the water repellency of conventional surface coatings relying only on the use of one type of hydrophobic component.

The *migrating* component consisting of polyolefins with a molecular weight up to 4000, will undergo some displacement due to preferential wetting but at a rate which is less than one tenth of paraffin waxes.

The *non-migrating* component, being a fatty acid of a very high molecular weight, forms submicroscopic particles which cannot be displaced and remains permanently embedded in the surface coating (Figs. 2 and 3).

Results

Over a period of more than 10 years, the different *double-barrier products* have undergone extensive laboratory tests, and have been exposed to natural weathering under widely different climatic conditions in Europe and Africa varying from the cold climate in Scandinavia to the hot, tropical weather of East Africa.

Surface coatings deteriorate and break down very rapidly under hot, humid conditions, and the evaluation of the double-barrier products carried out in Kenya, can therefore be looked upon as an accelerated weathering test under natural conditions.

In laboratory tests as well as during natural weathering, the different double-barrier products were compared with conventional and traditional products commercially available on the international market.

A: Laboratory tests

When wood is treated with the double-barrier products, it takes up less water and swells less than wood treated with conventional products.

Figures 4 and 5 show the result of tests carried out on Norwegian pine treated with three different double-barrier products especially formulated as water-repellent wood preservatives, and compared with three commercial products on the Scandinavian market. (The various experimental double-barrier products have been given the designation Aquanti and a number referring to specific recipes.)

The test pieces were completely immersed in water, and the water absorption and swelling were measured after 30 minutes immersion. Figure 4 shows the amount of water taken up by the wood, and Fig. 5 shows how much the wood swelled under the same conditions.

The reduction in water uptake and swelling is considerable on wood treated with the double-barrier products. Wood treated with conventional products take up 97·8 per cent more water, and swell 81·6 per cent more than wood treated with the double-barrier products. (Based on the average data for three conventional and three Aquanti products.)

The increase in water absorption when wood is completely immersed in water, is an extreme test for water repellency under the most adverse conditions. Such laboratory tests have been used for many years to test the efficiency of water repellents and surface coatings. It is considered to be a fundamental test for evaluating water repellents of all kinds (2).

B: Natural exposure tests

Exposure tests were carried out on standard exposure panels

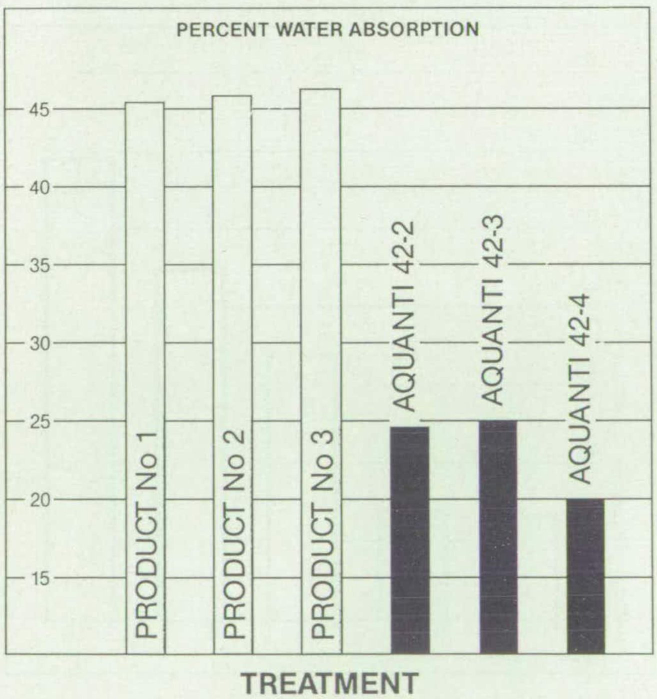


Fig. 4.

Water absorption of wood samples after 30 minutes immersion in water. Wood: pine.

Treated with:
1: Commercial product No. 1
2: Commercial product No. 2
3: Commercial product No. 3
4: Aquanti No. 42-2
5: Aquanti No. 42-3
6: Aquanti No. 42-4
All products are solvent-borne primer-impregnants.

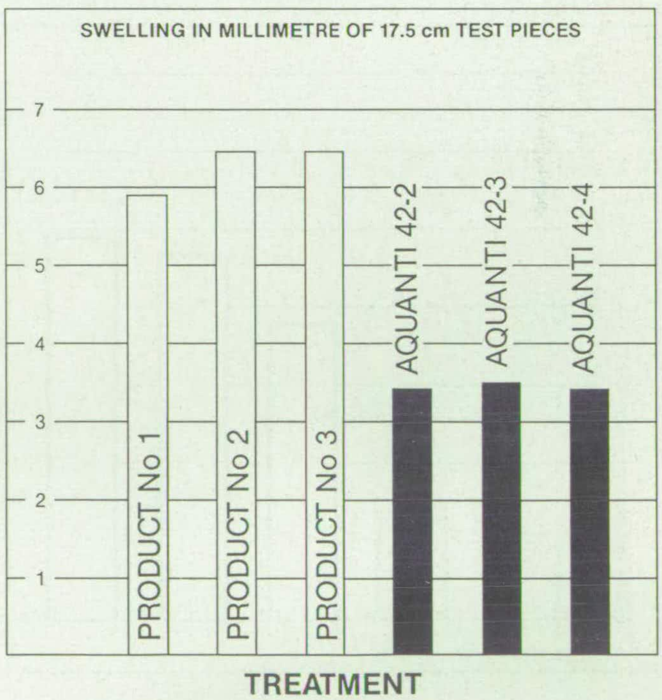


Fig. 5.

Swelling of wood samples after 30 minutes immersion in water. Test pieces 17·5 cm standard size from pine.

Treated with:
1: Commercial product No. 1
2: Commercial product No. 2
3: Commercial product No. 3
4: Aquanti No. 42-2
5: Aquanti No. 42-3
6: Aquanti No. 42-4
All products are solvent-borne primer-impregnants.

of pine and in some cases on hardwood. In Northern Europe the panels faced south at an angle of 45°, in Southern Africa the panels were orientated towards north at an angle of 45°, and in East Africa the panels hung vertically facing north.

The most important parameter to be tested was the amount of water taken up by the treated panel during the period of exposure to natural weathering. The panels were weighed at intervals during the test period and the amount of water absorbed calculated in per cent based on the weight of the wood.

The results presented in the following are based on the water uptake after rainy periods when the differences between the treated samples were most pronounced.

1. **Natural weathering in Northern Europe**

The results of the weathering tests as shown in Fig. 6 are striking. The two Aquanti products (Nos. 1 and 2) consist of water-based wood stains. The other three products, also water-borne, were a conventional oil-alkyd-modified acrylic (No. 3) and two commercial acrylic emulsions (Nos. 4 and 5).

Wood treated with the water-borne Aquanti, took up on an average 6·45 per cent while the samples treated with conventional water-borne acrylics absorbed as much as 21·83 per cent.

2. **Natural weathering in Tropical Africa**

From Fig. 7 it can be seen how wood treated with different products takes up water under hot, humid conditions in East Africa. Also in this case, the difference between the Aquanti and conventional products is remarkable.

One Aquanti water-borne wood stain (No. 1) and another Aquanti solvent-borne stain (No. 2) were compared with conventional wood stains of the solvent-borne type (No. 3) and two water-borne versions (Nos. 4 and 5). In this case wood treated with the Aquanti products took up 6·91 per cent water compared to 22·93 per cent in the case of conventional treatments.

3. **Natural weathering in Southern Africa**

Between the two climatic zones, referred to as the cold weather of Northern Europe and the hot weather of tropical Africa, is a broad belt on each hemisphere of Mediterranean or a temperate type climate. As representative of this type of climate, the Cape Province of South Africa was chosen for the tests.

Figure 8 shows some of the results. Nos. 1 and 2 are Aquanti products. No. 3 refers to a commercial oil-alkyd-modified acrylic, No. 4 is a commercial solvent-borne wood stain and No. 5 is a conventional acrylic emulsion recommended for wood.

Also in this case, the difference between the Aquanti and the conventional products was considerable. The wood protected by the Aquanti products took up on an average 5·48 per cent water while the panels treated with the conventional products absorbed as much as 23·92 per cent.

CONCLUSION

The prediction that a hydrophobic double barrier is more efficient than any conventional water repellent in preventing water absorption is confirmed by laboratory evaluations and natural exposure tests.

Of special importance is the fact that the reduction in water absorption was of the same order of magnitude under widely different climatic conditions. Figure 9 shows the average water content of wood during the *wet* season in Norway, Kenya and South Africa.

During the test periods, the average water content of wood

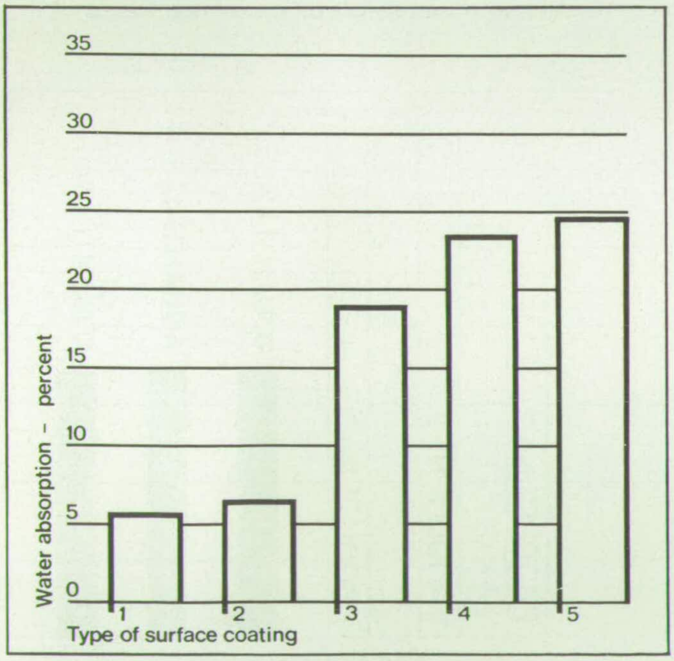


Fig 6.

Water absorption of wood during natural weathering tests.
Climate: Cold, wet. Northern Europe. Oslo – Norway.
Wood: Norwegian pine.
Measured after heavy rain.
Treated with:
1: Aquanti finish . Version No. 1
2: Aquanti finish . Version No. 2
3: Conventional acrylic
4: Conventional acrylic
5: Conventional acrylic
All products of the water-borne type.

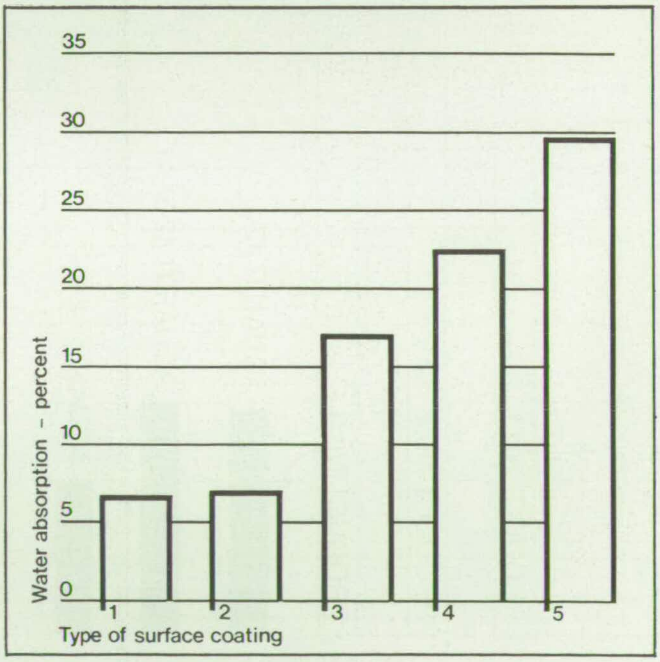


Fig. 7.

Water absorption of wood during natural weathering tests.
Climate: Hot, humid. Tropical Africa. Nairobi – Kenya.
Wood: Mahogany. Local variety.
Measured during rainy season.
Treated with:
1: Aquanti water-borne finish
2: Aquanti solvent-borne finish
3: Conventional solvent-borne finish
4: Conventional water-borne acrylic
5: Conventional water-borne acrylic.

treated with products based on the double-barrier system remained below 10 per cent, while the water absorption of wood coated with conventional products was around 20 per cent.

This means that wood treated with the new products does not reach the danger zone with respect to a moisture content above which wood may rot due to degradation by fungi, moulds and bacteria.

The most far-reaching conclusion to be drawn from this is that the double-barrier system makes it possible to protect wood from many types of microbiological attack without the use of biocides.

This opens up a new field of research in a world becoming increasingly aware of the environmental effect of any type of toxic material.

ACKNOWLEDGEMENT
The author would like to express his appreciation for the time and equipment made available by the Chemistry Department of Nairobi University in Kenya; the laboratories put to our disposal at Standard Kjemiske in Oslo, Norway, and the Dekro Group of Companies in Cape Town, South Africa; the close co-operation with Sadolin in Nairobi during exposure tests in East Africa; support and encouragement from Rentokil Limited in East Grinstead, England; and assistance for the electron microscopy investigations from the Department of Pure and Applied Biology of the Imperial College of Science and Technology in London, England, as well as the Institut für Holzbiologie und Holzschutz der Bundesforschungsanstalt für Forst- und Holzwirtschaft in Hamburg, Germany.

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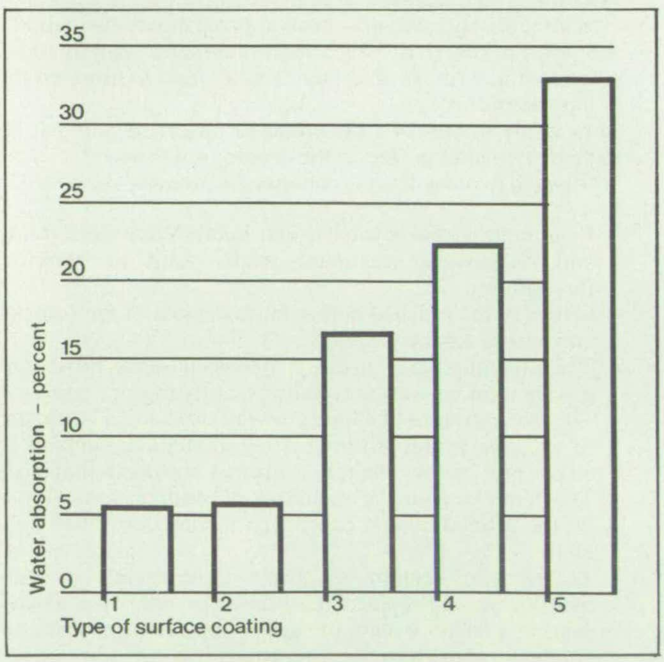
DISCUSSION ON PAPER 3

Chairman: Dr. C. R. Coggins

THE CHAIRMAN: Thank you very much, Prof. Borgin. That is a very stimulating thought on which to end. I am afraid we have used up all the time available this afternoon. Thank you very much for a stimulating and challenging paper. *(Applause)*.



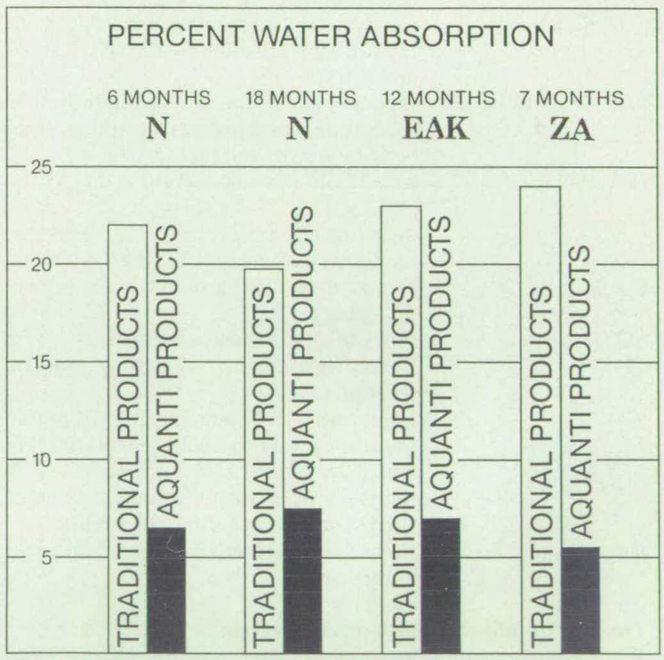


Fig. 8.

Water absorption of wood during natural weathering tests.
Climate: Temperate, Mediterranean. Kuils River. R.S.A.
Wood: pine.
Measured during the rainy season.
Treated with:
1: Aquanti finish. Version No. 1
2: Aquanti finish. Version No. 2
3: Conventional oil-modified acrylic finish
4: Conventional solvent-borne wood stain
5: Conventional acrylic finish. Unmodified.

Comparing water content of wood in three climatic zones.
Climates: Norway (N), East Africa Kenya (EAK) and Southern Africa (ZA).
Measured during the wet seasons
Treatments:
1: Average value of different Aquanti products
2: Average value of several conventional products.

B.W.P.A. ANNUAL CONVENTION 1989

COBRA'S EXPERIENCES WITH WOOD POLES OVER 40 YEARS

by Ian G. Smith
B.W.P.A., Cambridge, July 1989

Introduction

A great deal has been written and spoken about Utility and telegraphic wood support poles with regard to their suitability, durability and falability. Many thousands of hours have been spent theorising, examining and researching into cause, effect and probability by very knowledgeable and emminent gentlemen around the world.

The difference suggested here is that Cobra, through their privileged position over 42 continuous years of pole inspection and retreatment, are positioned – not through academic eyes but through sheer volume of sampled material – to make several observations and propose ideas and questions on which others can consider and hopefully comment constructively.

Glossary of Abbreviations and References

Poles	– Pinus – Scots Pine – Pinus Sylvestris – creosoted.
Pole rot	– principally the wood decaying basidiomycetes, including Lentinus Lepideus.
E.S.I. 43-88	– specifies pre-treatment of wood poles for the U.K. Electricity Supply Industry and parameters for Inspectors operating at pole treatment plants.
C.P.R.	– Control of Pesticides Regulations, effective 6.10.86.
P.P.S. – (P.S.P.S.)	– voluntary Pesticides Safety Precautions Scheme, operative prior to October 1986.
H.S.E.	– Health and Safety Executive, Bootle, Merseyside, U.K.
C.O.S.H.H.	– Control of Substances Hazardous to Health; new legislation effective 1.10.89 and 1.1.90.
W.P.16 and W.P.20	– Department of the Environment publications on wood preserving and arsenic-bearing wastes and their disposal.
H.V.	– wood pole lines operating at 11, 33, 66 and 132 kV.
L.V.	– distribution poles, usually light or medium size, at 415 volts or 240 volts.
F.P.R.L.	– Forest Products Research Laboratory, Aylesbury.
'A'	– Poles in satisfactory condition.
'B'	– Poles with slight rot which can be treated.
'C'	– Poles with rot outside the treatable area; poles with well developed rot which should be re-examined at yearly intervals; poles with mechanical damage such as caused by farm implements.
'D'	– Poles which should be changed immediately.

The case for effective lasting preservation

The following are the main issues that have to be considered either from within or from outside the industry:

(1) The mature trees that make the best poles grow not only without detriment to mankind but actually enhancing our environment chemically and aesthetically.

(2) The utility pole at present degrades in the U.K. twice as fast as its traditional one for one replacement grows in Northern climes.

(3) The neglect and replace policy is wickedly wasteful. Accounting practices which justify 40, even 50 year lifetimes and then replacement takes no account of pressures thus placed on existing growing stocks.

(4) To preserve requires effective preventative treatment at the outset: hence creosoting before implantation. Correct moisture content, sufficient depth of penetration and mature wood are all factors that have been defined by research and improved by practice and experience. Today's good pole is a delicate related balance between these factors; ideally containing sufficient bacteria killing material to ensure a 'no-go' area that will remain within the pole. This is the dilemma for the ecologists – some poison here to prevent the natural cycle of decay starting, which in our world will lead on to accelerated deforestation and the poisoning of an atmosphere laden with unabsorbed waste mankind-generated gases. We strongly argue for a reasonable attitude.

(5) Prevention is a sensible policy now, whether by injection of salts or implementation of rods in bored holes. Cobra have an open mind these days on the best treatment to be used. It can be repeated every 5, 10, 15 or 20 years according to its longlevity, but there should be no question that it is desirable.

The degree of toxicity is a very topical subject. Toxic boron rods can be inserted by comparatively unspecialised operatives, whereas Rentex can only be injected by Cobra's trained and regulated specialists. Boron has been shown to prevent, where Rentex has been shown to effectively kill already established rot colonies, as did the original D.F.A. salts.

Accepting that mistakes were made in the past at the initial pre-treatment stage, we now have approximately two million wood poles in the U.K. which require either a remedy to be applied to initial rot, or treatment and a repair to more established pockets of rot.

How many tonnes of CO_2 would be absorbed per year of growth by two million trees if these poles were saved?

It is as well to recognise the commercial pressures involved.

- Legitimate growers want to sell harvested mature trees, and responsible treatment plants want to optimise throughput.
- Sellers of the finished pole want to dispose of their stocks and ensure a good cashflow.
- The end purchaser needs a balanced stock provision/useage ratio, as well as equating quality to price paid.
- The two extremes of a long growing cycle and a hurricane or extreme winter storm creating immediate demand at either end of this chain will place a chronic imbalance. This lends to abuse of standards of conduct, particularly on the refined quality control parameters observed normally.
- The remedial section will always argue against inconvenient disrupting replacement; the pole sellers will always suggest a 'clean sweep' of supports at a time of cable or conductor, hardware or other change.

But other facts and figures should be considered:

- Around half the implanted poles do *not* develop premature rot, despite the odds apparently being in favour of them doing so. Will they continue to be satisfactory and for how long?
- There are also distorting circumstances which affect the true picture.

First example: After a hurricane in the late 50's, several thousand home grown poles were economically prepared for L.V. rural electrification projects being encouraged by the State at that time. Unsuitably prepared in haste, they have added to rotten pole statistics over the last 30 years.

Second example: A well husbanded pole population shows low rot figures over several years. Analysing these results, care and maintenance is reduced or withdrawn for a period of many years on financial grounds. This justification is well broadcast, without credance being given to past work. Even National figures are distorted. Eventually there is a 'roll-on' effect, necessitating a 'crash' replacement programme which in turn affects the commercial chain as outlined above.

Third example: Inaccurate inspection and diagnosis. Despite Cobra's experts being available these last 40 years, there is a tendency for the separate Utilities to go through phases of either limited neglect or conducting inspections themselves; opinions about the necessity of a thorough inspection are influenced by economics just as much as personal beliefs. Despite the belief that a Board employee will more carefully inspect the pole his colleague will climb, our experience is that the most suitable person is not always selected for the job. Accurate pole rot inspection has been developed by Cobra experience into a skilled job. No matter how many aids are provided (procedural instructions, diagrams, even modern sounding equipment) there is no substitute for a man who has been trained by an instructor who has 40 years experience.

Because there is a tendency to under inspect by Utility employees, early rot is often undetected and below groundline rot is usually missed altogether. Regrettably accidents do occur where pole-climbers are injured (even killed) in a fall due to pole collapse. Eventually when Cobra do inspect, a lot of poles have progressed through the early stages of rot such that treatment can no longer be considered 100 per cent effective and the pole has to be changed sooner rather than later as its residual strength is below acceptable safety levels.

Fourth example: When studying a pole population, the 'norm' for 'D' poles varies between 4 per cent and 12 per cent of the total. However, these days we are often limited to inspecting poles more than 25 years old in the belief that improved, controlled and inspected pre-treatment procedures have eliminated early failures. This is not so – poles as recent as 1975 have been found by Cobra in a 'B' condition.

After each contract we do a 'Year-on-Year' analysis of poles and their conditions. Whilst there is a definite tail-off in rot the younger the pole, the indications are that in another 20 years the main problem will have moved forward as well. But what distorts percentages in this example is the unrecorded data on why there are poles of younger ages in the figures.

Had they replaced older rotten poles revealed on a previous inspection? Are they extensions to existing lines? Are they new interconnections to reinforce the integrity of a supply? Or are they new L.V. service poles to supply new housing stock? To obtain more relevant percentages we now show figures for the total number of poles on a section of the network and a separate figure for poles which we have just inspected.

To try and provide un-distorted information, Cobra have extracted data from lines that have, in the main, been undisturbed over several years. Hopefully these case histories will give an insight into cause and effect, and either substantiate past myths or dispel them. With such a vast library on the condition of poles at various stages in their history available to us, the following have been selected by the writer mainly because they are not complicated by many other factors.

Summary (Photographs and charts on the following were expanded at Cambridge)

Case 1. Poles not re-treated by Cobra show heavier rot figures.

Case 2. Poles treated by Cobra regardless of rot condition at the time of injection virtually remain "frozen" as at 20 years previously. It is intended to present a future paper on this project.

Case 3. Poles rot, or do not rot, in groups. An explanation is offered.

Case 4. Results of destructive sectioning of removed poles to assess accuracy of Cobra's in situ rot inspections.

Case 5. A study of pole rot and its relationship to initial depth of penetration in creosoted poles.

HISTORY

The Cobra process was invented in 1937 and used in Europe from that date. In 1947 it was introduced to the U.K. and operated up to 1988 to inject salts into the base of wood poles. The special flat needle does little damage to the wood fibres and reaches untreated sapwood up to 100 mm deep. As the needle is withdrawn, some of the salts are left on the surface and this is covered with a bitumastic compound and sealed overall with sheet aluminium. In excess of 1·5 million poles have been treated this way after inspection during this 41 year period in the U.K.

Cobra excavate around the base of poles and examine for both internal and external rot above and below ground level. We also study the pole above reachable height for signs of damage and decay. Whilst specifications have varied slightly over the years, mainly affecting the interpretation of degrees of rot and their seriousness, and whether a pole should or should not be re-impregnated, the basic procedures have remained unchanged. The D.F.A. salts were supplied from the parent company in France. The quality of material was not checked in the U.K. and research and development was not encouraged by the parent organisation.

The principle changes that took place over 40 years concern the safe handling of the material and the provision of other safety equipment on site. Emergency provisions have been specified, labelling and warning notices improved and first aid kits that contain the proper equipment provided.

Cobra's confidential Site Instructions have always been quite specific on one principal point: Anyone who disobeyed standing instructions on inspection or handling of chemicals would face instant dismissal!

A 1947 report commissioned by Cobra was produced by F.P.R.L. in which W. P. K. Findlay stated that 1 kg/m^3 loadings of D.F.A. in wood would be effective against all wood rotting fungi. B.S. 838 methods were employed (19).

By 1955, Cobra had produced a sales booklet which constantly evoked that report, but also stated that the average life of poles after treatment by re-impregnation would be at least 15 to 20 years. No doubt this statement evoked some sensitivity as it had not been made by F.P.R.L. In addition, somewhat imprudently, Cobra had treated some poles that were far too decayed to warrant treatment, and encouraged by some disappointed customers a study was begun into the length of time D.F.A. salts could be expected to remain effective. After an interim report in April 1964, the final report R.W.248 was published in July 1966 (15). This suggested that eight to nine years after re-impregnation, Sodium Fluoride levels had fallen below toxic effectiveness.

Cobra battled on, and after Mr. J. J. Blair's paper on Wood Pole Strategy in May 1979 (11) (17) were able to promote their policy with confidence well into the 1980's.

In March 1987 a specific if somewhat difficult to follow article by Dr. Morris and B. Calver was published in the Electricity Council's "Distribution Developments" magazine (12) (18). It showed that sodium fluoride did remain in poles for up to 20 years, contrary to earlier assumptions, even though some disagreement remained about levels effective to maintain a toxic presence to Lentinus.

One of the many *opinions* ventured was that limited decay 'B' poles should not be re-impregnated. This opinion seemed to hinge on the speed of diffusion of Cobra treatments through the interior of the pole; yet the article also showed that an infected bait located between injection points did not show any live organisms present six weeks later. Future Cobra research will look at the distribution pattern with the newer Rentex treatment to confirm its speed of diffusion.

The past is almost swept aside by recent legislation, and most of the active part of Cobra's history begins in October 1986!

Cobra and Regulatory Legislation

D.F.A. salts contained a combination of three poisons, two of which Dinitrophenol and Arsenic, are very topically "out of favour". A great deal is known about Arsenic these days – its purpose in the original formulation being to kill termites and to fix the other components inside the pole. As the makers produced in bulk for shipment to various parts of the world the formulation was never changed. The main objection to Dinitrophenol seems to be that it is now considered out of date. Little data was compiled about it in the 1930's and 1940's, and to fill in the gaps to satisfy regulations is not considered justifiable economically. H.S.E. have considered a document and listened to representations from France but have not given D.F.A. approval as a new material.

In July 1981 Cobra were informed in writing that the D.F.A. injection process did not fall into the net of the P.P.S. scheme and need not be registered. Despite being a member of B.W.P.A., the Ministry stated that communications on developments in proposed legislation had been sent to the address vacated some years previously when questioned about the ban imposed on D.F.A. salts in September 1986. By that date they *had* found out the Company's address.

The former management of Cobra were of course to blame, for ingorance is no defence in matters of Law. The former owners had no incentive to offer a revised formulation since D.F.A. was still produced and in use in France in 1987.

The new owners and changed management stopped injection work as the following steps took place, with customers obliged to limit contracts to pole inspections only.

(a) Discussions took place with Rentokil who had Rentex registered in P.P.S. under H.S.E. 0149 for industrial use only.

 The material was chosen because its Fluoride content was so close to that of D.F.A. Cobra had always tested for Fluoride when demonstrating the dispersion and efficacy of its salts injection process in the past.

(b) With the help of the Scottish Hydro Board, suitable sections of older, well leached creosoted poles were selected for a test programme.

(c) A Pole Testing Station was established near Oban, Scotland.

(d) Dundee Institute of Technology, comparatively near at hand and showing great interest in a project to run concurrently with their development work in other fields of pole rot research, agreed to supervise the tests professionally as Independents. This relationship has since progressed and they now give Cobra advice over a wide spectrum of projects.

(e) Test poles were sited, tested, baited and injected between July and November, 1987, and the results of this work after 18 months have been very encouraging. The Trial continues; I.R.G. Document, 3556, Finland, May 1989, "A field evaluation of chlorinated fluoride as remedial treatment for creosoted wooden distribution poles" (7) (8). Rentex has been shown to work very rapidly.

(f) On the strength of initial results and the H.S.E. giving approval No. 3626 to Cobra, approximately 2,500 poles were injected in situ with Rentex before the end of 1988, using the established Cobra procedures with a pre-mixed slurry supplied in 15 kg tubs by Rentokil.

(g) Following the provision of operatives' health data, and having submitted an environmental study procedure for Rentex, the H.S.E. have advised Cobra verbally that a further 12 months work can be carried out. The extension of H.S.E. 3626 at the time of writing this document has not yet materialised. No doubt other more immediate and urgent matters have taken priority in a Department with limited resources (21).

(h) Consider Cobra's record when using D.F.A. Salts:

1) Operatives who continually used this material, mixing Salts with water using respiratory equipment on site have continued in good health (32, 18, 23, 11 and 16 years service as specialist injectors are typical examples).

2) Considering the law of averages, we feel it is remarkable that throughout the preparation of material and it's subsequent injection into wood poles over the last 40 years, only one accident occurred. The strict site instructions, proper supervision, a healthy and responsible attitude in the Company for the Salts, Regulations and procedures must have played a part.

 A loaded Cobra Vehicle was involved in an accident just 10 years ago. The vehicle hit a tree and this resulted in the death of the driver and spillage of dry salts. Emergency procedures were followed in conjunction with the police, and two other Cobra personnel, in the vehicle as passengers, were taken to hospital for observation for any possible side-effects of contact with the dry salts. None were found.

3) Prior to 1960, one or two claims were made against Cobra for cattle which had been allegedly poisoned when licking treated pole bases. In 1962, Parry & Ferguson analysed residues in the bitumen covering and confirmed livestock was not at risk. In 1960, in addition to covering the treated area with a brushed on bitumastic compound, Cobra sheathed the pole with aluminium sheet over the above ground section and extending down approximately 3 in. (8/10 cms) below the reinstated groundline. In the last 28 years no payments have been made due to a pole thus treated and covered affecting livestock.

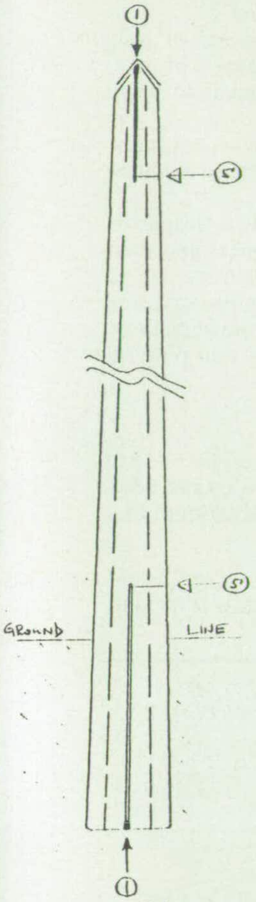
4) If the constituents of D.F.A. salts leach out of a treated and covered pole into the surrounding soil, presumably the contaminated fodder either would not grow, or would poison livestock. Neither has occurred.

5) In 1966, a report produced by The Forest Products Research Laboratory deduced an effective life of eight to nine years based on loadings of fluoride not falling below 0·01 lb/ft_3 (15). Cobra backed up their conviction of longer effectiveness by issuing a limited 10 year guarantee. Recent instructions regarding pole inspections seem to indicate an acceptance of 16 years effective control after Cobra treatment (12), a stance we fully support and which prompts congratulations to the original decision makers on a good investment.

THE FUTURE

Ideally, earlier remarks will be heeded; poles will be subject to regular efficient inspections, treated to either prevent or arrest rot in the early stages, and only be replaced with mature wood properly pre-treated.

In reality, the industry after Privatisation will be under pressure to give a level of service consistent with perceived customer satisfaction and ruled by an accountant's hand. Alternative trees will be used, probably home-grown, in an effort to support U.K. growers and reduce costs.



The sketch alongside is a suggestion for ensuring that pre-treatment is effective, and provides for subsequent prophylactic or remedial treatment in a convenient manner (16).

1) Holes are bored out during initial preparation to a length and bore to suit the customers' future plans. Boring in the heartwood they do not affect the strength or flexibility more than 1 per cent at most.
2) Seasoning and drying out are more easily monitored.
3) According to the initial treatment and planned subsequent treatment, the holes are sealed or left open in the initial process.
4) Before implantation, holes are capped and sealed.
5) Side entries are fitted with one way pressure valves, and capped against the weather, corrosion and interference.
6) Depending on future developments in pole treatments, a whole variety of preparations can be applied at calculated intervals through these valves in liquid or slurry form, allowing for leaching and dispersion rates determined by research beforehand.
7) The application of pole "furniture" can be anticipated at the design stage so that bolt holes cause the least possible disruption.
8) The "wicking" effect can be utilised to ensure good dispersion.
9) The audience's comments regarding this proposal are welcomed.

Cobra are at present doing work which involves inserting Boron rods into poles which are sound at the groundline. Again much has been written about the subject particularly with respect to wood railway sleeper treatments. Cobra believe this is a good prophylactic treatment to supplement the initial pre-treatment. Although tests have been done, we still have reservations about drilling holes into a pole at its most critical point where strength is concerned. If complacency or financial situations dictate that the rods are not replaced at the correct time, these voids could be the perfect starting point for pole rots!

The development of Biological Control methods is proceeding with enthusiasm at several research locations. Despite initial set backs there is always the spur of using Nature's products to replace the toxic elements currently employed. Implementation of selected biological agents in a nutrient solution could be done using the Cobra injection tool probably more effectively than multiple bored holes. The suggested centre void previously described could provide both air and/or moisture, or even be the depository for biological agents to prevent Lentinus getting established.

Cobra's role is also changing. Responding to customer's suggestions and needs, a team not only inspect and/or treat poles these days, but conduct a full line patrol, reporting on the condition of electrical equipment, whether tree pruning is carried out or needed, measuring span lengths, checking clearances, numbering odd poles, fixing statutory warning notices, tightening stays etc.

All these results are entered into a computer which produces reports with plan diagrams of rot in the pole and residual strengths using a laser printer. A complimentary computer programme allows the customer to receive his reports in disc format, and select and scroll through the information provided on screen, printing out extracts which can be used to prepare work instructions. Year-on-Year analysis of results of inspections are now produced at the touch of a button, previously a laborious time consuming job.

Cobra supply and fit Ensto steel pole repair sleeves, ideally treating the pole with injected salts first to arrest decay and strengthen the pole. This is particularly useful where an H-pole is carrying a transformer and associated heavy equipment and only one leg is rotten. Whether such a repair can be considered

Code File Listing

Code Type	*Description*	*Detail Code*	*Description*
A1	Pole Type		
		A	'A' Pole
		FS	Flying Stay Pole
		H	'H' Pole
		LP	Lay Pole
		OP	Other Pole Type
		RP	Rutter Pole
		SP	Single Pole
		WS	Wood Strut
B1	Pole Config.		
		AS	Angle Section
		AT	Angle Section Tapping
		CE	Combined Earthing
		CO	Concrete Pole
		FA	Flying Angle
		FW	Four Way Pole
		HE	HV Earthing
		IP	Intermediate Pole
		IT	Intermediate Tapping
		LA	Light Angle
		LE	LV Earthing
		LT	Light Angle Tapping
		OB	Other Configuration
		S	Section
		SE	Steel Pole
		ST	Section Tapping
		T	Terminal Pole
		UG	Underground Cable
F1	Land Use		
		2F	Meadow
		3F	Rough Grassland
		5F	Moorland
		6F	Verge
		7F	Fence/Wall/Hedge
		8F	Footpath
		9F	Private Garden
		AB	Growing Crop
		AF	Arable Land
		BF	Recreational/Parks
		BR	Rail Crossing
		CF	Caravan/Camping Site
		FF	Forestry
		FY	Farm Yard
		IW	Pole in Water
		OF	Other Land Use
		RC	Road Crossing
		RF	Roadway
		WC	River/Water Crossing
		WF	Waste Ground/Unused
G6	Tree Defects		
		OZ	Other Tree Defects
		TC	Complete Tree Rem Rq
		TP	Tree Limbing Reqd
		TS	Scrub Clearance Reqd
		TT	Tree Cutting/Trim Rq
		TU	Urgent Tree Att. Reqd
G7	Reinforcement		
		XX	Suitable for Sleeve
G8	Photo		
		PH	Photo Taken

semi-permanent will transpire over the years. What is known is that the sleeve has a "wicking" action which artificially raises the groundline area. Without preventative treatment the rot will be encouraged to progress above the top of the artificial support and defeat the whole exercise.

Apart from selling the Pilodyne, very useful for external soft rot investigations, and a whole range of pole testing equipment and labels to our customers, Cobra's sister Company manufactures and supplies the Protimeter. Developments by others, and internally within this Group, continue to try and replace or supplement the skills of pole inspectors. We have objectively tested many instruments utilising several approaches to the problem, but have either found them not sufficiently accurate or excessively time-consuming in reaching a plausible diagnosis. It is the internal divisions (extended shakes) and separations that seem to cofuse these machines.

Photographs have been used to great effect in supplementing the reports. Engineers can more accurately direct maintenance and repair work without specific site visits beforehand. Date/timed/numbered photographs have been used to ensure correct phasing of connections; identifying damaged insulators from ground level; allowing the correct replacement items to be requisitioned from stores, and aiding the selection of appropriate equipment for tree cutting or pruning.

Cobra have never believed in the effectiveness of pole bandages applied at the groundline, and a paper in 1970 seemed to confirm our own findings out in the field when inspecting poles (20).

Caps could be used against pole top rot however, but insertion of boron rods in this area under a pole top shield might be a better procedure for preventative treatment.

In the long term it seems that the future of Cobra, despite its many disciplines, lies in the hands of our customers and their accountants. The future of wood poles to which we are so closely associated lies mainly in developments in preservation and the reactions to those developments of the powerful regulating authorities in Europe. What is certain is that pole rot will not conveniently disappear!

ACKNOWLEDGEMENTS

Cobra wish to acknowledge with thanks the foresight of 13 of the Electricity Boards which cover England, Wales and Scotland for adopting an inspect and re-treat policy at various times in the last 42 years; in particular to:

General Guide to the acceptable amounts of decay relative to classification of poles with decay confined to the treatable area in the case of 'B' only. (All measurements shown in centimetres)

		'B' LIMITED ROT (Treatable)		*'C' SUSPECT ('S' Label)*		*'D' REPLACE*
POLE DIAMETER	*CIRC. OF POLE*	*MAXIMUM INTERNAL DECAY*	*MAXIMUM EXTERNAL DECAY*	*INTERNAL MAXIMUM DECAY BETWEEN*	*EXTERNAL MAXIMUM DECAY BETWEEN*	*('D' Label)*
21-22	Less than 180° 180° or more	3·5 1·5	1·5 1·0	3·5 - 5·5 1·5 - 2·5	1·5 - 3.0 1·0 - 1·5	
23-24	Less than 180° 180° or more	4·0 2·0	2·0 1·0	4·0 - 6·0 2·0 - 3·0	2·0 - 4·0 1·0 - 2·0	
25-26	Less than 180° 180° or more	4·0 2·0	2·0 1·0	4·0 - 6·5 2·0 - 3·0	2·0 - 4·0 1·0 - 2·0	
27-28	Less than 180° 180° or more	4·5 2·0	2·0 1·0	4·5 - 7·0 2·0 - 3·5	2·0 - 4·0 1·0 - 2·0	
29-30	Less than 180° 180° or more	5·0 2·5	2·5 1·0	5·0 - 7·5 2·5 - 3·5	2·5 - 5·0 1·0 - 2·5	
31-32	Less than 180° 180° or more	5·0 2·5	2·5 1·0	5·0 - 8·0 2·5 - 4·0	2·5 - 5·0 1·0 - 2·5	
33-34	Less than 180° 180° or more	5·5 2·5	2·5 1·0	5·5 - 8·5 2·5 - 4·0	2·5 - 5·0 1·0 - 2·5	DECAY IN EXCESS OF CATEGORY 'C'
35-36	Less than 180° 180° or more	6·0 3·0	3·0 1·5	6·0 - 9·0 3·0 - 4·5	3·0 - 6·0 1·5 - 3·0	
37-38	Less than 180° 180° or more	6·0 3·0	3·0 1·5	6·0 - 9·5 3·0 - 4·5	3·0 - 6·0 1·5 - 3·0	
39-40	Less than 180° 180° or more	6·5 3·0	3·0 1·5	6·5 - 10·0 3·0 - 5·0	3·0 - 6·0 1·5 - 3·0	
41-42	Less than 180° 180° or more	7·0 3·5	3·5 1·5	7·0 - 10·5 3·5 - 5·0	3·5 - 7·0 1·5 - 3·5	
43-44	Less than 180° 180° or more	7·0 3·5	3·5 1·5	7·0 - 11·0 3·5 - 5·5	3·5 - 7·0 1·5 - 3·5	
45-46	Less than 180° 180° or more	7·5 3·5	3·5 1·5	7·5 - 11·5 3·5 - 5·5	3·5 - 7·0 1.5 - 3·5	
47-48	Less than 180° 180° or more	8·0 4·0	4·0 2·0	8·0 - 12·0 4·0 - 6·0	4·0 - 8·0 2·0 - 4·0	
49-50	Less than 180° 180° or more	8·0 4·0	4·0 2·0	8·0 - 12·5 4·0 - 6·0	4·0 - 8·0 2·0 - 4·0	
51-52	Less than 180° 180° or more	8·5 4·0	4·0 2·0	8·5 - 13·0 4·0 - 6·5	4·0 - 8·0 2·0 - 4·0	

N.B. (a) In category 'B' sectors of internal decay rising to a maximum height of 70 cms from ground line would be treated, but where decay extends above 70 cms the pole would be placed in category 'C'.

(b) Should a pole be affected by external decay or Woodpecker attack outside the normal treated area, it would be placed in category 'C' or 'D' depending upon the severity of attack. Such reasons are identified on our reports.

1. The North of Scotland Hydro Electric Board.
2. The Merseyside and North Wales Electricity Board.
3. The Midlands Electricity Board.
4. The Eastern Electricity Board.
5. The South Eastern Electricity Board.

In addition, we particularly wish to thank the following for their present and past support and acknowledge their work referred to in this document:

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10. Mr. M. Hughes, (M.A.N.W.E.B.).
11. Mr. J. J. Blair, (Hydro Board).
12. Mr. B. Calver, (Eastern Board).
13. Mr. J. Ekbury, (M.A.N.W.E.B. and S.E.B.) (retired).
14. Mr. H. Wash, Cobra (retired).
15. Forest Products Research Laboratory, Princess Risborough, Report R.W. 248. "The distribution of Sodium Fluoride in 'Cobra' treated poles and its change with time." July, 1966.
16. Patent Pending.
17. "A Strategy for the 1980's" (Wood pole maintenance and replacement). J. J. Blair. May, 1979.
18. "Wood Pole Decay – Current Chemical Retreatment Methods". Dr. P. I. Morris, Imperial College, London and B. Calver, E.E.B.
19. "Detailed Report on Toxicity Tests on Cobra Wood Preservative Salts" – F.P.R.L. W. P. K. Findlay, April, 1947.
20 "The Effectiveness of Bandages for Remedial Treatment of Inadequately Creosoted Poles", F.P.R.L. for E.S.I., May 1970.
21. Written confirmation was handed to the speaker five minutes before this paper was presented.

And all employees of Cobra (Wood Treatment) U.K. Ltd., for their application to their field work, and for their care in gathering samples and data.

DISCUSSION ON PAPER 4

Chairman: E. M. Pearce

The Chairman: Before I invite the audience to ask questions, I should just like to make one little observation with regard to a fact that was put out during the talk. I think Cobra have missed an opportunity because didn't you say that woodpeckers do not attack rotten poles? Therefore, if you have a sufficient team of woodpeckers they would do all the assessments for you. I am sure they must have some keen assessment capability! Are there any questions?

Mr. B. Calver (Eastern Electricity Board): Ian could I ask you, please, if you have done any economic studies on the work that you presented, bearing in mind that you say that a lot of Boards do not look after their systems, and perhaps justifying our side of the question.

Mr. Smith: Yes. Unfortunately time was somewhat limited. I do have a complete folder of transparencies. Perhaps I will ask you to make a judgement. If I could use a piece of paper here. I will talk as much as I can in the meantime. *This (referring to data on screen)* is an assessment on your own system between different types.

Mr. Calver: Ian, as we are short on time, can I say that we can always do something with hindsight. What I am interested in is how do you make the decision before the event happens.

Mr. Smith: As to whether it is economical to inject the pole or not?

Mr. Calver: Yes, without seeing the information at all.

Mr. Smith: The process, I would say, costs about five per cent of the replacement cost of that pole. So I think that is fairly sensible investment.

Mr. Calver: How do you know what percentage of the pole is going to fail?

Mr. Smith: Indeed, I put that very question on one of the pages in my written paper. I do not know, but five per cent of the replacement cost surely is a good investment today.

Mr. Calver: On what age group of poles are you making your assessment? Is it on poles before the inspection scheme of 1958 or are you making it overall, or what?

Mr. Smith: I will show you the figures that I have got afterwards, if you would like, in detail because we are short on time, but I do have some reports here as transparencies which show that poles erected in 1963 and 1967 are already showing incidence of three or four per cent rot. So I question whether the pole situation has really improved, perhaps by 10 years, or has improved enough with the pole inspection scheme at the yard.

Mr. Calver: I will see you later.

The Chairman: It is a very complex question for you to answer.

Mr. M. Connell (Hicksons): You referred to the good health of your longstanding employees. Could you please tell me what sort of monitoring techniques you use to evaluate their health?

Mr. Smith: That is very interesting. Previously, none whatsoever. If a fellow reported for work he was fit. It has changed, obviously, with the requirements of the legislation becoming effective in October and in January of next year. We have submitted this protocol for health monitoring. We have given various facts and figures to the Health and Safety Executive. We have volunteered to go even deeper, but they say at the moment it is not necessary, but, of course, they will reconsider and I am sure it will be necessary in due course. Basically, in the past, very little was done from the Company's point of view, I am afraid, other than to try and ensure that people, as I state in my paper, had a healthy respect for the toxicity of the material and handled it closely in accordance with our site instructions. I mean, people could be dismissed on the spot for breaking those instructions. That was part of the contract of employment that they had. It is not a very satisfactory answer but it is a truthful one.

Mr. R. Newman (Southern Electricity Board): I should like to take you up on a couple of points, Ian. First of all, you made a statement that Cobra treated poles will show less rot than untreated poles. I would disagree with you. Our network shows conclusively that we have an excellent history in relation to poles which have not rotted and we have never had Cobra treatment. In fact, when I compare my statistics with other Boards that have had Cobra treatment, I can clearly show that we have got a healthier population, and the reason is the national pole inspection scheme.

Mr. Smith: But not all your poles, surely, are post 1953?

Mr. Newman: What I am saying is that the poles that we have on our network show a very low incidence of rot and we have not had Cobra treatment. I am pointing out to you that if you compare our poles with those of other Boards which have had Cobra treatment our poles compare quite favourably, and the reason must be, in my opinion, that we were operating a national inspection scheme in 1948, that is before any other Board. That is a fact.

Mr. Smith: I have just checked my list to see if we have ever done anything for the Southern Board and, no, we have not. I think that is admirable because presumably, whoever was involved, be it yourself or your predecessor, was very particular about the purchase of new poles.

Mr. Newman: Exactly. That was a point you also made about the national pole inspection scheme. Leaving that aside, could I just raise one other point, if I may. You asked a question. You said that with the coming of privatisation future managers will look at their systems and only repair or replace what is absolutely necessary.

MR. SMITH: Yes.

MR. NEWMAN: I must tell you that the state today is that from 1948 that is what has been going on. Recent work we have been doing clearly shows that we will have to have some kind of massive investment in the next few years to replace an ageing pole population because, at the end of the day, whatever life you attribute to a pole you have got to replace it at some time. That is an answer to a question that you raised.

MR. SMITH: Yes. I think that whilst the ageing population today presents a problem, if people really thought about it and were prepared to make the investment for the future, that pole could last twice as long.

MR. NEWMAN: Yes, I accept that you were talking about re-treatment.

MR. SMITH: Yes. I see what you are saying, but I am just saying you should look beyond that. Re-treatment or re-impregnation by Cobra is a remedial treatment, an attempt to put off the evil day. I say that people should go back further and be very particular about their poles when they take them in the first place.

MR. NEWMAN: Well, that is the point I made to you about our pole population. I rest my case, Mr. Chairman.

THE CHAIRMAN: I think we have come to the end of our time. I would like to thank you, Ian, for your most illuminating paper. I should like the audience to thank you in the normal way. *(Applause).*

EUROPEAN STANDARDS FOR WOOD PRESERVATION PROGRESS TOWARDS 1992

by F. W. Brooks
Fosroc Ltd (Timber Treatments Division)

Introduction

The British Wood Preserving Association Convention 1988 was the forum where many of us began to realise for the first time the full implication of the Single European Act, which came into effect on 1 July 1987, and is the agreement under which member states of the European Community undertake to enact the necessary legislation to create a single European trading market by 31 December 1992. The details and implications for our industry were clearly explained during the Convention by Dr Guy van Steertegem of the Western European Institute for Wood Preservation. His paper described the various mechanisms by which the barriers to trade will be removed, through the creation of European Standards to harmonise the technical/efficacy aspects of wood preservation, and it was noted that the deadline for production of these standards by the working groups of the European Committee for Standardisation (C.E.N.) was 30 June 1989. It was also discussed that a further major obstacle to trading within Europe, namely that of a common acceptance of wood preservatives by the various countries, would not be covered by the C.E.N. activity and no other formal arrangement had been assigned by the European Council or Commission.

In view of the speed of activity to enable the Single European Act to be implemented and particularly the timetable laid down by C.E.N. it was decided that a progress report should be presented to the B.W.P.A. Convention in 1989.

This review contains the up-to-date position as at mid-June 1989. We shall see in the details which follow that the 30 June 1989 deadline has slipped in many cases. This means that there are no finally agreed texts to bring to your notice and discuss, and it is inevitable that when this paper is published in the Record of the 1989 Annual Convention of the B.W.P.A. there will be additions, deletions and maybe some changes of philosophy. However much progress has been made during the last year and we expect that the details in this paper will form the basis of a harmonised approach to wood preservation in Europe by 1992.

Construction Products Directive

The creation of a single trading market in Europe was embodied in the original 1957 Treaty of Rome. Between 1957 and 1987 progress towards harmonisation was slow because each directive was written on the basis of setting objectives and writing detailed technical specifications. Also total agreement was required between the member states before legislation could be enacted.

This proved to be a very slow and laborious process and the Single European Act (S.E.A.) provided a new framwork and timetable for the creation of this single market. One of the most important provisions to ensure speedier progress with the production of directives was the replacement of the earlier requirement of unanimity between member states to one of weighted (or qualified) majority voting. Another provision of the S.E.A. to speed up decision making is that the new harmonisation directives will contain only 'essential requirements', and not detailed common rules as before, and the responsibility for writing supporting technical specifications is entrusted to standards organisations.

One of the first directives under this 'new approach' to be agreed by the European Council was the Construction Products Directive (C.P.D.) which was signed on 21 December 1988. Implementation of the directive throughout the Community is required by the 27 June 1991.

This directive defines the essential requirements of a construction as being:

- mechanical resistance and stability
- safety in case of fire
- hygiene, health and the environment
- safety in use
- protection against noise
- energy economy and heat retention

It also states that a construction product is fit to trade and may be traded throughout the Community without hindrance from technical and regulatory requirements and without the need for re-testing or re-certification to meet national or local conditions if it enables the construction to satisfy the relevant essential requirement for a reasonable period. Products are deemed to satisfy this requirement if they conform to approved technical specifications which may be a Harmonised European Standard, a European Technical Approval or a Non-Harmonised Technical Specification recognised at Community level. Such products will be entitled to carry the E.C. conformity mark.

One important provision of the directive (Article 3 para 2) states: 'In order to take account of possible differences in geographical or climatic conditions or in ways of life as well as different levels of protection that may prevail at national, regional or local level, each essential requirement may give rise to the establishment of classes in the documents referred to in paragraph 3 and the technical specifications referred to in Article 4 for the requirement to be respected.'

This means that member states retain the right to decide on their own levels of protection, provided that these are defined in the relevant harmonised standard. This point is vital to the progress which has been made in writing standards for treated timber and will be discussed later.

The C.P.D. states in Article 4 that harmonised standards shall be technical specifications adopted by C.E.N. and it is at this level that most of the activity has taken place by B.W.P.A. representatives during the last year.

Eurocodes

As has been stated the C.P.D. lays down the essential requirements of constructions and can be regarded as the new 'European Building Regulations'. The European Commission has sponsored the production of a series of Eurocodes, to support the C.P.D., to provide the structural details for the design and construction of buildings and civil engineering structures. These Structural codes will define a set of common rules to replace the different rules in force in the various member states. Eight Structural Eurocodes have been drafted of which No. 5 'Timber Structures' is the most relevant to our industry.

Eurocode 5 was issued in draft form in 1987 and comments were required by members states by March 1989. Eurocode 5 is the document which eventually will replace B.S. 5268 'The structural use of timber'. The final document will be prepared by a committee formed from the Member States and it is likely that the work will be transferred from the Commission to C.E.N. before the Eurocode is published.

C.E.N.

During 1987 the Technical Board of C.E.N. set up a Programming Committee (P.C.) to advise it on the need and format for European Standards for use in the construction industry. In particular the P.C. sought to identify standards required for reference in the Structural Eurocodes e.g. Eurocode 5 – Timber Structures.

In October 1987 the Technical Board of C.E.N. accepted the proposal, from the P.C. for building, to form a number of C.E.N. Technical Committees (T.C.'s) to support Eurocode 5.

These were formalised as:

C.E.N./T.C. 124 Structural timber
C.E.N./T.C. 112 Wood based panels
C.E.N./T.C. 103 Timber adhesives

In addition the scope of the existing C.E.N./T.C. 38, which had been in existence for 20 years to produce European Standards (E.N.'s) for the biological testing of wood preservatives, was extended to include wood protection and wood preservatives, and have the general title 'Durability of wood and wood based products'.

Subsequently a further T.C., designated C.E.N./T.C. 175 was created to produce E.N.'s for sawn timber and saw logs for non structural purposes e.g. fencing, pallets, packaging, joinery.

These new or extended T.C.'s began work in the early part of 1988 to produce E.N.'s in support of Eurocode 5. The mechanism of producing standards is by creating Working Groups (W.G.'s) to draft the various standards defined by the T.C.

The broad responsibilities of C.E.N. Working Groups in support of Eurocode 5 are as follows:

C.E.N./T.C. 124 Structural timber
W.G. 1 Test methods
W.G. 2 Solid timber
W.G. 3 Glued laminated timber
C.E.N./T.C. 112 Wood based panels
W.G. 1 Particleboard
W.G. 2 Plywood
W.G. 3 Fibreboard
W.G. 4 Co-ordination of test methods
C.E.N./T.C. 103 Timber adhesives
Structural and non-structural adhesives
C.E.N./T.C. 175 Sawn timber and sawnlogs
This committee has not yet begun work.

It is not in the remit of this paper to amplify the work of the above T.C.'s.

The work of C.E.N./T.C. 38 is of greatest importance to the wood preservation industry and this has taken much time by members of B.R.E., T.R.A.D.A., Imperial College and member companies of B.W.P.A. and the detail of progress follows:

C.E.N./T.C. 38

The first meeting of the C.E.N./T.C. 38 with its expanded remit was in April 1988 and the main decisions of the meeting were the creation of four Working Groups to produce draft E.N. standards for wood preservation.

Working Group 1 – Hazard classes

Scope: – Definition of biological hazard classes based on the work of the European Homologation Committee (E.H.C.).

Working Group 1 is specifying the biological agencies which attack wood and wood based products and grouping these into five hazard classes.

These hazard classes will be the basis for the specifications for wood preservatives and durability of timber being prepared by the other three working groups.

The detailed text is not finally agreed although it is intended that it should be completed by September 1989. Table 1 is taken from C.E.N. document N. 502. It requires some modifications but clearly shows the divisions of the five hazard classes into groups related to the moisture content which might be reached by timber in service, or to be more precise, the proportion of time during which the timber has a moisture content above 20 per cent.

Timber in hazard class 1 will always have a moisture content below 18 per cent and therefore will not be attacked by wood destroying fungi. It will be liable to attack by insects and this will depend on the timber species and geographical location. Four insect species need to be considered: woodworm (*Anobium punctatum*), house longhorn beetle (*Hylotrupes bajulus*), Lyctus powder post beetle (*Lyctus brunneus*) and termite species. The specifier will decide which insects are present, and whether they represent a significant risk to the construction, and will choose an appropriate preservative and treatment process, or alternatively a timber species of adquate natural durability.

The remaining hazard classes 2-4 and M represent situations where the moisture content of the timber will achieve 20 per cent for varying periods of time and so the timber will be at risk

TABLE 1

Draft definition of biological hazard classes (taken from C.E.N. document C.E.N./T.C. 38 N. 502)

Hazard classes	*Situation in service*	*Description of exposure in service*	*Wood moisture content*	*Biological Agents*					
				Fungi			*Insects*		
				Basidio-mycete	*Soft rot*	*Others*	*Beetles (1)*	*Termites*	*Marine borers*
1	Above ground covered (dry)	Permanently dry	Permanently <18%				U	L	
2	Above ground covered (risk of wetting)	Exposed to occasional wetting	Occasionally >20%	U		U	U	L	
3	Above ground not covered	Exposed to frequent wetting	Frequently >20%	U		U	U	L	
4	In contact with ground or fresh water	Permanently exposed to wetting, in contact with ground or fresh water	Permanently >20%	U	U	U	U	L	
M	In salt water	Permanently exposed to wetting by salt water	Permanently >20%	U	U	U	U	L	U

The agents exist universally (U) throughout the European area or only locally (L)
(1) Beetles are universally present throughout the majority of the European area but the risk of attack varies greatly from high to insignificant level.

from fungal attack. Hazard classes 2 and 3 cover situations where timber is not in ground contact, hazard class 4 is for timber in ground contract or in fresh water, and hazard class M includes timber in marine conditions.

The Table 1 shows the fungi relevant to hazard classes 2-4 and M.

Working Group 2 – Natural durability

Scope:
- Natural durability of wood against fungi, wood destroying insects and termites
- To classify species of wood by natural durability
- To list the species most used in Europe based on experience already available
- To establish a relationship between durability classes and hazard classes

This group is preparing classifications of timber species, grouped according to natural durability against fungi, (both in and out-of-ground contact), wood destroying insect larvae, termites and marine organisms. In addition a classification of timber species according to permeability (treatability) will be prepared.

The lists are not yet available, indeed it is not agreed how many timber species will be included in the classifications.

It is intended that this aspect of the work will be completed by December 1989.

A further task of W.G. 2, to be carried out in conjunction with W.G. 3, is to place the timber species, classified according to natural durability, in the five biological hazard classes produced by W.G. 1. This will equate naturally durable species with the conferred durability achieved by the chemical treatments specified by W.G. 3. The timetable for this difficult task is between April and September 1990.

Working Group 3 – Performance of treated timber

Scope:
- Specification of performance requirements for treated timber according to hazard classes
- Identification of treated wood
- Control of treated wood

This group is concerned with specification of treated timber which ultimately will form a European Standard and will replace the existing B.S. 5268: Part 5 'Code of practice for the structural use of timber. Preservative treatments for constructional timber', and B.S. 5589 'Code of practice for preservation of timber'. The outcome of this group will therefore be most relevant to those concerned with commercial timber treatment.

It is also important to note that remedial treatment of timber and treatment to protect against sap stain are not considered to come within the scope of the Construction Products Directive and so are not a part of the deliberations of the C.E.N. committees.

Working group 3 is making the slowest progress of the four working groups because of the diversity of timber treatment practices and specifications which exist between member states. So far, after six meetings held since September 1988, it has produced a framework for a specification for treated timber (see Table 2) but this is not yet a fully agreed document from the working group. The detail of the Table 2 must therefore not be read as the final version. Nevertheless certain principles in the table are important as they will mark radical changes from the way timber treatments are now specified in the U.K.

The first important change is that, in the proposed E.N. standard, timber components will have to be placed into biological hazard categories in order to determine the appropriate preservative treatment. At the moment B.S. 5268 part 5 and B.S. 5589 list timber commodities or components together with suitable naturally durable species or appropriate treatments where timber of inadequate natural durability is used. The European Standard will require the specifier to assign a biological hazard class to the particular component, according to its exposure conditions and likely moisture content in service, and then select the appropriate timber species and/or preservative treatment. For hazard classes 1, 4 and M there should be no difficulty in doing this. However hazard classes 2 and 3 require a judgement to be made about the length of time for which a component will be wet. An example is window joinery which, according to the 'situation in service' heading of Table 1 seems to come into hazard class 2. However it is known that a paint film which has broken down in service acts as a barrier to evaporation of water and so the wood moisture content may be frequently higher than 20 per cent, thereby bringing the window frame into a hazard class 3 designation. This flexibility will enable the specifier to make decisions about the biological risk of fungal and insect attack according to the local climatic conditions and the effects of other components in the construction.

The second important feature of Table 2 is the new concept of 'Preservation classes', within each hazard class, which gives the specifier the means of making a selection from a choice of treatment specifications, not all of which give the same level of treatment. This concept arises direct from the Construction Products Directive and is the means by which agreement has been reached within the working group to achieve the basis for a European Standard from the diverse treatments which are carried out at the moment in the different European countries. Thus it will still be possible for specifiers and treaters to continue their normal practices (provided that the essential requirements of the C.P.D. are met) and apply the same levels of preservation so long as these are incorporated into the E.N. standard. Provided that full details for compliance and marking the timber are available then it is the opinion of working group 3 that there are no barriers to trade created.

The third difference between the treatment specifications as summarised in Table 2 and the current U.K. specifications is that the proposed E.N. will specify timber treatment by a results-type specification and not a process specification. In the table each preservation class defines a particular penetration and preservative retention which must be met to enable the product to carry the E.C. conformity mark. This philosophy of adopting results-type specifications is embodied in the C.P.D., Article 7 para 2 states 'The resulting standards (i.e. C.E.N.) shall be expressed as far as practicable in product performance terms . . .', and was favoured by a qualified majority of members of W.G. 3. The group however has not yet decided how the treated timber will be checked for compliance with the specification and this was the difficulty which originally resulted in U.K. adopting specifications for treated timber expressed as preservation process, designed to achieve a result, rather than the result itself.

The work of W.G. 3 is intended to be completed by April 1990.

Working Group 4 – Performance of wood preservatives

Scope:
- Definition of performance levels to be determined by biological tests on wood preservatives and to select tests appropriate to the hazard class for use by approval organisations
- Identification of wood preservatives

Working group 4 is responsible for defining the performance required of wood preservatives under laboratory and/or field test conditions in order for them to be approved for the treatment of timber in the hazard classes defined by W.G. 1. The biological tests defined are the European Standards which have been published by C.E.N. arising from the original work of C.E.N./T.C. 38. In carrying out its work W.G. 4 has highlighted areas where performance needs to be specified but where no E.N. exists. In consequence further W.G.'s have been created by C.E.N./T.C. 38 to produce the necessary tests.

TABLE 2
Draft specification of performance requirements for treated timber (from C.E.N./T.C. 38 W.G. 3)

Permeable and moderately resistant wood species			*Resistant and extremely resistant wood species*		
Hazard class	*Preservation class*	*Treatment specification*	*Hazard class*	*Preservation class*	*Treatment specification*
1	1A	SURFACE TREATMENT Penetration: No requirement Retention: C.A. in 2 mm zone	1	1A	SURFACE TREATMENT Penetration: No requirement Retention: C.A. in 2 mm zone
	1B	IMPREGNATION Penetration: According to classes 2-4 Retention: C.A. according to class 1 requirement (or classes 2-4 requirements)		1B	IMPREGNATION Penetration: According to classes 2-4 Retention: C.A. according to class 1 requirement (or classes 2-4 requirements)
2	2A	SURFACE TREATMENT Penetration: No requirement Retention: C.A. in 2 mm zone	2	2A	SURFACE TREATMENT Penetration: No requirement Retention: C.A. in 2 mm zone
	2B	IMPREGNATION Penetration: According to classes 3-4 Retention: C.A. according to class 2 requirement (or classes 3-4 requirements)		2B	IMPREGNATION Penetration: According to classes 3-4 Retention: C.A. according to class 2 requirement (or classes 3-4 requirements)
3	3A	SURFACE TREATMENT Penetration: No requirement Retention: C.A. in 2 mm zone	3	3A	SURFACE TREATMENT Penetration: No requirement Retention: C.A. in 2 mm zone
	3B	IMPREGNATION Penetration: Min 3 mm lateral, sapwood 40 mm end grain Retention: C.A. in 3 mm zone		3B	IMPREGNATION Penetration: Ave 3 mm lateral 5 mm end grain Retention: C.A. in 3 mm zone
	3C	IMPREGNATION Penetration: Min 5 mm lateral, sapwood 50 mm end grain Retention: C.A. in 5 mm zone		3C	IMPREGNATION Penetration: according to class 4 Retention: C.A. according to class 3 (or class 4 requirements)
	3D	IMPREGNATION Penetration: According to class 4 Retention: C.A. according to class 3 requirement (or class 4 requirements)			
4	4A	IMPREGNATION All timbers: Penetration: Full sapwood Retention: C.A. in sapwood zone	4	4A	IMPREGNATION All timbers: Penetration: Ave 3 mm lateral 5 mm end grain Retention: C.A. in 3 mm zone
	4B	IMPREGNATION Round: Penetration: Full sapwood or 20 mm whichever is greater Retention: C.A. in sapwood or 20 mm zone Sawn: Penetration: Full sapwood and min 8 mm in exposed heartwood (thickness >40 mm) Retention: C.A. in sapwood/heartwood zone		4B	IMPREGNATION All timbers: Penetration: min 6 mm from all faces Retention: C.A. in 6 mm zone
	4C	IMPREGNATION As 4B but with a retention requirement of 1·5 x C.A.		4C	IMPREGNATION Round: Penetration: Full sapwood or 20 mm whichever is greater Retention: C.A. in sapwood or 20 mm zone Sawn: Penetration: Min 8 mm from all faces (for dimensions >40 mm) Retention: C.A. in 8 mm zone
				4D	IMPREGNATION As 4C but including thermal shock treatment immediately before impregnation
				4E	As 4C & 4D but with a retention requirement of 1·5 x C.A.
M	MA	IMPREGNATION All timbers: Penetration: Full sapwood Retention: C.A. in sapwood zone	M	MA	IMPREGNATION Round: Penetration: Full sapwood or 20 mm whichever is greater Retention: C.A. in sapwood or 20 mm zone Sawn: Penetration: Min 20 mm from all faces Retention: C.A. in 20 mm zone
	MB	IMPREGNATION Round: Penetration: Full sapwood or 20 mm whichever is greater Retention: C.A. in sapwood or 20 mm zone Sawn: Penetration: Full sapwood and min 8 mm in exposed heartwood Retention: C.A. in sapwood/heartwood zone			

Footnote: C.A. = Critical Amount: required retention of preservative: determined by tests specified for each hazard class by working group 4.

The tests which will characterise a wood preservative will be selected according to the hazard class and type of organism to which the timber is exposed in service, and according to the method of application of the wood preservative, from the following categories of biological tests:
- Insect resistance after treatment by surface application or impregnation.
- Basidiomycete fungi resistance after treatment by surface application or impregnation.
- Field tests for performance in ground contact, out-of-ground contact and in the marine environment.
- Artifical ageing (evaporation and water leaching).

E.N. tests are also available for determining the resistance of treated timber to blue stain organisms in service and these could be called by the specifier as additional tests if local conditions so require.

In addition to identifying the schedule of tests required for preservatives used to treat timber in each hazard class the working group will also define the minimum performance levels for a wood preservative, from each E.N. test, to demonstrate suitability for each hazard class.

Finally the group will define a scheme for identification of wood preservatives.

This work is scheduled for completion by December 1989.

STANDING COMMITTEE

This section of the paper introduces an element of uncertainty into what, up to now, has been a logical development of preparing European Standards by C.E.N. Technical Committees under instruction from the C.E.N. Technical Board and C.E.N. Programming Committee which is advising on the need and format of E.N.'s for use under the Construction Products Directive. The uncertainty arises because the draft standards which are being produced are not yet based on any agreed strategy from C.E.N. or the European Commission.

The Construction Products Directive is incomplete in a number of key areas, and a Standing Committee consisting of the European Commission, together with representatives from member states has the task of completing the directive and writing "interpretative documents". One of the key areas is the preparation of mandates for the development of technical specifications e.g. E.N.'s.

In other words, thus far, the preparation of C.E.N. standards has been carried out without precise terms of reference. Of particular concern is that one of the responsibilities of the Standing Committee is the identification of levels, or classes, of performance of construction products. We must hope that the Standing Committee takes the same view, when it writes the rules, as the members of working group 3 of C.E.N./T.C. 38 took when they drafted the standard for treated timber in respect of the acceptability of preservation classes.

CONCLUDING REMARKS

I emphasise again that the present situation with the development of European Standards by the working groups of C.E.N./T.C. 38, described above, represents the thinking of the working groups at June 1989. In most cases it is not a formally agreed position by the working groups and nothing has been ratified by C.E.N./T.C. 38 or the C.E.N. Central Secretariat. Additionally, some important requirements of the standards e.g. the concept of classes of performance, compliance with the standard (attestation of conformity) cannot be completed until the 'interpretative documents' which complete the details of the Construction Products Directive have been written by the Standing Committee.

Therefore this review is very much an interim statement on the production of European Standards for wood preservation.

For the closing remarks comment must be made of the problem highlighted in the introduction, that technical harmonisation of wood preservatives and treated timber is only one aspect of the trading barriers which must be removed. The other aspect is to achieve a common position in the E.C. of acceptance of wood preservatives based on a health and safety review. Unfortunately there is still nothing reassuring to report. During the year there has been considerable activity in the European Commission DG111 in reviewing the laws relating to the marketing and use of certain wood preservative components. No new directives have been issued by the Council and in any case these reviews do not fulfil the total requirements of the need for a scheme for common approval, or mutual acceptance by member states of wood preservatives, on health and safety grounds, to complement the C.E.N. technical standards. This vital question must be resolved before we can remove barriers to trade in our industry.

DISCUSSION ON PAPER 5

Chairman: Dr. J. W. W. Morgan

THE CHAIRMAN: Well, Ladies and Gentlemen, Frank has made look very simple what has been a very difficult year with very difficult discussions. I know he has it all clear in his mind, and I know that he is prepared to answer any questions you may have.

MR. G. EWBANK (Rentokil Ltd): Thank you very much, Frank, for a very clear and concise summary of what has been going on. As we move towards the results-type specifications the actual timber treater is going to need some guidance on how to achieve those results in the timber. So he is going to have the need for something. I wonder if you could comment on how perhaps the existing British Standards, B.W.P.A. Manual and other national formal documents might fit in in the future.

DR. BROOKS: I see a role for British Standards. Let me say that British Standards will be identical with European Standards. So whatever comes out of these European Committees will be issued as a British Standard. Having done that, I think we will then be able to write supporting documents to put what Britain or the U.K. or any region – I try to avoid the use of the word "countries" when we have these meetings because it tends to suggest some sort of nationalist approach, which we try not to do – but there will be certain regions of Europe which will have particular requirements. For example the Mediterranean region will have particular requirements for termite resistance, whereas Northern Europe will not.

What I see is that, probably within the framework of B.S.I., we will write some sort of supporting documents which will pick out of the European Standard what we think is important for the U.K. conditions. Taking the hazard class 3 as an example, I think we would say that we would not accept a dip treatment for timber out of ground contact for joinery for instance, or for external cladding. We would choose 3(b) or 3(c).

I cannot say how we will write a document to give guidance to the producer because I think we do not have all the information yet. To do that we need know what level of compliance we will need to achieve. If it is 100 per cent compliance, then we have a problem; if it is 90 per cent compliance, then how can we write a standard that enables 10 per cent of pieces of wood not to comply with a minimum standard. I do not know how it is going to work. This is one of the difficulties that Reg Orsler and I have had with this particular Committee: trying to explain that there are problems in having minimum standards when you cannot guarantee that every piece of wood is going to comply with that standard, and what is the position of those pieces with the application of the E.C. conformity mark? So I do not know how it is going to be done, but it is something that we are all aware of.

DR. C. R. COGGINS (Rentokil): Chairman, I should like to echo your comments and Gordon's comments and congratulate Frank on a very clear and helpful paper. But Frank, perhaps following on from Gordon's comment, you have not addressed the opportunities and difficulties that the fact of the new standards and the new scheme of things actually open up for us here in the U.K. Gordon's point, I think, was, well, the treaters have been doing things in a particular way for a long while, they know how to do it. We are going to bring in a new system that is not so easy to follow in terms of pressing buttons and following processes and ending up with treated timber at the end of the day.

It just seems to me that going to results-type specifications offers an opportunity of innovation in arriving at the end point. You do not have to follow a particular initial vacuum pressure period, and so on. There are many different ways of reaching the end point, and there could be an opportunity for tremendous improvements in the cost-effectiveness of reaching that end point. However, clearly there will be difficulties as well, and I wonder if you can comment on how you see that in the future.

DR. BROOKS: I think I can only comment that I agree with you. We are aware that the present rigid system of a process specification does create problems because, taking spruce as an example, it does not have a constant permeability from one part of the country to another and so we get different results from carrying out the same process. Equally, different preservatives which comply with our British Standards for preservatives may not have the same penetration characteristics and so you achieve different results. I agree that creating, or going back really to results type specifications, is allowing a good opportunity for product and process innovation.

MR. G. O. HUTCHISON (Calders and Grandidge): Frank, I should like to ask you a question on the preservation classes. There seems to be a rising demand from 4A, 4B and 4C and from MA to MB. 4B and 4C and MB are calling for less than full sapwood penetration if there is more than 20 mm of sapwood. Can you explain that?

DR. BROOKS: It says full sapwood or 20 mm, whichever is greater.

MR. HUTCHISON: 20 mm of penetration is not sufficient.

DR. BROOKS: If the sapwood is more than 20 mm then you require full sapwood.

MR. HUTCHISON: I am sorry, I misread it.

DR. MORGAN: Whilst we are waiting for the next question can I follow that up. There is one class, 4A, which has only sapwood requirement. Does that mean that you have no requirement to penetrate the heartwood in 4A.

DR. BROOKS: And 5A.

DR. MORGAN: And 5A, yes.

DR. BROOKS: That is how it is written. I think there could be difficulties with that. If you have a piece of wood which has a small amount of sapwood on it and a lot of heartwood and the heartwood is not of adequate durability then you have bad treatment. I think that is a point that has been recognised as this paper has been tabulated. It needs to be raised again at the Committee: are people happy with that or do they want certain limitations put on that penetration class.

MR. D. SCUTT (Fosroc Ltd): It is possibly unfair to ask you this question, Frank. Have you any idea whether the standards for timber may include moisture contents of timber in the future, because if that were so it would possibly make our problems much easier in this industry.

DR. BROOKS *(To Dr. Morgan)* Would you like to answer that?

THE CHAIRMAN: I was not quite expecting to answer a question but if I understand it you are asking whether, in fact, it relieves you of the duty of measuring moisture content?

MR. SCUTT: One of our problems is that in this industry the fact is that much of the timber of our customers is very wet wood, and I was wondering whether standards may be introduced for timber which would improve the situation as far as moisture contents of the timber were concerned. I presume there are going to be standards for timber which is used for construction.

THE CHAIRMAN: I think there are two issues there. The first one is that if you have a results-type specification then there should be no requirement upon you to define the process by which you would achieve that result. So in those terms, you do not need to have any limits on moisture content. On the other hand, there are other good reasons for wanting to control moisture content, and I would hope that something might appear eventually in the specifications which certainly gives advice on the levels that should be there.

DR. BROOKS: Yes. The reason I looked to you is that there are moisture content requirements in C.E.N./T.C. 124 Committee, because there was a discussion that certain strength classes relate to moisture contents, and those moisture contents are different from the limiting moisture contents which we tend to use, which are thresholds for fungal activity. We did have a discussion a while ago as to whether in any way these different moisture contents, one for structural and one for biological, should be brought together. We decided that there was no reason why they should be. But certainly some of the structural standards will require moisture content limits.

THE CHAIRMAN: I think that really emphasises the difference I was trying to make between moisture content at the time of processing and moisture content for service use, which is laid down by T.C. 124.

DR. D. G. ANDERSON (Hicksons): Could I just ask a fairly succinct question. will spruce round wood posts meet any of the in ground contact standards under the descriptions you have given. They are not going to have a 20 mm sapwood band as far as I can see, or that one will see very often.

DR. BROOKS: Can I just show you another slide.

DR. ANDERSON: Yes. I was not very clear about that.

DR. BROOKS: No, I did not talk about spruce at all.

DR. ANDERSON: No, you said this is all permeable; is spruce permeable or not permeable.

DR. BROOKS: *(Referring to a slide put up on the screen taken from Table 2 of the paper)*: You have not seen that slide. It might seem familiar but it has not been up yet. This is hazard class 4, ground contact, resistant species. This was the most complicated of all with five preservation classes. Class 4A is the one that we introduced in the hope that it covers the present practice in the U.K. now, i.e. a vacuum pressure treatment of spruce at the right moisture content. The Committee wanted it expressed as a result and that is what we derived: 3 mm lateral penetration, 5 mm end grain. We think that is what is achieved in a conventional vacuum pressure treatment of spruce now.

DR. ANDERSON: Preservation class 4C you are saying full sapwood –

DR. BROOKS: I see. As you go from 4A down the alphabet, then you become more stringent and from 4B onwards it would be our view you probably need some sort of mechanical aid to increase the permeability.

DR. ANDERSON: But what you are saying then is that spruce round posts, which have been profiled, will not meet the standard and therefore could not have an E mark for use in ground contact?

DR. BROOKS: No. We are saying if they achieve an average of 3 mm lateral penetration they will comply with preservation class 4A.

DR. ANDERSON: What is the difference between round timber which happens to be the one I am looking at, 4C.

DR. BROOKS: 4A refers to all timbers and 4C includes separate specifications for round wood and sawn wood.

DR. ANDERSON: So which takes precedence. If you happen to be a producer of round sapwood posts and these are going to be sold for use as vinyard stakes, which one would apply?

DR. BROOKS: It would be what they specify. 4A would cover that, or 4B, or 4C round timber or 4D round timber.

MR. M. CONNELL (Hicksons): Not in Switzerland.

THE CHAIRMAN: I am sorry, could you say that again?

MR. CONNELL: 4C comes from Switzerland and they get all the incising.

DR. BROOKS: I tried not to pinpoint any one country. I imagined it was fairly clear in some instances.

DR. ANDERSON: Can I again just make a point. It seems to me that in the deliberations between permeable species and resistant species, that in spite of the fact that process specifications have been used in the U.K. for 20 years or more in a market where we have probably the largest proportion of treated timber, what has been ignored is that process specifications produce a product which is suitable for a purpose. That was one of the reasons for the justification of process specification. As far as I can see it is being ignored for treatable species, yet you have encompassed it in arriving at a specification for resistant species. Is this latter inclusion not recognising that all you can do is treat the wood as well as the piece of wood allows you to treat it? Personally, I think the new system will create a very difficult situation for the treaters, whereas process specifications are an ideal way of practically treating wood.

DR. BROOKS: There are a lot of problems to come.

DR. ANDERSON: A heck of a lot of problems.

DR. BROOKS: The Directive seems to lead us down the road of being able to check what we have done, and a treatment certificate does not meet that requirement. Also seventeen out of eighteen countries wanted the way that it is being done now.

DR. ANDERSON: Yes, but they do not have to treat the vast proportion of timber. The largest proportion of the total timber treated is probably treated in the U.K.

DR. BROOKS: There is a lot of spruce treated in central Europe.

DR. ANDERSON: We know the amount of chemicals that are used, and on the quantity of chemicals used, the U.K. is well ahead in terms of the amount of chemicals; as a market share the U.K. is well ahead.

DR. BROOKS: I think if you are not happy with 4A as an achievable end from the point of view of current practise we do in this country, then by all means propose a modification.

DR. ANDERSON: Personally I think process specification for difficult to treat species, which is generally the European situation, is the ideal way to go about it. I think the results type specifications for Southern Yellow Pine or for Radiata Pine is an ideal way of doing it because you actually get quite narrow bands of distribution of uptake of chemical but where you have difficult to treat species – and the Canadians will tell you this – they do not meet results type specifications. They cannot do it industrially and the industry will be in grave danger of not surviving.

THE CHAIRMAN: I think that is a good statement and we will leave that statement there. Can we change to something else.

DR. N. BURGERS (ex-W.E.I.): In Germany spruce poles must be incised. that is part of the standard. Then you can attain 4C.

DR. BROOKS: Yes, I think if you are looking for poles, for round wood, that is more structural in its use than a fence post, then you do need something that gives you better confidence of a proper protection band. What we have found in this country is that the market for fence posts has been quite adequately served by the more limited penetrations that we get from a conventional vacuum pressure process on dried timber, without the need for incising. We want to continue to be able to do that. I hope we have been able to build in that appropriate preservation class.

DR. BURGERS: That is 4A?

DR. BROOKS: That is 4A.

DR. L. D. A. SAUNDERS (Fosroc Ltd.): Frank, it may seem premature to start talking about revising the standards before you have actually written them, but I wonder if we have any feel for how rigidly we are casting things in stone. I refer specifically to your comment on 4A, that there is an attempt here to describe what is happening in current U.K. practise, and this is embodied in the underlying philosophy, and we think that 3 mm lateral penetration is being achieved, but because that is not the way we have been measuring it – we have been actually measuring it in rather different terms – there is an element of guess in the matter. Supposing that guess is wrong. Are we then stuck with the figures which you have talked about or has there been any discussion of a mechanism for making amendments if, when we start measuring things in terms that they are being described in the current context, it turns out there is a need to adjust them somewhat.

DR. BROOKS: I believe that C.E.N. works on the same principle as with B.S.I.: producing standards and then reviewing on a five yearly basis. *(Addressing Dr. Bravery)*: Tell me, you know about C.E.N. standards, I know.

DR. BRAVERY (B.R.E.): I think the situation is quite adequately covered because C.E.N. is able and does issue amendments to standards at any time when they are needed, but there is, as it were, a compulsory review every five years. So a standard is reviewed anyway ever five years. If a need arises in the meantime, then an amendment can be issued, and the time it takes to issue it depends solely on how long it takes to get agreement within the Committee as to the content of the amendment. Then it is normal editorial and voting procedures.

DR. ANDERSON: Can I just raise one other point. On results type specifications the job of analysing is quite easy if it happens to be copper chrome arsenic. With the possibility of there being wider ranges of really quite sophisticated organic chemicals coming into the field, I think the difficulties in actually analysing accurately have been grossly under-estimated by C.E.N. I think that needs to be brought up very strongly.

DR. BROOKS: That is absolutely right. We raised this at the last C.E.N./T.C. 38 meeting. We said: "What is going to be the requirement for checking," and the Chairman M. Caston said he did not think there was a need for a European approved way of confirming retention. We think, at the B.S.I., that this may be wrong.

DR. ANDERSON: I mean I am not putting forward a European way. I am just saying that the sophistication which may be necessary to carry out an analysis has been under-estimated. HPLC is not freely available, and even that cannot be relied upon to give a good guide.

DR. BROOKS: It is a major difficulty and it is one the working group has steadfastly refused to address face to face.

THE CHAIRMAN: I have let this discussion run on, and I think there is time for one more question, if anyone has a burning question.

DR. BURGERS: Is the same mathematical system used for sampling?

DR. BROOKS: We have not talked about sampling or compliance with the specification yet. I do not know how it is going to work. It is going to be difficult.

THE CHAIRMAN: I think I must draw the discussion to a close at this point. Frank has been in the hot seat. I think you all appreciate that he is informing us what is going on at C.E.N.; he is not in the position of defending everything, and the discussion we have had will be very useful to him and to others who are involved in these C.E.N. discussions, in going back to the meetings and being better briefed on the feelings within the U.K. industry about how things are developing.

We have heard today of another series of changes under development and the wood preservation industry is going to have to face these in years to come. I am reminded of the Chinese curse: "May you live in interesting times!" I think they are going to be very interesting. Finally, it is just left for me to thank Frank for taking us through this difficult territory, for making it so clear and for entertaining us for the past hour. Thank you. *(Applause)*.

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DEVELOPMENT OF BORON BASED WOOD PRESERVATIVES

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1. Introduction

Boron has been used as an active ingredient in all areas of wood preservation for many years. Since the publication of promising results with borates by Bateman and Baechler (1937) and recommendations for the use of boric acid for the protection of green veneers against Powder Post Beetle in Australia (Cummins, 1938) various forms of borate have been in continuous use and development. Several general reviews of the use of borates have been published (Carr, 1959; Cockroft and Levy, 1973; Bunn, 1974). A review of recent research on borates in the U.S.A. has been given by Barnes *et al.* (1989). The purpose of the present paper is to briefly review the past and recent developments with particular reference to the U.K.

2. Properties of Boron Wood Preservatives

2.1 Treatment and Efficacy

Borates have been used as preservatives for timbers in the protected and semi-protected environment and, in combination with other active ingredients, for timbers in more severe situations. Fixation of borates in wood subjected to leaching has not been achieved and their use as sole ingredients has therefore been restricted to non-leaching situations.

This perceived 'leaching problem' of borates has often raised doubts in the minds of potential users. In any consideration of the likelihood of preservative loss by leaching careful analysis of the true leaching hazard is essential. For the leaching of borates from treated wood to occur it is necessary for the wood to be thoroughly wetted and for the surfaces to be in prolonged contact with water or a moist medium into which diffusion of the borate can occur (Carr, 1957; Harrow, 1959). Even in unpainted boron treated timber exposed for up to five years above ground significant depletion of the preservative only occurred in the outer three millimetres of the cross-section with considerable quantities remaining in the interior (Carr, ibid). No loss of boron through leaching from exterior painted woodwork was recorded after 11 years exposure in a test house (Carr, 1961).

The major use of boron as a pre-treatment preservative has been as aqueous solution of boric acid/borax mixtures or of disodium octaborate tetrahydrate ('Timbor'). Their most successful application has been in Australia and New Zealand for building timbers, including painted exterior joinery and weatherboarding. These preservatives have been applied almost exclusively by the 'boron diffusion' method. In this method unseasoned timber is usually dipped in a concentrated solution (e.g. 30 per cent) of the preservative and then stored under non-drying conditions for several days or weeks for the preservative components to penetrate the timber by diffusion. Diffusion is dependent upon the wood have a minimum moisture content of about 50 per cent (oven dry basis). Under suitable conditions timbers resistant to vacuum and pressure treatment methods can be fully impregnated by diffusion methods (Maclean, 1962; Thornton, 1964; Baechler and Roth, 1964; Smith and Williams, 1969; Markstrom *et al.*, 1970; Levy *et al.*, 1972; Vinden, 1984; Murphy and Dickinson, 1986). The ability to achieve good penetration in refractory timbers using diffusion technology is one of the greatest potential assets of this system.

The factors governing good boron diffusion treatments have been reviewed and will not be considered further here (Carr, 1959; Winters, 1957; Tamblyn, 1985). As with other wood preservation methods, several parameters (e.g. timber moisture content, solution strength, treatment time) require careful monitoring to ensure successful treatment.

Although borates have been most widely applied in pre-treatment by the boron diffusion process they may also be applied by other methods e.g. vacuum-pressure, Alternating Pressure Method (A.P.M.) (Vinden *et al.*, 1985). There is considerable opportunity for expansion and development of treatment methods for borates and this is considered in greater detail later in the paper. Borates have also been included in other preservative formulations, in particular in Copper Chrome Boron (C.C.B.) for vacuum pressure treatments and in the Boron Fluorine Chrome Arsenic (B.F.C.A.) diffusion formulation.

This extensive use of boron in wood preservation is made possible due to its wide spectrum of activity against wood destroying fungi and insects. As yet no wood decaying fungi have been reported to be tolerant to boron at normal preservative retentions. Results from a number of laboratory tests of boron preservatives have been summarised by Carr (1961) and are given in Tables 1 and 2.

2.2 Safety Aspects

In addition to this wide spectrum of activity against wood decay fungi and insects the low mammalian toxicity of the inorganic borates is well known. This is clearly reflected in $L.D._{50}$

TABLE 1
Boron toxicity to wood decay fungi

Organism	*Toxic retention (Kgm^{-3}, H_3BO_3)*	*Reference*
M. lacrymans 1	0·36-0·54	(a)
M. lacrymans 1	<1·60	(b)
C. cerebella 1	0·53-0·75	(a)
C. cerebella 1	1·00	(b)
C. cerebella 1*	1·92	(d)
C. cerebella 1†	1·92	(d)
L. trabea 1	0·52-0·72	(a)
L. trabea 1	<1·60	(b)
L. trabea 1	0·80-1·28	(c)
L. trabea 3	1·12-2·88	(c)
L. trabea 1	1·92	(d)
L. lepideus 1	0·54-1·40	(a)
L. lepideus 1	0·50	(b)
L. lepideus 1	0·80-1·28	(c)
P. vaporaria 1	0·50	(b)
P. versicolor 2	1·00	(b)
P. versicolor 3	1·12-1·92	(c)
P. vaillantii 1	<1·60	(b)
P. monticola 1	0·32-0·80	(c)
P. monticola 3	0·48-0·64	(c)
T. serialis 1	<1·60	(b)
P. xantha 1	<1·60	(b)
P. ragulosus 2	<1·60	(b)

1 Pine 2 Beech 3 Oak *N.Z. strain † P.R.L. strain
References: a) Anon. (1959); b) Findlay (1956); c) Baechler & Roth (1956); d) Harrow (1950).

TABLE 2
Boron toxicity to wood destroying insects

Organism	*Toxic retention (Kgm^{-3}, H_3BO_3)*	*Reference*
Anobium (egg-larvae)	0·11-0·21	(e)
Lyctus	0·64-0·80	(f)
Ambeodontus tristis	0·22-0·48	(g)
Hylotrupes	0·36-0·45* 0·18-0·29†	(i)

*12 week test †6 month test
References: e) Spiller (1948); f) Cummins & Wilson (1936); g) Spiller (1952); h) Becker (1959).

data for acute oral toxicity in the rat of Boric acid, Borax and Disodium Octaborate Tetrahydrate of 3,000-4,000, 4,500-6,000 and 2,000 $mgKg^{-1}$ respectively. Although this data is useful (it forms a guide for the Current European Communities Directive on the Classification, Packaging and Labelling of Dangerous Substances) there is as much, possibly more, interest in any long-term chronic effects. A recent Technical Report from the National Toxicology Program in U.S.A. (cited in Anon., 1988) has found no evidence of carcinogenicity in a full two year bioassay with boric acid in mice at feed doses of 2,500 and 5,000 ppm in the diet or in a variety of mammalian cell culture tests. Neither boric acid nor borax is a mutagen in the Ames Test.

In addition, no cases of borate intoxication through skin absorption have ever been authenticated either in borate manufacture or in industrial end-use applications. In fact borax/boric acid mixtures are in current use in many cosmetics and pharmaceutical preparations, as buffering agents in eyewash solutions or as preservatives in creams (up to 5 per cent concentration).

Toxicological and environmental aspects of boron have been reviewed by Fuller (1987), Anon. (1988) and Mance *et al.* (1988). Reports of borate toxicity do exist. However much of this is based on the effects of obsolete medicinal treatments in hospitals during the last 100 years since the introduction of boric acid as an antiseptic by Lister in 1875. Cases of accidental misuse have also occurred, for example when a 3 per cent aqueous boric acid solution was mistaken for distilled water and used to prepare a milk feed.

Boron, in large quantities, can be phytotoxic. Despite being an essential micronutrient for plant growth (often a serious deficiency in some forests both plantation and natural) a large excess can lead to leaf damage and necrosis (Shorrocks, undated).

3. Use of Boron Preservatives in the U.K.

3.1 Pre-treatments

The use of 'Timborised' timber in the U.K. has had a somewhat chequered history. With the U.K. being primarily an importer of dry timber, the establishment of boron diffusion as a treatment requiring application to green timber did not fit well into the existing industry whose technology and processes were developed for a dry raw material. However the B.W.P.A. did establish a Standard (105) to define the preservation of softwood timbers by means of 'Timbor' (B.W.P.A. undated).

Timber producers, both in the U.K. and overseas, then needed to be convinced that it was worthwhile treating timber in the hope that markets existed for their treated material. After considerable efforts by Borax Holdings Limited in the early 1960's 'Timborising', complying to the B.W.P.A. Standard 105, was established in Finland and a market generated in the U.K., principally in system built housing and joinery manufacture. Its use was certainly successful for the companies involved but it still only made a small specialized impact on the market. This was probably due to the fact that the potential for pre-treatment of timber for housing was only just beginning to develop.

The other main problem was that the smaller U.K. companies wanted to buy 'Timborised' timber from stock as and when they needed it. Sawmills in Finland however would not treat for stocking and, because of the long diffusion period, orders had to be placed up to six months in advance. Such arrangements were difficult for the large number of small and medium sized building companies in the U.K. The concept of 'Just in case' preservation therefore did not fit into the prevailing U.K. requirements and so the scene was set for the development of 'Just in time' preservation that was offered by the light organic solvent treatment.

Unsuccessful efforts were made to establish 'Timborising' in Sweden. Most of the mills were at that time investing heavily in kiln drying facilities which did not fit well with conventional dip-diffusion. This meant that timber buyers who wanted to use 'Timborised' timber were restricted to a very limited source of supply.

The Canadians however did make a determined effort to supply 'Timborised' timber into the U.K. This was highly compatible with the longer shipping times. Several U.K. companies committed themselves to using treated Canadian Hemlock but felt badly let down when the suppliers stopped shipments in the 1970's.

During this same period from the mid-1960's to the early 1980's the requirement for effective treatment of joinery was growing. This demand was satisfied by the rapid increase in the availability of light organic solvent based systems. This trend, coupled with the difficulties in the continued supply of 'Timborised' timber, resulted in a number of the larger users switching to light organic solvent treatments.

Throughout the 1980's the decline in availability of 'Timborised' timber continued. Finally, in 1987, Rauma Repola O.Y. closed its mill at Martinniemi in Finland terminating the last supply of 'Timborised' timber in Europe. Only the efforts of the B.W.P.A. in ensuring that 'Timborised' timber remained in their specifications and found its rightful place in the specifications for timber frame housing prevented 'Timborising' from disappearing completely from the U.K. scene.

3.2 Remedial Treatments

In contrast to this slow demise of the use of borates in the pre-treatment field through the 1970's and 1980's the advantage of borates were being recognised by the remedial treatment industry.

3.2.1 *Boron Rods*

Probably the most significant development in the use of borates for remedial treatments has been the development and extended use of fused borate rods. In the mid-1970's a major project was carried out in Sweden on the *in situ* treatment of railway sleepers with borate pastes (Bechgaard *et al.*, 1979). This work indicated that whilst injection of pastes was effective, what was really needed was a highly concentrated borate in a soluble form, but where solubility was controlled. This resulted in the development of the solid fused borate rods which maximised the active boron, gave controlled dissolution and were easily handled and inserted into wood.

About this time in the U.K. it was realised that these rods had potential in the *in situ* treatment of decay in joinery. The early work in the U.K. and Sweden established successful remedial treatments for joinery which were reported to this Convention in 1983 (Dicker *et al.*, 1983).

In 1986 a similar trial to that carried out in Sweden was conducted by British Rail, Biokil Limited and Imperial College (Beauford and Morris, 1986; Beauford *et al.*, 1988). In this trial it was clearly shown that redistributed borates from fused rods could contain and eliminate fungal decay in railway sleepers. Since then the concept has been extended to the treatment of large dimensional longitudinal bridge timbers for British Rail.

The use of rods has also been studied as a supplementary treatment for wooden transmission poles in the U.K. and Sweden (Dickinson *et al.*, 1988; Henningsson *et al.*, 1989). In the U.K. the work was carried out in conjunction with the Eastern Electricity Board and the results indicated that not only did borate rods prevent colonisation by decay fungi but were also capable of containing and eliminating pockets of existing infection. Extensive trials have now been established and already several of the Electricity Boards are prepared to accept the use of boron rods as an effective, safe supplementary treatment for internal decay in creosoted poles.

Current work at Imperial College in cooperation with Calders and Grandige is investigating the use of boron rods as a supplementary ground line treatment in new poles. Investigations in France have also demonstrated the potential of boron rods for the control of pole top decay (Dirol and Guder, 1989).

In the discussion of the paper on boron rods to the 1983 Convention of B.W.P.A. (Dicker *et al.*, 1983) Bravery pointed out the potential for the use of rods for specialised remedial treatments where it was desirable not to remove excessive amounts of timber. Since that time boron rods have been used in a range of specialised remedial treatment operations. These have included treatment of structural glue-laminated beams in hyperbolic paraboloid shell roofs, treatment of various timbers of architectural and conservation importance, and even in the treatment of the mast of H.M.S. Discovery during the replacement of a previous, inadequate repair. Since then borates and boron rods have been adopted as a standard treatment system by the Maritime Trust for similar wooden ships.

3.2.1 *Organic Borates in Remedial Treatments*

The use of organic solvent soluble glycol esters of boron e.g. Tri-hexylene glycol biborate and boron dissolved in co-solvents such as mono-ethylene glycol has allowed borates to be used in a range of formulations. These rely for their activity on the hydrolysis of the boron compound to the boric acid in the wood.

The remedial treatment industry has readily accepted the use of the boron ester formulations but very little work has been published on their biological activity. Early indications are that it may be incorrect to extrapolate their activity directly from the chemical conversion to the boric acid equivalent of the formulation. Research at Imperial College is in progress to determine the mode of action of a number of boron compounds (organic and inorganic) in relation to their availability in the water present in the wood. The presence of free glycols in the substrate may well interfere with the availability of boron to the fungus, suppressing its toxic effect.

The data in Table 3 show clearly the loss of activity of the boron when applied as a glycol ester as compared with boric acid (Rahman, 1988).

The results in Table 3 indicate that a toxic threshold was not established for Tri-hexylene glycol biborate in the range of 0·2-0·85 Kgm^{-3} boric acid equivalent. This is despite the fact that a toxic threshold from 0·54-0·63 Kgm^{-3} was found for boric acid alone. In another study simple additions of glycol to 'Timbor' in timber were found to raise the toxic threshold from 0·64 to 1·5 Kgm^{-3} for *Coriolus versicolor* in beech and from 0·68 to 1·3 Kgm^{-3} for *Coniophora puteana* in pine (Amofa, 1984).

Although these results are provisional they indicate that further work is necessary in conjunction with studies to establish the mechanism of action of boron in relation to availability to the fungus in wood. Despite these slight reservations with the boron glycol ester formulations, great potential exists for further exploitation of borates in the remedial treatment industry where their combination of low mammalian toxicity coupled with both fungicidal and insecticidal properties in the same active ingredient are highly desirable.

4. Current Developments in Pre-Treatments

At least one major producer of timber frame components and trussed rafters has indicated that if 'Timborised' material were still available they would use it, and has been very active in attempting to re-stimulate interest in Scandinavian mills.

The demise of 'Timborising' in the U.K. has not however been absolute. At least two small projects have helped keep interest alive and borates have provided the ideal answer to the specific requirements for treatment.

The first of these was in the treatment of small roundwood used for the construction of the new School for Woodland industries at Parnham Trust, Hook Park, Dorset. A small self-contained dip diffusion plant, supplied by Rentokil Limited, allowed the on-site treatment of locally produced small roundwood which could then be used for the innovative building techniques employed in this prestigious project.

The second example arose following the great gale of October 1987. The Essex County Council requested help from Rentokil Limited to treat quantities of wind thrown timber which they wanted to use to build a new visitors centre. The use of spray applied borates proved highly successful in achieving effective on-site treatment.

Although these two examples are of minor commercial value they have demonstrated clearly the advantages of the system. These techniques offer great potential as 'appropriate technology' systems for application in developing countries. For example, in recent trials of the treatability of three Burmese timbers at Imperial College (Nyunt, 1986) boron based diffusion treatments were found to be an ideal method of achieving deep penetration in refractory hardwoods (see Table 4).

TABLE 3

Comparison of the toxicity of a boron ester with that of boric acid to *Coniophora puteana* F.P.R.L. 11E

*Tri-Hexylene Glycol Biborate**			*Boric Acid*		
Conc. % ai	*Retention Kgm^{-3}*	*Weight loss %*	*Conc. % ai*	*Retention Kgm^{-3}*	*Weight loss %*
0	0	20·57	–	–	–
0·10	0·54	21·00	0·028	0·21	24·85
0·15	0·80	24·04	0·041	0·32	21·02
0·20	1·07	24·12	0·057	0·43	17·37
0·25	1·34	25·32	0·071	0·54	6·28
0·30	1·61	22·94	0·086	0·63	2·92
0·35	1·95	23·67	0·100	0·75	0·69
0·40	2·09	26·37	0·110	0·85	0·44

Agar mini-block test after Bravery (1975).

*Conc. ranges of tri-hexylene biborate and boric acid are approximately equivalent in boric acid terms.

TABLE 4
Retention and penetration of preservatives in three Burmese timbers

Timber	*Treatment*	*Retention* Kgm^{-3}	*Penetration (mm)*
In	Vacuum pressure* Boron diffusion†	9·2 2·9	3·5 25·0
Kanyin	Vacuum pressure Boron diffusion	3·2 3·8	0·9 15·7
Taung-thayet	Vacuum pressure Boron diffusion	5·0 2·7	2·8 25·0

*5% C.C.A. solution: vacuum 650 mmHg 1 hr.; pressure 1240 kNm^{-2} 3 hr.
†25% Boric acid equivalent at 55°C.; dipped for 15 mins. on 3 consecutive days. Diffusion storage at 50°C.

The timbers were refractory to vacuum-pressure treatment but were easily penetrated in the green condition by diffusion. Obviously, the diffusion treated timber would not be suited to ground contact exposure but it would be appropriate for many uses in construction. These diffusion treatments can also be applied by simple technology systems. Recent work on the boron diffusion treatment of Nigerian Abura wood (*Mitragyna stipulosa*) has shown that preservative application suitable for use in building timber can be achieved over a wide range of treating options (Matan, 1988).

However, if borates are to make their full contribution in the pre-treatment industry in the U.K. we need to consider their disadvantages and offer new systems which permit full commercial exploitation.

5. Technical Developments with Borate Preservatives

5.1 Background

Many of the disadvantages of borates relate to the need to treat at source and to the long diffusion storage periods that are necessary to achieve full penetration of the timber cross-section. A considerable amount of recent research has been conducted to obviate these problems and, at the same time, to develop improved control of the treatment technology. These advances are closely related to the treatment of products as opposed to the treatment of bulk timber.

Probably the single most serious perceived disadvantage of borates is their water solubility which makes them subject to leaching under certain conditions. It should be noted that this very solubility of borates and their consequent ability to redistribute in timber has been used as a major advantage in the remedial treatments described earlier.

Clearly the old arguments as to where and when a leaching hazard exist could have persisted indefinitely and continued to restrict the wider application of boron treatments. However, the current work on the new European Standards relating to Eurocode 5, will effectively settle this problem. The imminent new standards which will define hazard classes, minimum test requirements for products (including a leaching test as applicable) and the level of preservation required for a given hazard class will establish those situations and commodities where individual treatments, including borates, are acceptable.

Research and development with borate preservatives has expanded considerably in the last decade and particularly in the last five years. This has resulted from several factors:-

a) The search for new preservative components with enhanced environmental properties has led to a reappraisal of existing materials.
b) Availability in the U.K. of a resource of home grown (and therefore unseasoned) Sitka spruce that is difficult to treat by other methods.
c) Novel methods of application of borates e.g. vapour treatment.

5.2 Advances with Diffusion of Borates

The foundation for the application of boron diffusion to U.K. home grown timbers, particularly Scots pine and Sitka spruce, were established in research conducted in the 1960's by the Princes Risborough Laboratory (Smith and Williams, 1969) and by Borax Consolidated Limited (Thornton, 1964). These pieces of work showed the feasibility of local boron diffusion treatment of a range of U.K. timbers. However the problems of lengthy diffusion storage times and the need to maintain heated boron solutions to achieve suitable treating concentrations were not addressed in these studies. Both of these issues were significant barriers to the wider acceptance of the technique.

In recent years these problems have been investigated with a view to making the use of diffusion treatments more acceptable. There are two principal ways in which the rate of penetration of a diffusable chemical into timber can be increased
1) Increasing the concentration gradient and
2) Increasing temperature.

In conventional dip diffusion the amount of preservative applied to the wood surface during the dip phase which establishes the concentration gradient for the subsequent diffusion is often limited by the surface topography of the wood. In the case of a smooth surface e.g. planed this can be a very serious limitation. Heating is necessary to make concentrated boron solutions for dip diffusion treatment in order to apply a sufficient loading for acceptable penetration.

Two approaches have been adopted to overcome these problems. Research at Imperial College has investigated the potential of a steam cold quench process for the treatment of home grown Sitka spruce and birch in order to improve surface uptake of preservative during dip treatments. This was based on reports of successes with this method in the diffusion treatment of Radiata pine in New Zealand (McQuire and Goudie, 1972). Results of a comparison of steam-dip treatment with conventional dip diffusion in Sitka spruce and European birch are given in Table 5.

The data show clearly the substantial increases in absorption of solution achieved in steam dip treatment. In particular the difference between absorption in rough sawn and planed birch demonstrate the significance of surface effects on uptake and the way in which steam dip treatment reduces these.

Another approach to improving the surface uptake has been in the use of thickened diffusion treating solutions developed in New Zealand at the Forest Research Institute, Rotorua. These solutions were originally developed for use with copper containing preservatives (Vinden, 1984). Recent developments have led to boron based formulations which are now in successful commercial applications in New Zealand (Vinden, personal communication).

TABLE 5
Comparison of boron solution uptake and diffusion in steam dip and conventional dip treatment

Timber	*Uptake* $l\ m^{-3}$		*Penetration mm*	
	Dip	*Steam/dip*	*Dip*	*Steam/dip*
Sitka spruce sapwood	20·6 (0·8)	42·4 (4·2)	14·2 (0·7)	24·5 (0·1)
Sitka spruce heartwood	12·0 (0·4)	17·4 (2·1)	13·2 (0·8)	16·9 (1·1)
*Birch sapwood rough sawn	5·6 (0·9)	119·6 (30·3)	N/A	22·1 (3·9)
*Birch sapwood planed	2·0 (0·4)	82·6 (19·8)	N/A	17·1 (2·4)

*Data from Konabe (1986)

It is well known that increasing the diffusion storage temperature will increase the rate of penetration of the borate and thereby reduce the diffusion storage times. This is illustrated in Fig. 1 for both boron and copper based diffusion preservatives.

The wider introduction of kiln drying facilities has led to investigations on the effect of elevated temperatures on the rate of diffusion penetration of borates and the possibility of combining diffusion treatment with the drying process. Initial results are given in Table 6.

These results show clearly the improvement in diffusion penetration rate that is achieved by storage at elevated temperatures. However when the samples are subjected to drying during diffusion, further penetration is stopped and, in the case of sapwood, showed signs of being reversed. At present it must be concluded that drying during the diffusion period should be prevented. However this work is being continued to determine the influence of higher diffusion storage temperatures and a much wider range of drying conditions.

TABLE 6
Influence of high temperature storage and the effect of drying on the penetration of borates in Norway spruce.

	Penetration (mm)					
	Sapwood			*Heartwood*		
Diffusion (days)	*20°C*	*70°C*	*70°C w/drying**	*20°C*	*70°C*	*70°C w/drying**
3	4·3	8·4	8·4	3·0	3·0	3·6
7	6·3	10·8	6·7	4·7	7·1	4·5
14	9·8	15·4	4·7	9·0	12·0	4·9
21	14·2	24·5	4·6	13·2	24·5	6·0

*Samples stored under non-drying conditions for three days, followed by open stacked at 70°C. Sapwood and heartwood moisture contents were 12% by 14 days of diffusion storage under these conditions.

TABLE 7
Retention of boric acid resulting from vapour treatment.

Board	*Thickness*	*Retention of Boric Acid % wt/wt Board moisture contents (%)* 0%	2%	4%
Orientated Strandboard	15 mm	1·13	1·36	1·75*
Medium density fibreboard	15 mm	1·15	1·72	1·79
Chipboard BS5669 type 2·3	17 mm	1·10	1·56	1·90*
Aspen waferboard	20 mm	1·10	0·86*	n/a

Treatment time 45 minutes @ 65°C
All samples completely penetrated through board faces except* (all samples were edge sealed).

TABLE 8
Relationship between treatment time and boric acid retention for Orientated strandboard ('Sterlingboard')[a].

	Retention % wt/wt	
Treatment time mins.	*20°C*	*50°C*
1	0·2	0·3
5	0·8	1·5
10	1·3	2·0
20	1·8	3·1
45	2·7	4·8

[a] Board moisture content 6%, board thickness 18 mm. All samples showed full penetration through board faces (samples were edge sealed).

5.2 **Vapour Phase Treatment**

Certain esters of boron have a high vapour pressure making them readily volatile. This property has been investigated in recent research on the treatment of wood and wood based board materials (Vinden *et al.*, 1985; Turner, 1986; Turner and Murphy, 1987). In these studies the deposition of boric acid in wood results from the combination of trimethyl borate with moisture present on or within the wood cell wall in the following reaction:-

$$B(OCH_3)_3 + 3H_2O \rightarrow H_3BO_3 + 3CH_3OH \quad (1)$$

In a cooperative research programme between Imperial College and the Forest Research Institute, New Zealand a wide range of wood and wood based materials have now been treated successfully using vapour boron methods and the technology is subject to patent application in a wide range of countries. In the case of board treatments the data in Table 7 and Fig. 2 from some of the early trials illustrate the good penetration and retentions that can be achieved in a variety of boards.

These results show clearly that a variety of different board types are treatable with borate vapour under appropriate conditions. It will be noted that moisture content had a significant effect on treatment retention and penetration with retention rising and penetration decreasing at higher board moisture levels. Work to refine the process has continued and recent results have given considerable improvements in terms of reducing treatment times and reduced sensitivity to board moisture content. Results for the orientated strandboard "Sterlingboard" are given in Table 8.

These recent data, obtained using a purpose built laboratory treatment plant (Fig. 3), show clearly the extent of improvement in treatment characteristics that have been achieved

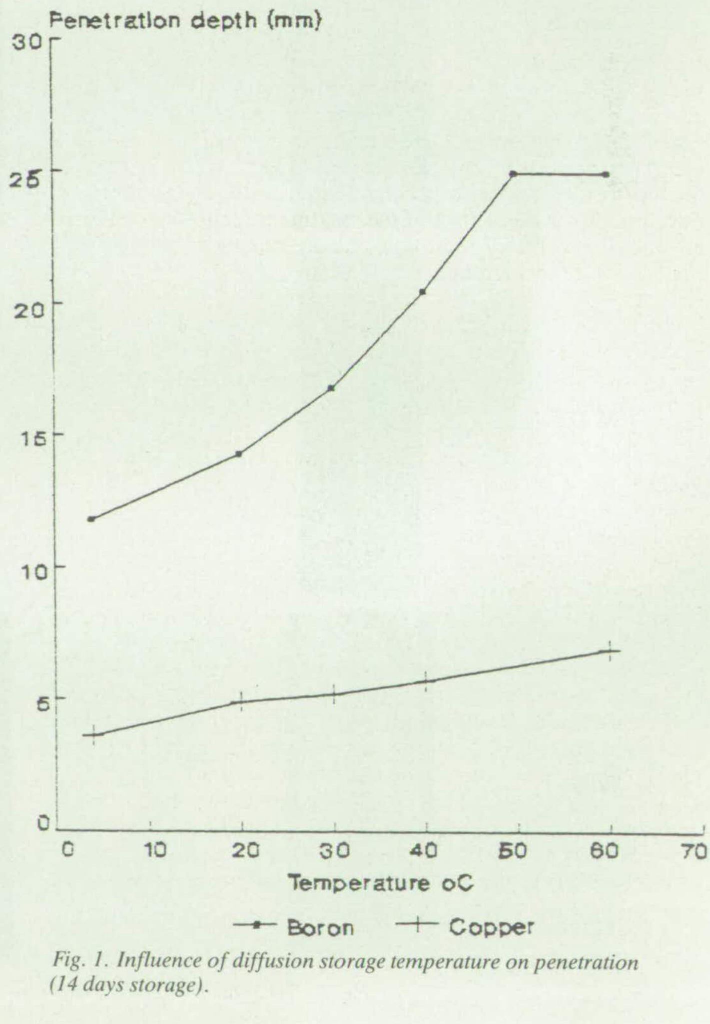

Fig. 1. Influence of diffusion storage temperature on penetration (14 days storage).

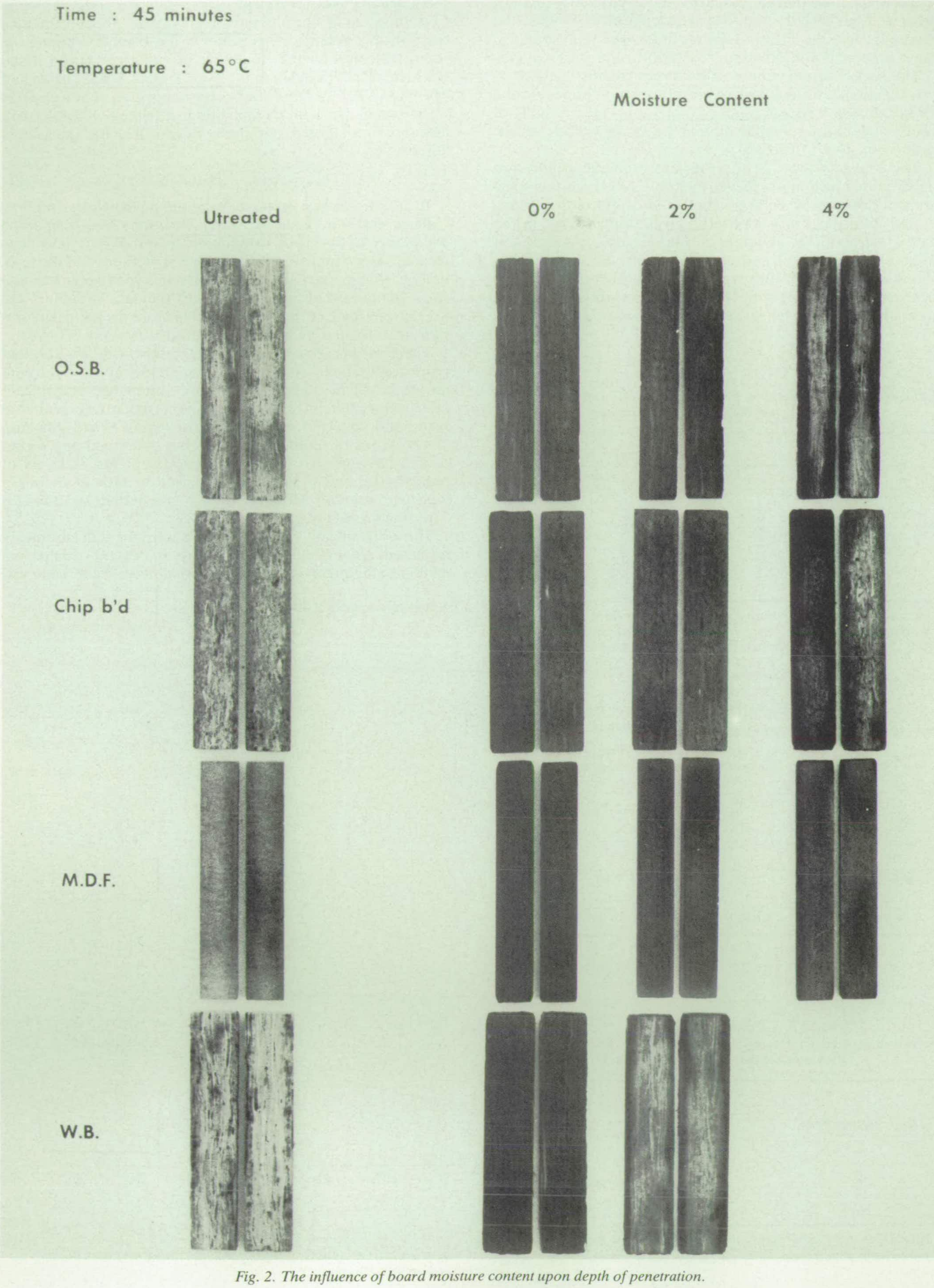

Fig. 2. The influence of board moisture content upon depth of penetration.

TABLE 9
Weight loss of untreated and vapour boron treated board materials.

Board	Retention % wt/wt Boric Acid					
	Brown rot†			*White rot‡*		
	0	*0·5*	*2·5*	*0*	*0·5*	*2·5*
Orientated strandboard	45·6	2·0	3·1	13·8	2·3	3·2
Medium density fibreboard	56·8	2·0*	2·8	28·3	4·2	3·5
Chipboard	48·6	1·8	2·3	19·2	2·2	2·7
Aspen waferboard	32·7	0·2	1·4	34·9	1·6	1·5

Test by agar mini-block method. †*Coniophora puteana* FPRL 11E
Mean of 6 replicate blocks. ‡*Coriolus versicolor* FPRL 28A
*mean of 3 replicates.

since the earlier trials. In particular it is clear that treatment times of only a few minutes at ambient temperature, on boards at equilibrium moisture content are now feasible. Adjustment of the treatment time or temperature can be used to influence the retention of boric acid in the board. In order to check the retentions of boric acid required to protect these board materials against decay, biological trials have been undertaken.

Preliminary tests of vapour boron treated samples against decay fungi have shown control of decay at retentions of approximately 0·5 per cent boric acid, see Table 9.

Further studies of the decay resistance and toxic thresholds of an extended range of vapour boron treated board materials are being conducted in cooperation with the Building Research Establishment.

The technology of vapour boron treatment of solid wood that has been developed at the F.R.I., New Zealand is also well advanced. In this case a unique combination of drying technology and vapour boron treatment has provided a single stage process for the production of preservative treated, dry timber directly from green lumber. Commercial trials of the process are in progress in New Zealand.

Vapour boron treatment is considered to offer many advantages for both solid wood and board material, not least of which is the ability to produce dry, treated products on demand i.e. 'Just in time' preservation. The treated product is ready for immediate use as no liquid solvent is used. Application of the system as a post-manufacture treatment of wood based boards board allows board fabrication to proceed under optimal production conditions. The potential of the vapour boron technology for the production of flame retardant boards is also under active investigation.

Summary

The background to the use of boron compounds as timber preservatives with special reference to the U.K. market has been reviewed. In the past the use of borates has never been extensive despite attempts to foster their application.

Diffusion treatments offer a very useful approach to overcoming many of the penetration problems of refractory timbers. In addition, various boron diffusion treatments are available to suit a wide variety of technological and economic situations.

However in the U.K. a change in the perception of boron treatments is needed. They should not only be considered, as they have been in the past, as inconvenient systems or products suitable for speciality applications.

The recent advances in the technology of boron treatments described in this paper should help create a climate in which the industry can take full advantage of the properties of these safe, effective, well-proven wood preservatives.

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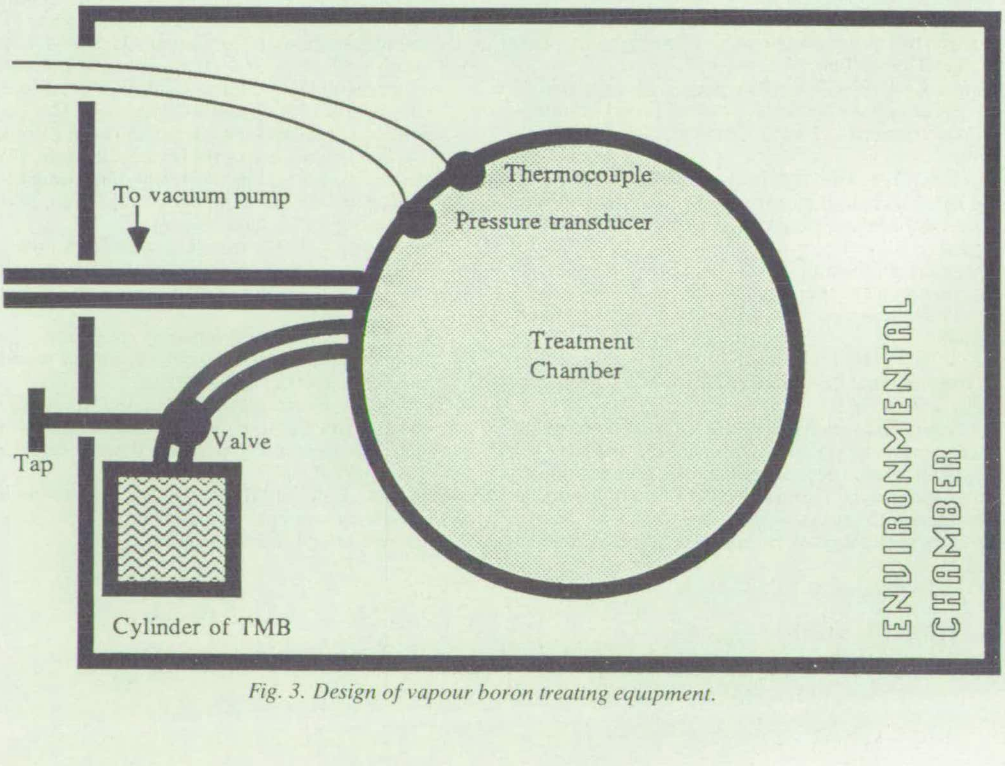

Fig. 3. Design of vapour boron treating equipment.

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DISCUSSION ON PAPER 6

Chairman: P. G. Shaw

THE CHAIRMAN: Well, I suspected, ladies and gentlemen, with the complexity of the subject and having Richard and David speaking in tandem, there would be little time left for questions. However, I am not going to disillusion David and Richard because we will invite questions. If we have to overshoot by five or ten minutes, then we do so. I think it has been a very interesting lecture. Let me invite your questions now, please.

DR. L. D. A. SAUNDERS (Fosroc Ltd.): Richard, you referred to short treatment times and specifically you had already mentioned 8 minutes at 20°C. to get the one kilogram cubic metre loading. You also mentioned though that there was going to be a solvent recovery phase at the end and presumably there will be a short time for pre-treatment at the beginning. What would you estimate as the total processing time for an 8 × 4 sheet?

DR. MURPHY: We would be aiming, I think, for within half an hour: between 20 and 30 minutes from point of loading the cylinder to the point of removing. Enough time for a tea break!

DR. A. BRAVERY (B.R.E.): Can I raise two points, if I might. The first is a very specific, technical one directed to one of Richard's slides showing the problem caused by biological durability; decay resistance test in a petri dish. You have talked already about residual methanol and the very enclosed environment in which those tests were carried out would be one which was vulnerable to any residual volatiles. Were measures taken to avoid that or might that be an influence?

DR. MURPHY: Yes, that is quite right, Tony. We appreciated these were indicative decay tests. They are not, in fact, standard tests at all. The blocks were conditioned. They were not evaporatively aged, but they were conditioned in the open laboratory for several days – weeks in fact – before exposure in the petri dish test. So we feel confident that all the residual methanol would have been removed. In the same test, of course, untreated samples gave us quite high decay levels.

DR. BRAVERY: Is the protective effect leach resistant too, or if the board gets wet enough to rot is there a risk that some of the boric acid may be removed?

DR. MURPHY: Well, I think there is certainly a risk that the boric acid would be mobile, to some extent, but the question whether it is leached out of the board or simply re-distributed is one which still remains to be resolved, and it depends very much on the particular application.

DR. BRAVERY: Could I just ask for your reaction to what seems to me a possible scenario if these types of treatment or variety of treatments with borates find favour. If they are indeed, or can be regarded indeed as, safe as I think you suggest or tend to believe at the moment, could we foresee an occasion where there might be justification for extending the range and variety of pre-treatment specifications – I am thinking particularly of roofing timbers, for example – so that we avoid the need at some future date to have to use the rather more aggressive remedial chemicals that we have to rely on.

DR. DICKINSON: I think that is the obvious direction we are hoping that this work will go. I would just remind Richard that we did have two slides, which he decided not to show because we were running out of time, of timber frame housing. I think this treatment for timber in the protected environment is a very good one. Certainly your point about the choice of using a very acceptable, benign system as an insurance policy, so that, at a later stage, if problems do arise, we do not have to resort to less benign systems to put problems right, is a very good one, and one which I think, in the present climate, ought to be very acceptable.

DR. C. J. D. GEORGE (A.T.I.C.S.): I am very interested to see the remedial treatment *in situ* and I wondered if you had any information on the effect of these compounds on metal fixings and glues?

DR. DICKINSON: In joinery, in the work which we presented in 1983, there is data about the movement of material from these rods across glue lines. I must confess that the work was done to show that glue lines would not be limiting to diffusion, but at the same time it showed there was no detrimental effect to glue lines. The essentials for being sure of that, of course, is the treatment of glue laminated beams. There is quite a lot of work going on in France at the moment on the use of these systems for treating glue laminated beams, and there does not appear to be any problem with glue lines. On the second point, similar products to these are used as corrosion inhibitors in mining operations. I do not think there is any problem from corrosion. Of course with the neutral mixture of the "Timbor" there is no problem at all.

DR. D. G. ANDERSON (Hicksons): Boric acid, which is the product from the hydrolysis of methyl borate, is a relatively volatile component in itself. Have you done any ageing tests on M.P.F. or any boron rods treated with it.

DR. DICKINSON: The biological programme will involve full evaporative ageing and that whole issue, of course, will become clear.

DR. MURPHY: To add to that point, I think we are probably considering temperatures over 60° before we start getting into the range of the volatility of boric acid.

DR. MORGAN (B.R.E.): I am intrigued by the idea of recovering methanol from this process. It leads me to speculate that if you use triethyl borate you might have a very useful by-product which you could sell in other spheres. That was not my question. My question is, when you are making any board product you do have the advantage of having the material in dissembled form, in the form of particles. Have you looked at the alternative prospect of putting the boron in before you actually make the board?

DR. MURPHY: This is one of the areas that we considered when we were first beginning to investigate this approach to treating board materials. We felt that there were strong advantages for the treatment of fabricated boards after manufacture, especially processing that is simple and straightforward. In particular, it means that the manufacturers can treat to demand. They do not have to set up lines of stock treated products. We believe that we can incorporate the borate by vapour treatment perhaps much more readily and with a much more even distribution than might be possible with a particulate approach. There is a cost factor associated with it. The short answer is that we have not looked at incorporating borax into the manufacturing process of boards. I believe some work has been done on that.

DR. D. G. ANDERSON (Hicksons): I believe it is actually commercialised in some board products in the U.S.A.

DR. MURPHY: Yes.

DR. ANDERSON: Could I ask one other question. With board products biological decay is only one aspect of their fitness for purpose. The other ones are the strength of the glue under damp conditions and the basic stresses that are released in the board when it is exposed to a high humidity environment. Was that taken into account in the work that you were doing. Were you using glues that would be affected.

DR. MURPHY: We measured bond strength across a range of retentions from very low retentions up to really quite high retentions, and it is true to say that at the higher retentions we noticed a reduction in the I.B. strength. At wood preservative retentions there was no reduction at all. In fact we noticed a very slight increase.

DR. DICKINSON: This is also one of the problems with the incorporation of boron in manufacture. Certainly, at wood preserving levels, we get round that problem.

DR. L. D. A. SAUNDERS (Fosroc): Thank you for letting me come back, Chairman. Repeating my reference to the mobility of boric acid, at the risk of irritating Richard by asking again the question I asked before, when you are treating boards at nought per cent moisture content by my understanding of chemistry you cannot get wood preservative retention of boric acid unless you actually get a reaction. Are you sure, therefore, your reaction is to water or is it, in fact, to the hydroxides in the timber.

DR. MURPHY: We believe it is with water because, I think, when we are talking about nought per cent moisture content, we are talking about moisture content in terms of oven dried at just over 100°, and there is still some residual water in the wood under those conditions. There is a possibility, of course, that the tri-methyl borate is reacting with other groups. We believe that it is reacting with water, but as yet we still have to prove that particular point. In addition, we would not be treating boards at nought per cent moisture content commercially. I do not think we could manage to persuade the manufacturers to dry it out to that extent. However, we were very pleased with the results we got when we treated with T.M.B. across quite a wide range of moisture contents.

THE CHAIRMAN: One final question.

MR. A. C. OLIVER (Private Member): I should like to thank the authors for their useful addition to the subject. My question concerns the performance of borates against soft rot, which is ot included in your paper.

DR. DICKINSON: If I can refer back to our 1983 paper again. That was an issue that we did tackle in that paper and, in fact, there is data in the paper to show that all the soft rot fungi that were isolated in the survey of joinery were tested and in all cases, the toxic thresholds were lower for all the soft rot fungi than for the most resistant basidiomycetes. Our work on the action mechanisms of borates, which is primarily using microfungi to try to get some idea as to how boron actually kills fungi, indicates that the critical factor is that the organism is in the cellulose or lignin utilization phase for the fungicide to be effective. So there is no problem with soft rots. In fact, they do not seem to be as big a problem as basidiomycetes.

THE CHAIRMAN: Dr. Lewis wishes to ask a question so I will let him do so.

DR. D. A. LEWIS (Hicksons): We have heard much talk about benign chemicals. Probably we can accept that in timber with boric acid although I think they have pollution probnlems in the Rhine with borate compounds, but could you perhaps tell me a bit about the toxicology and hazard associated with the useof T.M.B., particularly at the treatment plants you were considering.

DR. MURPHY: I think obviously we would consider this as an enclosed treatment process. We would not want to expose the chemical directly to evaporation etc. It would have to be a contained system. I think that what you said in your paper about organic solvents indicates that the best sort of technology for this is being developed as rapidly as possible, and that this is the way things are going to go in the future. I do not anticipate any significant problems with containing these materials, but I think it is good practise to contain them.

THE CHAIRMAN: Well, ladies and gentlemen, it only leaves me to thank David and to thank Richard for a very informative and, indeed, a very excellent paper. I think the paper has given us all much food for thought. Undoubtedly, I am sure we all believe that boron, in various forms and for a multiplicity of applications, will play a greater part in the wood preservation market place. I have enjoyed the paper and I am sure everybody else has here. If the delegates could please show their thanks in the usual way. *(Applause).*

B.W.P.A. ANNUAL CONVENTION 1989

CHEMICAL DAMP-PROOF COURSING 1978-1988

by C. J. Jones *Director, British Chemical Dampcourse Association.*

Introduction

The title of this paper may prove to be a misnomer. It alludes, only, to the period during which a Trade Association has existed, namely the British Chemical Dampcoursing Association. However, it is essential to record information beyond the period specified to enable readers to appreciate the extensive background which has nurtured developments. At last year's convention, delegates were made aware of some historical facts and others have contributed technical and analytical factors which are also worthy of review.

Such reviews are not unique to this convention and have been ably presented by such notable contributors in the past, such as W. Bruce and S. A. Richardson, reminding many delegates of their obligations to continue research and development. They do not possess technical content and this paper will be no exception.

History

The history of dampcoursing in buildings is documented and is recommended as a general practice when construction begins in comparatively modern times. The Building Regulations and Codes of Practice prescribe and instruct the designer and builder where and how to prevent ground water from entering the structure through the foundations. However, prior to the adoption of the impervious membrane, less durable materials were used and even earlier, stones were skilfully laid or hard baked bricks or specials such as Staffordshire "blues" were employed in lower courses. The mortar used in many old buildings was weak and sparsely distributed and externally required "pointing" to protect it, to provide weathering, prevent rain penetration and erosion of the bedding material.

Cavities, spaces between masonry leaves of various thicknesses are often found to be filled with rubble, the spacing variable and without the stabilizing assistance of wall ties, which is a feature of modern construction methods. The variety of construction methods employed in both town and rural areas without proper provision of a dampcourse to prevent rising damp provided a ready market for contractors already engaged in the business of woodworm and dry rot control or eradication. Wood decay is inevitably linked with dampness in buildings so that control of dampness has always been of concern to the remedial contractor. Development was slow at first with adoption of diffusion or low pressure of natural water repellents such as siliconates (1950's), silicones and stearates (1960's) and injection mortars, mid 1960's. However, the real surge of chemical dampcoursing occurred in the early 1970's when the sales drive began to market chemicals and equipment indiscriminately to "jobbing builders" who became experts and specialists overnight. At the same time, dampness detection devices were quickly adapted from instruments previously used to detect moisture in timber, to identify dampness in plaster and masonry. Armed with these products, the "cowboy" was created to come and go as he was pleased to do, more often than not. Not only did the number of expert contractors increase, so did the number of companies formulating chemicals. Competition grew and standards diminished. The "old guard" recognised the deterioration. Elements within the industry met together and created small federations or associations to maintain a better image. The British Chemical Dampcourse Association (B.C.D.A.), was created by the merging of these smaller organisations in 1978. It is interesting to note that the B.W.P.A. gave an airing to the idea of taking an interest in chemical dampcoursing in the late sixties by discussing the subject within a working party. The resolution to adopt chemical dampcoursing was narrowly defeated. Very few of the working party are here today or are still active in the Association so the wind of change has blown almost unheeded since.

Industrial Organisation

When the British Chemical Dampcourse Association was formed in 1978, it consisted of founder members who were in three distinct categories. Manufacturers of Chemicals, Chemical formulators and Installers of Chemical dampcourses. In the first two categories were some large and well established companies who had previously initiated research and test programmes and would continue to provide the bulk of personnel and facilities which the third category could not. Subsequently, other categories provided additional assistance when associated industries such as plaster manufacturers joined. Prior to the formation of the B.C.D.A. and its founding organisations, the Agrement Board (now the British Board of Agrement) (B.B.A.), as well as the Building Research Establishment (B.R.E.) at Garston, mounted a small programme of research centered on the construction of test walls using modern bricks and mortars which it hoped would ultimately be used to determine the efficacy of products. This programme continued when the new Association formed a Technical Committee and assigned the project of test walls to a sub-committee primarily to create rising damp under laboratory conditions. Needless to say, all three efforts failed to produce a conclusive standard by which all known methods of in-situ chemical damp coursing could be assessed. However, from the experience gained it can now be claimed that M O A T 39 by the British Board of Agrement published in 1988 will provide a means of testing products and systems which profess to prevent moisture rising up walls in the absence of a conventional damp proof course (dpc).

From the beginning, the B.C.D.A. has worked hard to achieve all its aims and objectives. Certainly the publication of The Code of Practice giving guidance on the installation of chemical damp-proof courses first published in 1978 which became British Standard 6567 in 1985 and its technical publications has enhanced the status of its members with the aid of B.R.E. and B.B.A. representation on the Technical Committee. An early attempt to establish test methods for chemical dampcoursing systems failed. Progressively Technical Information Circulars have been published at intervals on the following subjects:

- TIC 1 The use of Moisture Meters to establish the presence of rising damp.
- TIC 2 Plastering in Association with Damp-proof coursing.
- TIC 3 Condensation.
- TIC 4 Methods of analysis for damp-proof course fluids.
- TIC 5 Chemical damp-proof course insertion – the attendant problems.
- TIC 6 Safety in Damp-proofing.
- TIC 7 Chemical damp-proof courses in walls – detection techniques and their limitations.
- TIC 8 Damp-proof barriers (Tanking) in association with chemical damp-proof courses.
- TIC 9 Guidelines to survey report writing.
- TIC 10 Hygroscopic salts and rising damp.

Some are technical, some are advisory.

Consumer Affairs

The industry, through the B.C.D.A., has been unable to establish a Code of Conduct which would provide a means of arbitration. Attempts have been made in negotiation with the Office of Fair Trading to constitute such a Code. The main reason why such a scheme has not been adopted is the division within the O.F.T. This central government department has two sections. Consumer protection and competition policy. The former is the watchdog which associates itself with misrepresentations under the Trades Description Act administered by Trading Standard Officers, centred in Town Halls and County Headquarters. The latter effectively control malpractices under the Restrictive Trade Practices Act. The scheme offered by the B.C.D.A. was found to be acceptable to the former with some suggested amendments. The latter never gave their approval.

However, a scheme has been operated by the B.C.D.A. which enables conciliation and mediation to occur between consumers and member companies with a high degree of success.

New hope of agreement has arisen following the completion of a report prepared by a D.O.E. Working Party, meeting to discuss "the cowboys" and how to overcome the problems they cause. Negotiations with industry are to be resumed to enable Codes to be established which would be operated voluntarily. The only mandatory procedure would be the registration of such schemes for the purposes of the Restrictive Trades Act and perhaps the strict application of an Arbitration Scheme through the Chartered Institute of Arbitrators.

The consumer has been acutely aware for many years of the problems which will arise when a contractor professes to be an expert or specialist, offers a long term guarantee (unique in any market), infers assurances and insurances in support of claims. Undermining this facade, is the knowledge that the industry is grossly under financed and in concert with the jobbing building trade generally, does not support stability or the ability to sustain an after sales service.

One of the most controversial areas of malcontent which has blighted the industry during this progressive period of development is the contentious subject of re-plastering walls which have been damp. Most of the complaints received about work carried out by Chemical dampcoursing contractors, relate to the condition of the decorative rendering of walls. There are several reasons why so many complaints arise when consumers are holding 30 year guarantees.

1. The contractor has not recommended replacement of the existing plaster.
2. The re-plastering is quoted as being an integral part of a chemical damp-proof course (dpc).
3. The contractor's quotation for re-plastering has been ignored by a main contractor.
4. A main contractor employs a very capable and experienced plasterer who used the wrong materials despite recommendations to the contrary.
5. The speculator or private owner who is keen on do-it-yourself reduces costs for a quick profitable sale (invariably the second or third succeeding owner makes a complaint).
6. The reluctance of consumers to fully comprehend or to accept the existence of condensation and neglect.

A research programme was mounted a few years ago to investigate plasters recommended as renovation materials, following chemical dpc installations. It failed because laboratories, time and finance could not be sustained to establish a reliable test method which would enable all laboratories to follow an exacting standard test which incorporated the conditions likely to be encountered in old buildings subject to damp. Possibly in future, with the help of government funding and the collective assistance of industry through trade associations, this programme of research will be allowed to be completed and provide a solution to this troublesome area of complaint by consumers and contractors alike. There are other areas of research which should benefit from government assistance. It has been suggested that this sponsored research can be allocated to universities and polytechnics or to government research laboratories provided it is recognised that such projects do not expect direct support or augmentation by existing government funding.

There should be an in-depth investigation of all electronic moisture detection devices to determine their efficiency when diagnosing dampness in buildings, thereby eliminating commercial inexactitudes expressed in sales literature.

Education and Training

Education and Training has, from the beginning, stemmed from in-company schemes of the larger organisations operating in the field of pest control contracting, developing strongly in woodworm and dry rot eradication and latterly with the elimination of damp.

The early industry splintered in the face of take over policies and growing competition forcing the shedding of personnel which assisted the growth of operating companies. Nevertheless, the operators, surveyors and supervisors affected by these events had basic training and an awareness of the industry. Naturally, operators, or as some term them, technicians, jumped or leaped rapidly into the role of managing directors or perhaps more modestly, proprietors of very small businesses. Their ability to function in all spheres of business activities relied mainly on assistance from the professions, (mainly solicitors and accountants), rapid accumulation of work experience or even to improve the situation by collaborating with partners who had or professed to have had, expertise in a particular aspect.

However, there were many more joining the industry who had merely observed the experts or specialists at work or had been encouraged to join in the bonanza by very enthusiastic salesmen without any experience or knowledge.

Recognising the need for training courses to be organised, a meeting was arranged with Mr. W. A. Chugg of High Wycombe College to create an awareness of the need for specialised education. The College organised a seminar to gather the views of industry and the educationalists. The initiative proved successful. Staff were diverted and engaged. Courses commenced for surveyors and supervisors. First of all the courses concentrated on wood preservation, in particular, woodworm and dry rot control. Later it incorporated developments in dampcoursing. Contributions were made by industry in supplying lecturers to explain specific products or processes which provided a wealth of data, including experience, which might otherwise have been misinterpreted by the college staff.

The courses met with early success although the duration of six weeks full time attendance began to take its toll of those who found it difficult to release themselves or their employees for two complete three week periods. In 1975, a meeting was arranged, again by Mr. W. A. (Bill) Chugg, to find ways to remedy the situation. The courses were reduced in content, extra hours introduced and consequently the duration became four weeks. At this time it was agreed to organise separate courses of one week's duration for dampcoursing subjects. Meanwhile, the B.W.P.A. instituted their Certificated Timber Infestation Surveyor Examination (1980), the responsibility for which was passed to the Institute of Wood Science. It was not until 1982 that the British Chemical Dampcourse Association began to organise its own examination for Surveyors. The first examination was held at High Wycombe College, organised by the B.C.D.A., in 1983, employing a panel of chemists, experienced surveyors and educationalists. The B.C.D.A. issue a certificate to successful candidates who are ultimately encouraged to display C.R.D.S. – Certificated Remedial Damp-Proofing Surveyor.

The examination has become popular, being held three times a year at one centre reaching a peak in 1988 by registering 60 candidates at two centres.

The establishment of courses, for surveyors, operators, supervisors and now specifiers, has been extended to Oldham Technical College in Lancashire. Courses are being prepared by Telford College, Edinburgh to fulfill a need in Scotland.

Government funding has been provided on a small scale for attendance at education centres and to assist training programmes to be prepared and delivered by consultants. These schemes were publicised by the Manpower Services Commission (M.S.C.) to be pursued by individual companies.

Guarantees

The adoption of 30 year guarantees for in-situ dampcoursing followed that offered for timber treatments. As far as the author is aware, there has not been an analysis published or indeed is there sufficient evidence available to prove that damp coursing systems will support the issue of such long term guarantees.

Certainly what has happened is, that most contractors who commence operations in this business declare immediately that they issue a 30 year guarantee. They rarely consider the implications and frequently they are guided by a salesman. The form of guarantee is often copied directly from a competitors literature or that of the former employers. In some cases, legal advice is not sought and in others, blatant forgeries have been issued.

Since 1983 the Guarantee Protection Trust (G.P.T.) has offered independent protection to guarantees. However, it is not compulsory for any contractor to offer such a service to the consumer and some difficulty has arisen in negotiations with the O.F.T. on matters of restrictive practices. There are contractors who consider that their companies give adequate protection without this assistance. Many insure themselves yearly to protect their workmanship, most do not. This can be coupled with an indemnity against professional negligence, again, most do not. Therefore, the lack of protection, the lack of adequate funding, the lack of proper training and supervision, in the face of more acute consumer awareness, makes the majority of contractors extremely vulnerable. This, of course, is not confined to the remedial treatment industry alone, however the "cowboy" stigma attached to many contractors operating within the building industry is attached to this section in turn when fruitless enquiries reveal a worthless guarantee.

Association Membership or Registration

It has been suggested and supported by many contractors that all companies professing to operate in a section of industry should be encouraged to join an Association. Indeed, such a scheme has been approved by the B.C.D.A. without being implemented in view of a proposed merger. Because it is stated that standards should be maintained it would be a requirement of any organisation to have a positive means of removing companies who are not prepared to observe established Codes. This development I am sure would be welcomed by all government departments who wish to monitor trade and industry, eliminating what they see as "closed shop" or "cartel" tactics. The revenue engendered would enable an organisation to increase its activities. Surely this must be adopted, unless it is anticipated that remedials will not continue at a similar volume in the next ten years.

The following is the transcript of the author's talk to the previous paper.

DIFFICULTY AND COMPLEXITY OF BUILDING STRUCTURES IN THE U.K.

There are difficulties derived from the complexity of Building Structures in the United Kingdom! I would like, first of all, to illustrate this with a number of slides showing various types of buildings and building materials which require chemical dampcoursing. They are subject to attack by the U.K. climate which is maritime.

High winds – driving rain – high humidity – poor heating and ventilation – bad maintenance or none at all – coupled with war damage repairs which were carried out during a period of severe austerity and builders were required to be licensed and materials were under similar control.

The need for housing after hostilities was adequately met by housing programmes which used devastated areas and created new satellite towns for the reduced population. However, population explosions as well as immigration changed this situation as the years passed and prosperity demanded investment in second homes hence a boom in the refurbishment industry, encouraged by the introduction of home improvement grants from central government, administered by local government offices. Vast areas of old housing were demolished in cities such as Liverpool and Manchester and there was a population shift to tower block estates. As we are all aware, this changed to a policy of urban renewal and many local authorities maintain considerable departments and personnel on such programmes for their housing stock. This is again undergoing a change as more and more Housing Associations are founded to take over the responsibility of local authority housing, which, together with change to the Housing Acts, will permit the re-examination of finance previously vested in the Housing Corporation which I understand is being phased out by the Government.

If we are to consider this afternoon the numerical factors associated with Chemical Dampcoursing we must recognise that the most significant element is the contractor or installer. They employ the greatest number of people on a full or part time engagement, (sometimes they are self-employed) as managers, supervisors, surveyors, operators or technicians as well as customary office staff, often doubling up. Many rely on accountants to maintain their financial control other than the issue of invoices. The advent of computers and word processors has improved record keeping but the industry remains labour intensive by virtue of the very nature of the work which is manually operated and controlled.

An analysis of the industry's total personnel engagement should be sought if it is going to be subject to mandatory regulations and bombarded by published inaccuracies from environmental groups. If it can be established that one person in a million has been the subject of an enquiry while working in an industry would this not be more effective than an adverse comment about one person. Analytical chemists talk in terms of parts per million *why not apply this* to personnel.

When preparing this paper I researched previous papers which had either made direct reference to dampness in buildings or were giving guidance on education and training. This led me to discover much of this information has not been heard or read by the wider audience, the contractor. Some consider training courses are always too long, they apply this opinion to conventions and will go as far as to ignore one-day seminars which I will mention again later.

The damproofing industry recognises that somewhere within all the presentations noted on the back of my paper there is aid and advice.

John Bricknell in 1986 highlighted changes in the remedial industry but the knowledge and expertise recorded in the Convention proceedings since 1966 on subjects co-related to U.K. structure problems, particularly damp, do not change and this is perhaps where I ought to move quickly on to my main subject. The achievements of the British Chemical Dampcourse Association.

CATEGORIES

The Association was formed with just over 30 founders in the first three categories.

Category 1: Suppliers of raw materials, silicones, siliconates and stearates.

Category 2: Consisted of formulating companies producing water repellent fluids numbering 12.

Category 3: The contractors listed as installers making up the rest. Mainly situated in the Midlands and the North of England where contractor federations had been established previously. They included most of the national companies who were represented in the federations on a regional basis.

The growth has been accelerated in recent years by the inclusion and expansion of the remaining categories. The membership now consists of over 200 Members, 80 per cent of which are installing contractors.

Regretably, the Raw Materials suppliers are no longer active in the Association with one exception.

The main achievements of the B.C.D.A. may be highlighted by reference to the aims and objectives established at the beginning.

To enable standards to be established and maintained it was necessary to have a Code of Practice to provide guidance on the subject of Chemical Dampcoursing installations. This was published firstly in 1978, revised in 1982 and revised again in 1986 in line with the British Standard 6576, 1985. Prior to this date, only chemical dampcoursing fluids were specified and described. B.S. 6576 included the cementitious slurries which had been marketed for 20 years in the U.K. without recognition.

The responsibility for the B.C.D.A. Code of Practice and the creation of technical and advisory literature was placed with a Technical Committee. As you can see, from the list of participants, the input was enhanced by the presence of representatives from the Building Research Establishment, Garston, Herts. and the Agrement Board (now the British Board of Agrement) also housed now at B.R.E., Garston.

The Codes of Practice, B.C.D.A. and B.S. 6576 are assisted by Technical Information Circulars which are listed in my paper and to which I would like to refer briefly to describe their functions as opposed to the content.

T.I.C. No. 1: Moisture detection with all sorts of aids, particularly electronic devices have been used indiscriminately by some contractors, qualified surveyors and on occasions by consumers. This leaflet describes the limitations likely to be encountered and the advantages of oven-dry laboratory analysis to segregate the elements influencing the presence of moisture in a substrate.

T.I.C. No. 2: Re-plastering after dampcoursing produces many problems for an unsuspecting contractor. However, the recommendations made in this leaflet using sand and cement plus an additive was instituted before the renovating light weight plasters had become firmly established. The problems are described in my paper, on page 3. What is not explained is the tendency in many cases to buy sand of poor quality, to throw into the mix a couple of extra shovels full to make it go further which in turn makes the recommended additive ineffective.

T.I.C. No. 3: Advice on the subject of condensation is essential as an aide to a contractor, especially when a consumer has doubts about the surveyor's ability to diagnose his or her problems which is often aggravated by alternative sources of information.

T.I.C. No. 4: The analysis of dampcoursing chemicals has not caused problems for the industry simply because there is no standard established for the level of active ingredients when supplying water repellents for this purpose. However, levels of active ingredients are specified for the purpose of Agrement Board certification of dampcoursing system fluids.

T.I.C. No. 5: This leaflet highlights the problems envisaged when installing d.p.c.'s in close proximity to damp-proof membranes in new converted oversites and with differing ground levels necessitating the employment of waterproof renders and slurries.

T.I.C. No. 6: The need for advice on safety when handling chemicals is as important in chemical dampcoursing as in any other.

T.I.C. No. 7: One of the greatest demands made on my services within the Association is for a means of confirming the efficiency of a chemical d.p.c. installation. The Committee formulated this leaflet to explain the difficulties likely to be encountered in attempting diagnosis. Detection of water repellency may be simple short term. Long term unlikely. Quantitative analysis is not possible.

T.I.C. No. 8: Very often buildings in the U.K. have cellars or semi-basements. These often provide scope for conversion as living or storage areas. What this leaflet endeavours to achieve is to give advice on the various types of materials available to provide what are termed 'tanking systems' in other words, to create a waterproofed area within four walls and a floor.

T.I.C. No. 9: The purpose of these guidelines is to help the industry, especially the surveyors or building inspectors, to become more professional. To provide their clients with comprehensive reports instead of the three line estimates issued by many contractors in the past.

T.I.C. No. 10: Credit is due to Dr. Colin Kyte, who has contributed several papers to this Convention, for information contained in this leaflet. It clearly gives an appraisal of conditions within masonry which has been subjected to rising dampness.

The monitoring of the industry has, during the past 10 years, been electrified by the imposition of two schemes introduced by government sponsored agencies.

The first certification scheme for contractors was introduced by the British Board of Agrement some 10 years ago when it was declared that similar schemes operated by suppliers of chemicals for their approved contractors were not fully implemented or recorded.

The cost of certification for the small contractor proved to be one of the prime reasons for the abandonment of the scheme in favour of trade association membership. In the last four or five years quality assurance has been encouraged by the Department of Trade and Industry, particularly for manufactured goods as prescribed in B.S. 5750. There have been attempts to press the chemical damp-coursing industry into adopting schemes. As far as the B.C.D.A. is aware, such schemes are so far confined to suppliers in-house approval schemes. Again the cost of adopting quality assurance is proving prohibitive. It is claimed that Quality Assurance to B.S. 5750 ensures efficiency in all operational systems within a company. Rather surprisingly, of eight contracting firms who are approved in this way, who have recently applied for membership of the B.C.D.A., only four have been acceptable to their standards.

CONSUMER PROTECTION

There is a section within the Office of Fair Trading which acts as a 'watchdog' to give advice and protection within the laws without giving direct assistance. Agencies such as Citizens Advice Bureaux, Trading Standard Offices, Consumer Advice Centres supported by local authorities offer advice which often refers the consumer to trade organisations. Mistrust exists as it is thought that trade associations are formed to protect the members interests (not all enquiries concern Members).

Over a period of 10 years the B.C.D.A. has recorded within its files 1,123 complaints in writing.

718 were associated with member companies.

The most complaints (480) were about guarantees, mainly from persons who had inherited a Thirty Year Guarantee without any knowledge of the contract carried out under the instructions of a previous owner or speculative builder developer.

155 complaints were made subject to unpaid accounts. Very often consumers complain when secondary advice is given by a well meaning friend or relative who may have had a bad experience or may have witnessed a different system being installed.

27 complaints were attributed to claims of negligent surveys which is an incredibly low figure when the industry is well aware of the number of inspections which are carried out by surveyors over this 10 year period amounting to hundreds of thousands.

The remaining 56 is accounted for in the analysis of inter-member disputes which is monitored under a Code of Ethics rule. This rule discourages Members from commenting on other companies work which is often encouraged by the devious tactics of some consumers when confronted with a pro forma request for a re-inspection fee.

Complaints confirmed in writing about non-member companies are fewer because initial telephone enquiries often give sufficient advice and guidance. It is perhaps interesting to note that of the 400 or so complaints received, 68 did not or would not, name the contractor involved. 100 involved companies falsely claiming membership of the Association. A further 11 were of a considerably less serious nature. 202 were recorded on file without further action except to advise the use of a Consultant. In the last three years, 29 complaints have received advice involving former Members and finally in 1987/88, 15 were referred to member chemical suppliers who had endorsed guarantees issued by their approved contractor.

There are contractors who consider Trade Associations are protection agencies. This situation cannot exist when an organisation creates standards both commercial and technical which the membership or the industry cannot sustain. Both the B.W.P.A. and the B.C.D.A. aim to enhance their reputations by maintaining an image contrary to the usual concept established by much larger organisations.

The Trade Associations governing the greater proportion of the building trade in the U.K. do not support such stringent controls because their members come from extremely diverse trades but are classified as Builders. They may not have built anything in their lives.

Protectionism is abhorrent while a section of industry supports a system of such long term guarantees which creates insuperable liabilities for many small companies and proprietorships.

Many advocate legislation to regulate an industry which is out of control, largely untrained, under manned, under financed yet strangely the damproofing fraternity does not come under the scrutiny of the media as regularly as many other specialist sectors. Therefore, it is important to support and maintain a system of control which should be communicated regularly to consumers offering them advice and in many instances, consolation. To sustain a specialist section of an industry it has to publicise and promote its strength of resolve to maintain standards and creditability in the face of competition from casual and unprofessional elements whose cheap and unscrupulous methods continue to present problems.

The Association have had their share of failures but the numbers are minimal compared to the general statistics attributed to the building trade.

EDUCATION AND TRAINING

I have devoted a large amount of space to this subject as I consider it is one of the most important developments we have to face in the 1990s, plus my personal involvement ever since the initial discussion with Bill Chugg culminating in courses on Remedial Treatment subjects.

Again, this vastly labour intensive industry requires training. The bosses require training in business management. The supervisors, surveyors and operators require constant revision of their ability and their practices. In small firms the managing director or proprietor has to be capable of carrying out all the tasks.

In chemical dampcoursing it is a simple task to train unskilled labour to drill holes in walls, to attach an injection lance to a brick or stone to saturate a section of masonry with a water repellent.

The training and education of surveyors has proved to be more difficult as much more time is needed to explain and absorb the technical data gleaned from such frightening subjects as Chemistry and Physics.

The B.C.D.A. has examined since March 1983 – 457 candidates for their Surveyor's qualification. 328 successful candidates received appropriate certification. This indicates a high failure rate which is generally attributed to an inability to produce the written word to answer the question posed. I am sure that if such examinations were elevated to an Ordinary National and Higher National Standard, the failure rate, without support from prolonged study, would rapidly rise. When we consider the thousands employed in this industry who profess to be surveyors, the figure of 328 appears to be very insignificant.

The urgency of qualifications has been highlighted by the insistence of the B.C.D.A. and the B.W.P.A. to rule that a percentage of surveyors must be qualified in each firm engaged in *in-situ* treatments within a specified period.

Added to this, the Control of Substances Hazardous to Health Act, Consumer Protection Act, Health and Safety at Work Act are all to be communicated to contractors in some form. The B.C.D.A. aid their Members by holding regional meetings at which these subjects can be discussed. They have within their membership, associate firms who specialise in the formulation of in-house schemes such as manuals for Training, Health and Safety, Employment Liabilities.

Two National one-day Seminars and several Regional Seminars have been organised within the last six years to advance the need for education. In my opinion, more needs to be achieved in this area of communication; particularly to the specifiers. The consumer should not be encouraged to Do-it-himself and provide fodder to the environmentalist.

Finally on this subject, there is disappointment in store for the future as funding for training by the Government is now being targetted to business enterprise projects no doubt to create more competition. This does not auger well for the programme of legislation now imposed on our trade.

GUARANTEES

Sir Gordon Borrie as Director General of the Office of Fair Trading has made it clear in statements to the press and in publications issued by his department that any guarantee issued should be properly insured and appealed to the insurance market to do so.

He was not, in my opinion alluding to the 30 year statements made by most contractors in this industry. Usually long term guarantees or warranties are only available by the payment of a premium to grant an extension of a short term guarantee normally of one year for the Sale of Goods. Why this crazy system of Sales gimmickry persists I have failed to discover. Somebody told me a short while ago that he offers a long term guarantee but if the customer does ask for it he said I don't give it.

So many have proved to be useless pieces of paper I am sure that legislation will eventually appear on the Statute book to control indiscriminate issue of documents without proper insurance, perhaps, by amending the Consumer Credit Act or even the Trades Description Act although this is opposed by the Restrictive Trade Practices Act.

In conclusion I must allude to the general opinion within the B.C.D.A. that membership of the Association should be expanded to include all firms who profess to trade in dampcoursing of existing buildings. This would include a multitude of small contractors and a small number of formulators. It is said that this is the only way to exercise complete control, educate and train, provide finance and statistically impress the public, the specifiers and government departments.

Certainly the B.C.D.A. and the B.W.P.A. jointly would require a complete overhaul of their organisations to cope with the situation. The opinion is often expressed that standards would be lowered by such actions. Much more publicity can be gained by displaying a strong body which is ready to reject the worst elements, eliminate the 30 year guarantee, influence the insurance underwriting fraternity, create an in-house quality assurance shceme, provide data on marketing and management, have an inspectorate worthy of respect, create regional organisations to deal with local issues and to command respect in those localities.

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DISCUSSION ON PAPER 7

Chairman: C. H. M. Marsh

THE CHAIRMAN: Ladies and Gentlemen, the Deputy President, who is all-powerful, as we all know, has instructed me to finish early because he feels we ought to have an oxygen break a little earlier. So we will keep the questions going for a few minutes but I would think we would all be agreeable to a breath of fresh air before the next and final talk. Would you kindly let us know your name and designation before you ask your question. The floor is open and Charles is quite happy to answer your questions, unless they are difficult!

MR. A. J. BUIJS (Flexichemie): Nowadays we do not hear very much about the electro-osmosis systems in damp-proofing. I suggest that this method was not wholly successful. Is that right?

MR. JONES: As a chemical dampcourse association we have disassociated ourselves from that particular problem. As far as Agrement Board certification is concerned, it has not been obtained in this country. What will happen in the future, when perhaps a merger occurs and we embrace all damp-proofing systems, we will probably encourage the electro-osmosis people to come in and tell us all about themselves. Certainly, it would be welcome because we have many enquiries from people wanting to have their equipment changed or improved or just general enquiries about where they can find a source of supply. I only know of one in this country at the moment. Does that answer your question?

MR. BUIJS: Thank you.

MR. D. A. FREEMAN (Guarantee Protection Trust): I appreciated very much what Charles said about standards in industry, but I was sorry that he finished on a rather despairing note on the question of guarantees and insurance. He quoted Sir Gordon Borrie, and I think I got it right, as having invited the insurance industry to get behind long term guarantees and back up those that were respectable. He then went on to speak as though we were seven years in the past. Six years ago the Guarantee Protection Trust was founded. Its first guest at its first meeting was Sir Gordon Borrie, on which occasion he commended the insurance cover given to long term guarantees for registration by the G.P.T. That progress is being made.

It is made more difficult, and I would like to know what Charles thinks about this aspect of things, by confusion in the public mind between insurance back-up and manufacturers' endorsements. That confusion, I think, bedevils the situation. We must all work to clarify the difference in the public mind over the next few years.

MR. JONES: David, thank you for mentioning that. It is a problem that the industry has. I tried to explain that the industry, as we know it in membership, is extremely small, and your service, to a lot of small contractors, covers that particular area. But we have to appreciate that there are probably a thousand other firms who are not insured to the same degree as you insure, plus the fact we do have national companies supporting their own insurance schemes. However, fundamentally I was talking about Sir Gordon Borrie who, through his Department, has had disappointments for a lot of people where their guarantees had been found to be completely worthless, with no insurance whatsoever. It is true to say that many of these companies are under-insured all the time, and many of our members are not insured against their problems to the degree that the insurance market would desire. So therefore the insurance underwriters would be in the same position as ourselves, of saying, "If you all came in, if you were all insured, then the problem would not arise." Does that, to some degree, answer your question?

MR. FREEMAN: Yes.

MR. J. BRICKNELL (Consultant): Charles, thank you for your paper. It is nice to have a revision of what we have done in the past. We can, of course, look back. You made reference, to a degree, to the need for training, and obviously I support you. I am going to ask a question which I do not think you can answer but I should really like to use this as a platform to report a problem. By the end of this year we hope that both Associations will have merged. Both Associations support examinations. The B.W.P.A.'s is through the Institute of Wood Science and the B.C.D.A.'s is through themselves. We do not want any hiccups; we do not want any less training to take place. Has it been agreed what will happen about these examinations between the two Associations? If not, and I suggest it may not have been, can we press, before even the merger takes place, for a clear run-on, so that we do not, in fact, get any less training but, in fact, we get more.

MR. JONES: I should like to say that John is very much involved in our examinations and in the B.W.P.A. examinations and he knows the problems which have arisen. In my opinion we have improved our examinations as the years have gone on. What we need to do is to make quite sure that the training, which I think John is indicating, is in line with what we require for the industry. The examinations, as far as I am concerned, ought to continue and will continue while this pressure is being applied to have all surveyors qualified. I can say this quite candidly, that there are something like 50 candidates coming up for examination next week. We have already examined 60 in March, and the programme is already formed for another examination in the Autumn, whether we merge or not.

The whole thing has to move forward if training is going to be completed, certainly in health and safety, and many other aspects. I feel that the industry has before it the need to achieve much more than it has done so far. Does that back up what you are saying, John?

MR. J. BRICKNELL: Yes.

MR. JONES: If you want to make a further point, please do.

MR. J. BRICKNELL: It is just that if we have one Association are we going to move forward and have one examination in two parts. Who is going to be the examining body for the B.C.D.A. examinations because the B.W.P.A. have already said they do not see themselves as an examining body. Will the Institute of Wood Science do theirs?

MR. JONES: Well, the official reporter is recording that and I would be delighted if it comes out on the record and the new Association will no doubt put it into being.

THE CHAIRMAN: Thank you, John. I am sure it is slightly beyond Charle's brief, but the point is well made and I am sure we are in sympathy with your sentiments.

MR. H. F. SALTER (Protim Services): Charles, in the timber remedial industry in the last two years or so we have seen a lot of changes. All of us, or most of us, are using a new generation, may I call it, of chemicals. We are being urged to use single purpose products rather than dual purpose products; we are being urged only to treat where there is something wrong rather than where something may go wrong in 20 years' time. Using your crystal ball, can you foresee changes of a similar nature happening within the B.D.C.A. and, if so, what do you think they might be.

MR. JONES: It is already, quite frankly, happening because quite a number of the complaints that we receive are on the problem of the use of solvents, and with party walls in terraced properties or semi-detached properties, where grants are being made to consumers for improvements, we have had complaints about the smell. Some local authorites, I am well aware, are now encouraging the use of non-solvent products: the siliconates and the cementitious slurries in certain places, where there is no problem of smell afterwards. But as far as chemicals are concerned, the dampcoursing industry does not have this problem as much as the wood preservation industry because the active ingredients are fairly innocuous in that sense. The only problem which you might have is when you are mixing concentrated siliconates which are quite corrosive and can create problems. We still insist on contractors, when they are inspected, having the necessary safety devices on hand despite that.

THE CHAIRMAN: I think we have time for one more question before the oxygen falls. *(No response)* That normally prevents anyone asking any more questions! It is very hot and sticky, and I do sympathise.

It is, as you have gathered, a very appropriate time to have the Director from our sister Association giving us a talk on the achievements that he has led, helped, of course, by many committees over the past years. You have seen from his paper some of the real inroads that the Association has made. Hopefully the merger will take place. It has dragged on a long time and I would compliment you, Sir, on the way that you have handled the Association in what must have been quite unsettling times for you and your staff, to keep your heads held high. You have done a remarkable job. When I was President of the Association I had a sense of great relief knowing that Charles was there helping, or not helping to run but actually running the Association. I thank you very much indeed for presenting a very useful update at such an appropriate moment, just as the two Associations, hopefully – hopefully – will merge. Ladies and gentlemen, will you join me in thanking Charles for an excellent presentation. *(Applause)*.

REMEDIAL (IN-SITU) TIMBER TREATMENT: A STUDY OF OPERATOR AND POST-TREATMENT EXPOSURE

by G. McCutcheon, *H.M. Principal Specialist Inspector*
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Introduction

The Agency Agreement under which the Health and Safety Commission agreed to perform functions under Part III of the Food and Environment Protection Act 1985 (F.E.P.A.) has been in operation since June 27, 1987. Even before then, however, the Health and Safety Executive (H.S.E.) has been involved both with the clearance of pesticides under the "old" Pesticide Safety Precaution Scheme (P.S.P.S.) and the protection of workers using pesticides at work, and of others who might be affected by such work.

Active ingredients destined for use as wood preservatives undergo a stringent evaluation of their hazardous effects. Pragmatism has been the essential tool used to determine the risk to workers and others with little real exposure information available until the mid 1970's when information started to become available on exposure to workers and others during and after treatment.

With an estimated 100,000 to 150,000 remedial treatments per annum using over 40 different active ingredients (and hundreds of formulations) it is hardly surprising that concern has been expressed about the possible harmful effects of such remedial treatment. It should also come as no surprise that accusations of ill-health directly attributable to exposure to substances used for remedial treatment have so been made. Whether the effects cited are the result of exposure to formulations used for treatment or arise out of chance is a matter under constant debate.

Given H.S.E.'s role in evaluating pesticides under consideration for approval or review, its enforcement role under F.E.P.A./Co.P.R. and H.S.W. Act, the lack of comprehensive exposure data and increasing public awareness of the use of pesticides and possible harmful effects, it was proposed that a study be made of operator and post-treatment exposure. This paper summarises the findings of the study carried out in 1987/88.

Objectives

1. To determine airborne and dermal exposure of operators to pesticides used in remedial treatment of timber.
2. To acquire first-hand experience of operational procedures, systems of work and precautions used in such work.
3. To investigate air contamination by pesticides during and after remedial treatment.

Scope

Professional remedial (in-situ) treatment using spray application was investigated. Industrial pre-treatment and D.I.Y. activities were not included.

The British Wood Preserving Association (B.W.P.A.) and the Nationwide Association of Preserving Specialists (N.A.P.S.) were each approached and their co-operation sought. Each organisation nominated 12 companies offering remedial treatment services, from which a total of 12 were selected for visits. Arrangements for visits were made with each company individually and for practical reasons the visits were limited to London, the South East, South and East Anglia.

The companies visited ranged from a single man operation to a contractor operating 5-10 teams each comprising two men.

All the properties treated were private dwellings, some undergoing complete renovation and therefore unoccupied, and others where more minor work was being undertaken which remained occupied. Table 1 lists details.

Work Pattern

Although 12 different contractors were involved in the study, the work pattern remained fairly constant. The operations involved in a typical operation are outlined below.

(1) Inspection of premises to determine the nature of the problem and the nature and degree of treatment needed.
(2) Preparatory work e.g. lifting of floor boards, removal of severely affected timber, some pre-cleaning, fitting new timber, disconnection of electricity where necessary. This part of the process takes a significant part of the whole time.
(3) Advise house occupants of the precautions needed during and after treatment, post warning notices.
(4) The treatment phase e.g. transfer concentrate to spray tank, dilute to working concentration; apply spray to timber until surface saturated. All spray equipment seen was air pressurised by hand pumping or use of electric or petrol operated pump.
(5) Replace floorboards, reconnect electricity and generally make good.

The typical treatment job requires most time to be spent on preparatory work; in the operations studied, application of spray took from 7 to 110 min., usually about 40 to 50 min.

Personal Protection

The standard of personal protection used by the workers seen during the study was reasonably uniform.

(1) Overalls – cotton polyester overalls were worn by workers at all the sites visited. The standard of cleanliness was variable.
(2) Eye protection – eye protection (either goggles or visor) was worn by operators at 6 of the 12 sites visited.
(3) Gloves – gloves or gauntlets (P.V.C. or rubber) were used by operators at all but one of the sites.
(4) Footwear – safety footwear was worn by workers at nine of the sites visited. At the other three sites, lightweight 'trainers' were worn.
(5) Respiratory protection – all but one of the companies involved in the study supplied ori-nasal half mask respiration with dust/fume cartridge (to B.S. 2091) to their workforce. The other company supplied disposable filtering face masks.

Evaluation of Operator Exposure

Exposure of operators to pesticides during remedial treatment arises from:

inhalation of contaminated air;
ingestion of deposited material;
and absorption of material through the skin.

The use of effective protective clothing and good personal hygiene before eating, drinking or smoking reduces to a minimum the contribution of ingested material. The provision and use of protective clothing and washing facilities will be discussed later; no measurement of material available for ingestion was attempted (but see later).

The degree of contamination of the workplace air was determined by a combination of personal and static, background samplers.

For formulations containing Lindane, operators wore Rotheroe and Mitchell C500 pumps set to draw air through standard Tenax tubes at a rate of 100-400 ml/min. dependent on expected exposure duration. Where permethrin was in use, samples were collected on large Tenax tubes at a flow rate of 1 l/min.; some were also collected on standard Tenax tubes at 100 ml/min. Background samples were obtained using a similar set-up.

Fungicides were sampled using the same equipment, although problems were subsequently encountered with the analysis of these (see later).

To evaluate the deposition of pesticide onto and through protective clothing, operators were asked to wear paper disposable overalls (with hood) underneath their own overalls. At the end of the sample period, the paper overalls were retrieved and cut into the following sections:

- Right arm
- Left arm
- Right leg
- Left leg
- Torso
- Head (hood).

This procedure was adopted to obtain information on the degree of penetration of pesticides through the normal coverall worn for this work.

Swab samples were obtained from operators immediately after spraying was completed. Samples were taken from the hands, face/neck and from the interior of any respirator used, using cotton gauze damped with surgical spirit.

Evaluation of Post-Treatment Airborne Pesticide Concentrations

Seven of the premises in which operator exposure during treatment had been evaluated were re-visited at intervals over a period of about 6 months after treatment. Atmospheric samples were obtained in living and/or treated areas.

Samples were taken mostly in triplicate on Tenax tubes at a flowrate of 100-200 l/min. with the sample tubes mounted about 1 m. above floor level. During sampling, windows and doors were kept closed. Room temperatures ranged from 15-22°C.

Analysis of Samples

Lindane and Permethrin were determined by gas chromatography after thermal desorbtion or solvent extraction in the case of the coveralls.

Pentachlorophenol laurate was encountered on one site and an attempt was made to analyse by G.C.; however, the method was insufficiently sensitive to obtain quantitative results.

Similarly, formulations containing boron esters were encountered at three sites but available analytical methods proved too insensitive to permit quantitative analysis.

Results

The results are set out in the following tables:

	Table Number
Description of Treated Property	1
Nature and Extent of Treatment	2
Airborne Exposure: Permethrin	3
Airborne Exposure: Lindane	4
Penetration of Protective Clothing: Permethrin	5
Distribution of Coverall: Permethrin	6
Penetration of Protective Clothing: Lindane	7
Distribution of Coverall: Lindane	8
Swab Samples: Permethrin	9
Swab Samples: Lindane	10
Atmospheric Concentrations Following Treatment: Permethrin	11
Atmospheric Concentrations Following Treatment: Lindane	12

Discussion

Industry Sample

The intention of this study was to obtain a cross-sectional view of operating conditions and exposure levels in this industry sector. Although relatively large numbers of firms are members of one or other of the trade bodies approached (B.W.P.A. and N.A.P.S.), it has been suggested that these bodies represent a minority of companies or individuals who offer remedial timber treatment services. The small scale of the study (12 companies studied) and the fact that the list of companies from which the firms were selected for study, comprised "volunteers" raises the question of bias in the group studied. An additional factor which needs to be considered is the effect of the presence of H.S.E. personnel on the work pattern of those visited. It is relatively easy for operators to work with special care and at a low work-rate whilst the inspector is present. In addition, H.S.E. had in principle no influence on the choice of properties treated during the study.

However, there is no evidence of any bias and the visiting inspector (one individual was involved with all the sites studied) gained no impression that the operators 'worked to rule' or that particular premises had been selected. Indeed, quite the reverse with several companies bringing forward or holding back jobs to suit the needs of H.S.E.

Exposure Time

The time spent actually applying treatment fluid ranged from 7 to 110 mins., averaging 40 to 50 mins. Discussion with the operators engaged on the work indicated that each team or individual carried out only two to four timber treatments per month. Whether this is wholly typical of the industry is not known but does seem rather a low number of jobs per team.

Personal Protection

The nature of the work places a heavy dependence upon the use of personal protective equipment for operator protection. The personal protection used by operators has already been stated viz. cotton/polyester or polypropylene coveralls, (12/12), gloves/gauntlet (11/12), goggles/visor (6/12), head protection (5/12), safety footwear (9/12). Respirators protection fitted with dust/fume cartridge(s) to B.S. 2091 was worn by workers at all but one site; at the other site, the company supplied and operators used disposable filtering face masks. The following observations were made regarding the protective equipment provided.

Coveralls. The standard of cleanliness was variable; most were soiled on the outside but appeared clean on the inside. Only one company supplied operators with sufficient sets of clothing to allow fresh coveralls to be used each work day (five sets issued). However, in every case, the employee was responsible for laundering. Whether an allowance was paid to employees for the laundering of coveralls was not determined but it seems clear that the most likely route used would be to include coveralls as part of the domestic wash. This study clearly demonstrates the extent to which clothing (protective and otherwise) becomes contaminated; inclusion of such contaminated clothing with other clothing for washing may simply transfer contamination to the clothing of the family. Whether normal detergent/water washing is an effective way of removing pesticide contamination from clothing is questionable, particularly for solvent based formulations. The ease with which pesticide spray penetrates the current standard coverall raises doubts about the use of such clothing for long term protection. At a minimum fresh, clean coveralls are needed each work day with spare sets to change into as soon as liquid penetrates through to the inside. The increasing range of cost-effective disposable clothing offers an alternative to re-usable clothing, which should not be laundered with domestic laundry; arrangements for specialist laundering/dry cleaning are needed.

Gloves/gauntlets. A high standard of hand protection is needed, particularly when handling solvent-based concentrates or ready for use products. No gloves were worn at Site 2; swabs of the operator's hands showed contamination levels not greatly above that found at most other sites where gloves were worn. Indeed, much higher levels of hand contamination were found at other sites (Sites 1 and 5 in particular). How can this be explained? Some care is needed to select glove materials which are effective barriers to the passage of pesticide and other materials. Even so, for most glove materials/pesticides protection against penetration is finite and a time comes when material does break through. However a more likely cause of contamination of the inside of a glove (and the hand it protects) is direct transfer of material to the inside either by liquid running down the sleeve and into the cuff, or by poor technique in taking the glove off. Some care is needed in the selection of gloves appropriate for the job and product used; training is necessary to ensure operators get maximum effectiveness from the use of gloves. Procedures for cleaning gloves, inside and out are essential (unlined gloves may be better than lined for ease of cleaning. If linings are essential, then an inner cotton glove may be used). Whatever material is selected, gloves will have a finite life-time and will therefore need to be changed regularly, before the glove breaks down mechanically e.g. by cracking or pin-holing, or is penetrated.

Eye Protection. Disappointingly, only 50 per cent of the sites studied used goggles or a visor when handling concentrate or applying spray. In most cases, this was a contravention of the approval conditions. Eye protection serves two functions; firstly to protect the eye from the acute effects caused by splashes of concentrate and secondly to minimise absorption of materials either as concentrate or when diluted. A full face visor is likely to be the most acceptable and effective method of eye and face protection.

Head Protection. Operators at less than half the sites visited used hard-hat head protection; operators at other sites used hooded coveralls or cloth caps. Hard-hats offer advantages in the degree of protection against bumps and knocks and in addition are easily decontaminated. The comments made about coveralls apply equally to hoods; cloth caps offer little protection and large areas of the back and side of the head are unprotected. In addition, they are unlikely to be laundered regularly and could become sources of exposure long after treatment has been completed.

The results of the paper coverall sampling show that in some circumstances, the head may become grossly contaminated and requires effective means of protection. A hooded coverall (re-usable or disposable) where necessary combined with a lightweight hard-hat offers a suitable standard of head protection.

Total penetration through protective clothing ranged from 80 µg to over 7000 µg. The likely explanation of this wide variation is a combination of the nature of the work undertaken (restricted/open areas, low/high level spraying) and personal operating practice.

Applied volume and the duration of the work are both important factors but clearly comparisons of the results from Sites 1 and 6 demonstrate that local conditions and work practice are more important in determining the degree of whole body exposure. The distribution of material penetrating protective clothing is much as might be expected; the head and legs are most at risk.

Swab samples from operators hands also show wide variation, not obviously linked to volume applied, duration of exposure, or degree of atmospheric exposure. In particular, the assistant at Site 1 had almost as much contamination on his hands (600 µg) as had penetrated his protective clothing (900 µg).

Lindane

Generally, higher concentrations of Lindane in air were found compared to results for permethrin. Personal airborne exposure ranged from 19 µg/m^3 up to 640 µg/m^3, measured for the duration of the spraying. This compares with occupational exposure limits of 500 µg/m^3 8hr. T.W.A. and 150 µg/m^3 10 min. T.W.A. Airborne exposure is clearly significant and depending on the nature and duration of the work, could exceed exposure limits. If the effect on airborne concentration of active ingredient observed with White Spirit formulation (Table 3, site 4), was repeated for Lindane/White Spirit, operators exposure would easily exceed exposure limits.

Total penetration through protective clothing was also somewhat greater with Lindane, ranging from 1000 µg to 9500 µg. The somewhat unusual distribution of penetrating Lindane found at Site 9 is explained by the confined nature of the work site (a low cellar, partly obstructed with rubble). This site also provided the only measured exposure to T.B.T.O. which exceeded the occupational exposure limit. Concentrations of 124 p.p.m. (personal), 13 p.p.m. (background in treated kitchen) and 54 p.p.m., 52 p.p.m. and 65 p.p.m. (in untreated hall) were also measured. The occupational exposure limits for White Spirit is 100 p.p.m. 8 hr. T.W.A. and 125 p.p.m. 10 min. T.W.A. Spraying took only a few minutes (at floor level) but created a considerable vapour/aerosol cloud which engulfed the operator and spread to untreated areas rapidly.

Footwear. Operators at a large number of the sites studied (9 of 12) used some form of safety footwear. The nature of the work creates conditions where impervious footwear is essential; how effective safety footwear is in preventing penetration of pesticide is unknown, but once material has been absorbed into e.g. leather, it is likely to be extremely difficult to decontaminate. Clearly, all forms of lightweight "trainers" with breathable uppers, ventilation holes, etc. offer little protection. The use of such footwear by spray operators should be discouraged. Impervious safety footwear capable of being easily and readily decontaminated should be used.

Respiratory Protective Equipment (R.P.E.). Operators at each site studied used some form of R.P.E.; only one site used equipment which was considered inappropriate, namely a disposable filtering face mask intended for limited protection against low toxicity dust. Although other sites used equipment manufctured to B.S. 2091, the cleanliness of the equipment and standard of maintenance were generally poor. Some respirators seen were dirty to the point of being unhygienic; another (a relatively clean example) had a faulty exhalation value. In addition, the manner of use by some operators was perfunctory; one operator held his respirator in place by hand whilst spraying with the other; another was heavily bearded, reducing the effectiveness of the device very greatly. The swab samples taken from inside the R.P.E. clearly show that contamination of the equipment is common, most likely because of poor storage when not in use e.g. by direct deposition of spray mist onto the inner surface.

The highest level of airborne exposure found marginally exceeded the occupational exposure standards for Lindane and T.B.T.O. (Site 9). In such cases, a properly maintained half mask respirator fitted with an appropriate dust/fume cartridge and properly worn, provides some margin of safety. However, where longer periods of spraying are used, particularly in areas having restricted ventilation, a higher standard of R.P.E. may be needed.

Operator Exposure

Permethrin

Five sites using emulsion concentrates dispersed in water gave results ranging from 12 to 131 μg/m³; one site used a ready-for-use product in White Spirit produced a single result of 447 μg/m³ – background levels were also somewhat elevated (see later). No occupational exposure limit has been set for Permethrin.

Post Treatment Exposure
Two sites where Permethrin had been used were re-visited up to 42 days after treatment (Table 11). Airborne concentrations appeared to fall rapidly immediately following treatment, although at Site 1, two samples taken nine days after treatment gave results similar to that found on the day of treatment.

Lindane was used at the other five sites and resulted in much higher airborne concentrations on the day of treatment and subsequently compared to the Permethrin treated sites. After more than 100 days following Lindane treatment, airborne concentrations of 10-20 μg/m³ were found in treated areas. Ambient temperatures may have played a part in the concentrations measured, treatment having taken place in late winter and the final monitoring in the summer. No information was collected on ambient temperatures during monitoring.

The results for Lindane was very similar to that reported to others (Dobbs, *et al* 1979, Dobbs and Williams 1983, and Coggins and Lothian 1979).

TABLE 1

Site	*Description of Treated Property*
1	Open barn under conversion.
2	Detached house, including roof space.
3	Large bungalow, floors only.
4	Small flat.
5	Large semi-detached house. Boarded roof space.
6	Small semi-detached cottage. Very restricted roof space. Underside of upper floor sprayed from below (down stairs ceilings removed).
7	Semi-detached house. Ground floor only treated.
8	Small semi-detached house, including roof space.
9	Terraced house, cellar treated.
10	Semi-detached house.
11	Detached house, roof space only treated.
12	Large ground floor flat.

TABLE 2
Nature and extent of treatment

Site	*Active ingredient (nominal concentration)*	*Spray Time (min.)*	*Area Sprayed (m^2) (Enclosed vol. m^3)*	*Vol. Used (l)*
1	Permethrin (0·2%)	65	236 (310)	67·5
2	Permethrin (0·2%)	45	294 (256)	67·5
3	Permethrin (0·3%)	68	154 (189)	39
4*	Permethrin (0·2%)	7	6 (12)	7
5	Permethrin Loft (0·2%) Rest of House	60 95	98 (17) 152 (230)	205
6	Permethrin (0·26%)	90	180 (153)	58
7	Lindane (0·64%)	25	78 (92)	25
8	Lindane (0·5%)	110	95 (140)	50
9	Lindane (0·6%)	14	70 (94)	10
10	Lindane (0·5%)	50	290 (247)	70
11	Lindane (0·6%)	60	135 (65)	35
12	Lindane (0·6%)	40	145 (208)	68

*White Spirit based formulation.
All others emulsion concentrates.

TABLE 3
Airborne exposure: Permethrin

Site	*Operator*	*Personal Exposure (μg/m³)*
1	Sprayer Assistant	12 22
2	Sprayer	29
3	Sprayer	44
4*	Sprayer	447
5	Sprayer (In roof space) (Rest of house)	73 97
6	Sprayer Assistant	44 131

*White Spirit based
Occupational Exposure Limit (EH40/88)
Permethrin None specified.

TABLE 4
Airborne exposure: Lindane

Site	*Operator*	*Personal Exposure (μg/m³)*
7	Sprayer Assistant	33·5 30·3
8	Sprayer	18·7
9	Sprayer (T.B.T.O. in formulation – close to sprayer)	586 249
10	Sprayer	247
11	Sprayer Assistant	425 245
12	Sprayer	640

Occupational Exposure Limits (EH40/88)
Lindane 500 μg/m³ 8 hour TWA 1500 μg/m³ 10 min. TWA
T.B.T.O. 100 μg/m³ 8 hour TWA 200 μg/m³ 10 min. TWA (as Tin).

TABLE 5
Penetration of protective clothing: Permethrin

Site	*Operator*	*Total Penetration (μg)*
1	Sprayer	236
	Assistant	932
2	Sprayer	1268
3	Sprayer	683
4*	Sprayer	80
5	Sprayer	4595
6	Sprayer	7321
	Assistant	5309

TABLE 6
Distribution of coverall: Permethrin

Site	*Operator*	*Hood*	*Distribution (μg)*		*Legs*
			Torso	*Arms*	
1	Sprayer	48	33	65	90
	Assistant	710	116	65	129
2	Sprayer	649	178	129	312
3	Sprayer	99	147	36	401
4*	Sprayer	9	35	18	18
5	Sprayer	222	791	925	2657>
6	Sprayer	2140	646	878	3657>
	Assistant	2465	693	318	3833>

TABLE 7
Penetration of protective clothing: Lindane

Site	*Operator*	*Total Penetration (μg)*
7	Sprayer	3703
	Assistant	3238
8	Sprayer	1435
9	Sprayer	9460
	Assistant	1249
10	Sprayer	6725
11	Sprayer	2404
	Assistant	1282
12	Sprayer	935

TABLE 8
Distribution of coverall: Lindane

Site	*Operator*	*Hood*	*Distribution (μg)*		*Legs*
			Torso	*Arms*	
7	Sprayer	62	587	722	2232
	Assistant	515	530	393	1800
8	Sprayer	217	60	131	1023
9	Sprayer	233	4330	1074	3824
	Assistant	44	219	115	871
10	Sprayer	80	2250	1670	2725
11	Sprayer	530	510	220	1144
	Assistant	228	399	240	415
12	Sprayer	145	242	73	475

TABLE 9
Swab samples: Permethrin

Site	*Operator*	*Hands (μg)*	*Face/Neck (μg)*	*Inside Respirator (μg)*
1	Sprayer	99	2	6
	Assistant	604	17	41
2	Sprayer	58·7	2·9	–
3	Sprayer	8·4	[Bearded – not taken]	
4*	Sprayer	14	1	10
5	Sprayer	167	36	26
6	Sprayer	40	171	20
	Assistant	54	110	44

TABLE 10
Swab samples: Lindane

Site	*Operator*	*Hands (μg)*	*Face/Neck (μg)*	*Inside Respirator (μg)*
7	Sprayer	25·3	37·6	2·9
	Assistant	14·8	8·3	0·6
8	Sprayer	41	27	6
9	Sprayer	–	10·7	–
	Assistant	–	11·0	–
10	Sprayer	58	15	41
11	Sprayer	93	37	28
	Assistant	33	14	64
12	Sprayer	55	23	22

TABLE 11
Atmospheric concentrations following treatment: Permethrin

Site	*Location of samples*	*Conc. during spraying* ($\mu g/m^3$ *date of treatment)*	*Time after treatment measures concentrations* ($\mu g/m^3$)				
			2 Hour	*24 Hour*	*9 Days*		*42 Days*
1	Converted Barn	0 5	5 10 32	6·4 6·4 6·4	0 0 6 4		6 Samples All zero.
			2 Hour	*48 Hour*		*14 Days*	
2	Bedroom	22	<1 <1 <1	<1 <1 <1		0 5 2	

TABLE 12
Atmospheric concentrations following treatment: Lindane

Site	*Location of samples*	*Conc. during spraying* ($\mu g/m^3$ *date of treatment)*	*Time after treatment measured concentrations* ($\mu g/m^3$)					
							28 Days	*126 Days*
7	Kitchen/ Dining Area	31 28·8 25·3 (29-03-88)					7·3 7·7 8·2	21 18 14
					7 Days		*35 Days*	*112 Days*
8	Landing	6·7 (22-03-88)			10·5 12·9 8·9		6·3 8·5 7·0	8·4 7·8 7·7
			2 Hour	*24 Hour*		*13 Days*	*35 Days*	*181 Days*
9	Cellar	663	72, 41, 47	54, 48, 34		37, 48, 26	26, 25	9·5, 12·6, 12·2
	Living Room	– (18-02-88)	3, 1·5	5, 4·3, 4·4		7, 4, 6	2	0·7, 0·6, 0·6
			2 Hour	*48 Hour*		*18 Days*	*37 Days*	
10	Landing (21-03-88)	49	9, 11, 10	35, 31, 39		8, 7·2, 9·2	8·9, 9·3, 9·5	
								162 Days
12	Front Room Hall Back Room	500 280 (11-03-88)						9·4 8·7 6·9

CONCLUSIONS

1. Operators exposure to airborne pesticide active ingredients used in emulsion concentrates or ready-for-use formulations in White Spirit may approach or exceed occupational exposure limits.
2. Despite the use of recommended personal protective equipment, the potential for dermal exposure is significant and contributes substantially to total exposure and hence potential absorbed dose.
3. Improvements are needed in the provision and use of suitable personal protective equipment used by remedial treatment operators. Improvements are also needed in the level of training of operators and their supervisors to ensure work procedures are used which minimise potential exposure. The provision of an adequate number of sets of protective equipment and arrangements for laundering contaminated clothing also require attention.
4. The extent and duration of post treatment exposure to pesticide active ingredients and Lindane in particular has been confirmed. Measurable levels of active ingredients remain in treated areas for many weeks after application and there is some evidence of contamination of untreated areas, albeit at much lower concentrations.

This exercise although limited in scope has demonstrated that remedial in-situ treatments can give rise to occupational and para-occupational exposure to pesticide active ingredients. The guidance contained in H.S.E. Guidance Note G.S.46 if fully implemented, will reduce potential exposure to a minimum, and the advice regarding the supply and laundering of protective clothing should be followed.

More information is needed on variation in total exposure with site conditions, formulations (particularly, solvent based ready-for-use products) and application technique (including spray nozzle size and application pressure).

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DISCUSSION ON PAPER 8

Chairman: P. D. North

THE CHAIRMAN: George has said, with the sound of hope in his voice, "Do we have much time for questions". I think we probably have a few minutes. Before questions are asked, I would like to make an observation on this question of dermal contamination, which I know worries a lot of us. My own staff are equipped with cotton overalls because a more impermeable overall is really impracticable, particularly in the summer. The temperatures, as you probably know, in some roof vaults in summer are well over 100°F. In fact, very regularly our staff are entirely naked underneath their overalls. This presents an arresting sight, I can assure you! If they are now going to have to wear something impermeable, then I think we are going to get very, very serious problems because we have discovered just in this room how hot it can be. If we are going to have to work in temperatures much higher than this, it is going to be impossible. That is just an observation because I had hoped that perhaps you were going to make some recommendations to us as to clothing.

MR MCCUTCHEON: Could I respond to those observations by linking the observations with some comments I made about the laundering of re-usable clothing. I see that there is a link here, because there are problems with effective laundering of re-usable clothing. There are also clearly difficulties with the permeability of traditional materials used for protective clothing, and I wonder, in fact, whether the answer to both problems is to move towards disposable clothing, of which there is a wide variety available now, which is lightweight and which offers a high degree of penetration resistance, and which, of course, avoids the difficulty of laundering.

THE CHAIRMAN: Does anybody want to take that or any other matters up?

MR A. G. WILKIE (Consultant): I wondered whether when you were doing the sampling exercise you inverted the sampling heads or shrouded them to try to minimise the aerosol fallout. Was that possible, because differences in the characteristics of the spray equipment would perhaps go some way to explaining some of the huge differences you had, for example, between Site 7 and Site 9, both of which were of comparable size and comparable amounts of fluid were used. I accept that you would be interested in the total amount of contaminant in the air, but equally one would expect quite a lot of fairly heavy fallout from the overspilling.

MR MCCUTCHEON: Yes, it is a problem that you have identified. It is a more severe problem with an open filter holder to sample particulate material. In this case we were using very narrow tubes which were pointing downwards, with the opening to the tube at the base, in which case deposition of aerosol into the open end of the tube was very unlikely. But the direct answer to your question is "No", the sampling equipment was not shrouded, but I do not think, in fact, that that was a significant factor in the results that we obtained.

DR. COGGINS (Rentokil): I have a question and two comments, if you will indulge me. I think I have just picked up the answer to my quesiton from what you have just said, but your Tables 4 and 5, George, are called "Airborne Exposure". I think what they are actually is air levels adjacent to the operator – is that right – because if they are wearing R.P.E. it does not necessarily follow that these levels will be their actual exposure.

MR MCCUTCHEON: If you accept that the R.P.E. was actually effective in preventing exposure, then what you have said is correct. What I did not have time to actually go into was the cavalier way in which R.P.E. was maintained and worn by the bulk of the operators that we saw.

DR COGGINS: I am not trying to minimise whatever may be interpreted from these figures. I am simply trying to understand what they are actually. I was surprised that you felt unable to comment on the significance of the atmospheric concentrations, particularly as far as Lindane is concerned, because in a previous B.R.E. paper acceptable air concentrations were derived from WHO acceptable daily intake figures, and I am pretty certain that the figure that was arrived at was quite a bit higher than these figures you have after seven and 13 days.

MR MCCUTCHEON: Yes. You are referring to the air concentrations post-treatment?

DR COGGINS: Yes.

MR MCCUTCHEON: I am uncertain that the method of calculating an acceptable airborne concentration using the WHO acceptable daily intake figures is actually fully justified or can be satisfactorily explained. It is a way of deriving an environmental exposure level – I accept that – but it may not, in fact, be fully justified.

DR COGGINS: Finally, in the context of your comment that as an industry we need to go a lot further in terms of training and education, may I just make the point that we do have a Training Committee in the B.W.P.A. which is trying to pull together, as quickly as possible, training standards for its members which will obviously address the sort of issues you have raised here.

MR C. H. M. MARSH (Peter Cox): Following on very much from what has just been said, I think you said that those are representatives of N.A.P.S. and this Association and therefore they tend to represent, hopefully, the *bona fide* part of the industry. Yet you have uncovered an awful lot of "worry beads" if you like. Do you, therefore, favour some form of compulsory registration for those people who are operatives and operators in order to minimise these sorts of things which could get well out of hand.

MR MCCUTCHEON: The way I would escape from that question *(laughter)* is by saying that really that is a policy matter, which is better addressed by others in H.S.E.

THE CHAIRMAN: Very good.

DR L. D. A. SAUNDERS (Fosroc Ltd.): George, thank you for your paper. Whenever anyone presents a comprehensive compilation of information like this there is always some smart Alec who says, "Would it not have been better if you had done so and so." I would try and shy away from doing that, but you did refer to doing further work. Can I suggest that in your further work you look at the difference between organic solvent formulations and emulsion formulations. I have long had misgivings about emulsion formulations, both on account of their efficacy and on the ground that it is much more difficult to formulate them for permanence. I would be very interested to learn whether the aerial concentrations of Lindane you get after organic solvent treatment are lower than those you get after emulsion treatment. I would just make that comment. Obviously you cannot respond to that because you have not had the opportunity to do the work.

MR MCCUTCHEON: If I could respond by saying that my reference to further work was a plea to this Association to perhaps undertake some further work.

DR SAUNDERS: Following on from that, and given my preference for organic solvent formulations, I was initially disappointed to see that formulation 4, the only organic solvent formulation there, gave you aerial concentrations of up to an order of magnitude higher than all the other formulations, and I was perplexed to see, when you look at the deposition of the coverall and so forth, it was up to one or two forces of magnitude lower than all the other products. Can you throw any light on that apparent anomaly?

MR MCCUTCHEON: Yes. The actual area that was treated was six square meters and seven litres of formulation were used in the treatment of that six square meters, and the actual treatment took a total of seven minutes. I think that what we were actually seeing was the immediate volatilization of the white spirit. It was not actually the deposition of large droplets because it was all applied at floor level. That possibly explains why there was an apparently high airborne concentration but a relatively low rate of deposition on the protective clothing.

MR J. DAVID (Catomance Ltd.): I was disappointed to find that my previous comments some years ago on Miss Dobb's paper referring to "Lindane – Concentrations in Atmosphere" bore no fruit whatsoever. Can I remind you that Lindane is used, and has been used, extensively in moth proofing carpets, and carpet in housing nowadays will contribute to the Lindane background significant figures and long term exposure. If you do not take those into account you cannot really blame the remedial industry for what you find.

MR D. SCOBIE (Personal Member): Over the last 10 years we have tried paper overalls, as George is suggesting. On each occasion, when I was at work, the overalls did not last a day without tears and so on, but more recently we have acquired some rather advanced overalls and there is a gentleman in the room who was given some on behalf of the B.W.P.A. to test. I do not know whether he has anything to say or not about the testing.

MR S. GULLIVER (Surrey Timber): Yes, we did try them and we found that they split very quickly. There were two types, one which was of a heavier material, perhaps P.V.C., and apart from the obvious perspiration problem, we found those to be very good. The other ones, which were lighter and of a more cotton basis, the chemicals seemed to go through them very quickly.

MRSCOBIE: It is difficult to find the ones which are going to work for a particular man.

MR MCCUTCHEON: Could I just comment on the current provision of protective clothing to say, as a matter of urgency, there is a need to look at how protective clothing is provided: the actual provision, in terms of the numbers of overalls which are made available to spray operatives, to ensure that they, at the very minimum, have a fresh set to use at the start of each working day where they are going to be handling spray chemicals and, secondly, that they have a spare set that they can change into as soon as there is any sign of the material penetrating through their protective clothing.

MR SCOBIE: The last company I was with where I was responsible for protective clothing had a nationwide contract with a laundry, and each employee had five overalls per person per week. Employees did not use them, but they were tailor made to fit the individual, they had their names on them and they were designed to be for that type of work. It was quite expensive but it was an answer.

THE CHAIRMAN: We must make this the last question.

MR H. W. HISLOP (Maljon Ltd.): I was rather perturbed to hear the speaker say that our industry needs much more training etc. I agree with that to some extent. We, in our company, over the past 10 years have kept a very strict monitor on our technicians and their medicals, with which the B.W.P.A. have always helped us, and, as Mr Scobie has said, we have used, for the past 10 years, five pairs of overalls per week nationally and the company have had them laundered in that particular way. They do not use them at all times. What you said, I think, latterly bears that out. There are an awful lot of problems occurring in this industry with the cavalier attitude of the men. We can train men and we can give them everything, but if they do not use them, then really it is not a company's fault, is it?

SOME MEMBERS: It is.

MR MCCUTCHEON: Can I make a point there. At the 12 sites which we visited we were unaccompanied by any form of supervisory staff, nor did we actually see any supervisory staff. The companies ranged from the one man firm up to more local firms of a fairly large size with 10 or 15 sets of operators operating at any one point in time. Not once did we see a supervisor.

MR HISLOP: You were on the job for a full day?

MR MCCUTCHEON: Yes.

MR HISLOP: I am surprised.

THE CHAIRMAN: I think we must draw this discusison to a close at this stage because it could clearly go on much longer than our President would like it to. The word "cavalier", that has just been used, is a word that was used by George and I when I was discussing this with him this morning. It is a word that I certainly believe is a good word to use. I have always been astonished at the casual attitude of a lot of my staff to the hazards that they may or may not face, and I recall many years ago, for many years, dry rot fluid was known to possess aphrodisiac qualities. Whether this is going to change now, I really do not know.

Certainly it is a fact that some of us are probably much more responsible in our attitude to our staff than others. Hugh has mentioned one: I know that Peter Cox have reviews. I am not sure that my own staff are sufficiently monitored. But I am pretty sure that those of us who have any access to the paper that has just been presented will probably step up our precautions, and I sincerely hope that we will have a return visit from George. So I hope you will join me now in thanking George for what has been another thought inspiring paper. Thank you very much. *(Applause)*.

CLOSING REMARKS BY THE PRESIDENT

THE PRESIDENT: Ladies and gentlemen, we have had an interesting Convention. We have had a wide range of papers. We started with a paper dealing with the corrosion of metals which is, after all, one of the most important side effects of wood preservation. We finished with listening to the effects of wood preservation on health and safety. That is, without doubt, the most important subject matter. In between we have had a review of joinery treatment over the last 25 years, a review of the activities of the B.C.D.A. and we have heard about progress towards 1992. We have heard the latest views on the treatment of poles and about the latest developments with boron preservatives and with water repellents. Overall a wide range of papers have been presented and discussed and I hope and expect that everybody here found something of interest to them.

This brings me to the close of the 1989 Convention, which I do with the announcement of the date of the 1990 Convention. This will run from Tuesday, July 3rd to July 6th and will be here in Cambridge. Ladies and gentlemen, thank you for your attendance. We have had a good Convention. Let us hope we have a good evening.
(*Applause*).

THE BRITISH WOOD PRESERVING ASSOCIATION
1989 ANNUAL CONVENTION – 4th-7th July

LIST OF DELEGATES AND VISITORS

Total number attending 185

Name	*Company or Organisation*
	A
Adams J. F.	Borax Consolidated Ltd.
Anderson, Dr. D. G.	Hickson World Timber Ltd.
Aston, Dr. D.	Hickson Timber Products Ltd.
Attygalla, M.	State Timber/Sri Lanka
	B
Bailey, Dr. G.	Capcis/UMIST
Baines, Dr. E. F.	Rentokil Ltd.
Baker, J. M.	Building Research Establishment
Barfoot, Ms. C.	T.R.A.D.A.
Barr, A. R. M.	Catomance Ltd.
Battershill, J.	Health & Safety Executive
Baxendale, A.	Cemontone-Beaver Ltd.
Beauford, Dr. W.	Bio-kil Chemicals Ltd.
Belford, Dr. D. S.	Personal member
Belford, Mrs. D. S.	Partner
Birrell, D.	Rentokil Ltd.
Blow, D. P.	Fosroc Ltd.
Borgin, PROF. K. B.	Consultant
Borgin, Mrs. K. B.	Partner
Braithwaite, C.	Hickson Timber Products Ltd.
Bravery, Dr. A. F.	Princes Risborough Laboratory
Brazier, Dr. J. D.	Institute of Wood Science
Bricknell, J. M.	Private Consultant
Brooks, Dr. F. W.	Fosroc Ltd.
Brown, G.	Fosroc Ltd.
Buchan, E. M.	Hon.Treasurer B.W.P.A.
Buchan, Mrs E. M.	Partner
Buckley, D. G.	Protectahome
Buijs, A. J.	Flexchemie b.v.
Burgers, Dr. N.	Western European Institute
Byrne, A. C.	North West Electricity
	C
Calver, B.	Eastern Electricity
Carmo A. Milne, E.	Anglo Portuguesa PQ
Carmo Dr. J. Milne, E.	Anglo Portguesa PQ
Cashman, T.	Rentokil Ltd.
Chalmers, I. M.	Calders & Grandidge Ltd.
Chamberlain, J. A.	Catomance Ltd.
Chapman, R. G.	Schering Chemicals Ltd.
Cheales, N. V.	Rentokil Ltd.
Chiddle, T. C.	Fosroc Ltd.
Chipperfield, P.	AKZO Coating
Clarke, J. M.	Yorkshire Electricity Board
Coggins, Dr. C. R.	Rentokil Ltd.
Connell, M.	Hickson Timber Products Ltd.
Coutts, A.	Rohm and Haas (U.K.) Ltd.
Coyle, P. J.	Protim/Fosroc Ltd.
Cross, J. N.	Capcis/Umist
	D
Davey, R. N.	Cuprinol Ltd.
David, J.	Catomance Ltd.
David, Mrs. J.	Partner
David, R. C.	Rentokil Ltd.
Davidson, R. S.	Exe Terminators
Day, A.	Cementone-Beaver Ltd.
de Jong, D.	Private Consultant
de Jonge, J. T.	Ministry of Housing
de Mey, ir. C.	Hickson Garantor
Dickinson, Dr. D. J.	Imperial College
Dixon, Ms. A.	Timber Trades Journal
Ducloux, M.	Rhone-Poulenc Specialities Chimiques
Duncan, R.	Robert Duncan/Rentokil
	E
Endoux, X.	Rhone-Poulenc
Esser, P.	Timber Research Institute
Ewbank, G.	Rentokil Ltd.

Name	*Company or Organisation*
	F
Fitzsimons Dr. P.	Cementone-Beaver Ltd.
Fowlie, I. M.	Calders & Grandidge Ltd.
Franitza, A. G.	Bayer U.K. Ltd.
Freeman, D. A.	Guarantee Protection Trust
Frost, R. A.	Cementone-Beaver Ltd.
	G
George, Dr. C. J. D.	All Timber Infestation & Consultancy Service
Gill, Dr. C. J.	T.R.A.D.A
Gray, Dr. S.	Imperial College
Grout, D.	Rhone-Poulenc
Gulliver, R. C. P.	Gulliver Timber Treatments Ltd.
Gulliver, S.	Surrey Timber Preservation Co. Ltd.
	H
Hanson, R. M.	Hickson Timber Products Ltd.
Harling, D. L.	Mechema Chemicals Ltd.
Hawkins, Dr. J.	I.C.I.
Heathcote, M. J.	Cle-Pol Manufacturing Co. Ltd.
Hilditch, E. A.	Cuprinol Ltd.
Hilditch, Mrs. B. F.	Partner
Hindle, S.	Yorkshire Dampcourse & Woodworm Co. Ltd.
Hindle, Mrs. S.	Partner
Hislop, H. W.	Maljon Timber Preservation Ltd.
Hurst, R. G.	Fosroc Ltd.
Hutchison, G. O.	Calders & Grandidge Ltd.
	J
Jackson, R.	H. S. Jackson/Rentokil
Jones, C. J.	British Chemical Dampcourse Association
Jones, M. G.	Hickson Timber Products Ltd.
Jonker, Dr. J. A.	M. & T. Chemicals
	K
Kaczmar, P.	TRADA
Keep, D. J.	Cuprinol
Kelly, Dr. A.	GORI
Kenyon, A.	Fosroc Ltd.
King, Prof. B.	Dundee Institute
King, D.	Rhone-Poulenc
King, T. C.	Cementone-Beaver Ltd.
	L
Lamb, K.	Cuprinol Ltd.
Landsiedel, H.	Schering Chemicals Ltd.
Leegwater, R.	Van Swaay Garantor
Le Grys, P.	Heritage Preservation
Leightley, Dr. L. E.	Rohm & Haas
Lewis, Dr. D. A.	Hickson Timber Products Ltd.
Lindenheim, V. E.	American Wood Preservers Association
Lindenheim, Mrs. V. E.	Partner
Lingard, Miss. H.	Stenographer
Lloyd, G. R.	Albright & Wilson Ltd.
Lockyer, A. A.	Timber Trades Federation
	M
MacDonald, J.	MacDonald Turner Ltd.
MacDonald, Mrs. D.	Partner
Margolis, S. D.	British Woodworking Federation
Marsh, C. H. M.,	Peter Cox (Preservation) Ltd.
McCutcheon, Dr. G.	Health & Safety Executive
McLellan, A.	Building Magazine
Medcalf, P. J.	Cuprinol
Medcalf, Mrs. P. J.	Partner
Mill, R. L.	R. H. Campbell Ltd.
Mill, Mrs. L.	Partner
Miller, Dr. E. R.	Building Research Establishment

Name	*Company or Organisation*
Miller, D.	Calders & Grandidge
Moore, G. B.	Fosroc Ltd.
Morgan, Dr. J. W. W.	Building Research Establishment
Murphy, Dr. R. J.	Imperial College
	N
Newman, R.	Southern Electricity Board
Nicholson, D. D.	Borax Consolidated Ltd.
Nijman, H. F. M.	Consultant
Norman, Rear Admiral	St. Catharine's College
North, P. D.	Timberwise Consultants Ltd.
North, Mrs. P. D.	Partner
Nubel, D.	British Pest Control Association
	O
Oliver, A. C.	Consultant
O'Neill, Mrs. I.	Health & Safety Executive
Orsler, R. J.	Building Research Establishment
Oxley, J. E.	Sovereign Chemicals Ltd.
	P
Palfreyman, Dr. J. W.	Dundee Institute
Parker, J.	Calders & Grandidge Ltd.
Parks, A. G.	Burt Boulton (Timber) Ltd.
Payne, B. M.	MacDonald Turner Ltd.
Payne, C. J.	Solignum Ltd.
Pearce, E. M.	Fosroc Ltd.
Perriton, R.	R. P. Associates
Pinion, L. C.	B.W.P.A.
Plowman, D.	R.T.Z. Chemicals
Pretty, A.	Cementone-Beaver Ltd.
Prins, J. H.	Stichting Keuringsbureau Hout
Pritchard, D.	Sovereign Chemicals Ltd.
Pugh, Mrs. S.	B.W.P.A.
	Q
Quasem, A.	B.F.I.D.C./Bangladesh
	R
Richards, G.	East Midlands Electricity
Ross-Jones, A.	Rentokil
Rowe, J. E.	Sovereign Chemicals Ltd.

Name	*Company or Organisation*
	S
Sachs, Dr.	Schering Chemicals Ltd.
Salter, H. F.	Protim Services Ltd.
Saunders, L. D. A.	Fosroc Ltd.
Schollema, E.	Markerink's Houtbedrijf
Scobie, D.	B.W.P.A.
Scutt, D.	Fosroc Ltd.
Shaw, P. G.	Hickson Timber Products Ltd.
Sinclair, P.	Schering Chemicals Ltd.
Smith, I. G.	Cobra (Wood Treatment) Ltd.
Smith, K. M.	Albright & Wilson Ltd.
Sparks, C. R.	Cuprinol Ltd.
Supple Prof. B. E.	St. Catharine's College
	T
Tasker, N. R.	Buckman Laboratories
Thomas, K.	Catomance Ltd.
Tillott, Dr. R. J.	Rentokil Ltd.
Tinning, K.	Catomance Ltd.
Tompetter, H. W. F.	Flexchemie b.v.
Tuck, M. J.	B.W.P.A.
Turkmenoglu, Mrs. D.	H.E.M.E.L./Hickson
	V
Valcke, Dr. A. R.	Janssen Pharmaceutica
van den Eynde, R.	Buckman Laboratories
Vincent, R.	Fosroc Ltd.
	W
Wallace, R. J.	Portsmouth Polytechnic
Weavers, J.	Cementone-Beaver Ltd.
Wedel, C. V.	Anglo Norden Ltd.
White, J. A.	Hickson Timber Products Ltd.
Wilson, D.	R. H. Campbell
Wilson, G.	Health & Safety Executive
Wing, S.	Rohm & Haas
Winslow, G.	Catomance Ltd.
Woodhouse, L. B.	Cementone-Beaver Ltd.
Woods, M. M.	Catomance Ltd.
Worringham, J. H. M.	Cuprinol Ltd.
Wright, M. E.	Utility Technology
Wright, R. A.	B.W.P.A.

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