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Record of '91 Convention

Cambridge

July 2nd - 5th 1991

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of the
BRITISH WOOD PRESERVING
and DAMP-PROOFING ASSOCIATION

Cambridge
July 2nd-5th, 1991

Issued by the
BRITISH WOOD PRESERVING AND DAMP-PROOFING ASSOCIATION
BUILDING NO. 6, THE OFFICE VILLAGE, 4 ROMFORD ROAD,
STRATFORD, LONDON E15 4EA

P. G. Shaw
President of the British Wood Preserving and Damp-Proofing Association

THE BRITISH WOOD PRESERVING AND DAMP-PROOFING ASSOCIATION

BUILDING NO. 6, THE OFFICE VILLAGE, 4 ROMFORD ROAD,
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BRITISH WOOD PRESERVING AND DAMP-PROOFING ASSOCIATION

The British Wood Preseving and Damp-Proofing 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 plus techniques for damp-proofing buildings. It sponsors scientific research into the use of preservatives and fire retardants plus damp-proofing materials 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. Amongst other objectives 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 plus fire retardant and damp-proofing materials.
Users of timber.
Firms operating all forms of treating plant.
Specialist in the remedial and curative treatment of timber in-situ, plus damp-proofing buildings.
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 and damp-proofing buildings.

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

On several of these Committees there are representatives of the nationalised industries, consuming industries, and organisations such as the Building Research Establishment, T.R.A.D.A., T.T.F., B.B.A. and the Health & Safety Executive.

SERVICES

It offers a free advisory service on all problems connected with timber preservation and damp-proofing.
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 and damp-proofing treatments.
It arranges visits to the works of manufacturers and treaters.
It represents the industry on a number of international committees connected with timber preservation and damp-proofing.
It acts as the Secretariat to the European Wood Preservative Manufacturers Group.

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.

The British Wood Preserving and Damp-Proofing Association wishes to emphasise the fact that the papers represent the authors' own views, which do not necessarily coincide with those of the Association.

CONTENTS

PRESIDENT'S OPENING REMARKS

Ladies and gentlemen, it is time to start the proceedings. It is both my privilege and pleasure to welcome you to this, the 42nd Convention of the BWPDA. I would particularly like to welcome the overseas delegates – this year there are 21 of you – and I would also like to give a special welcome to those attending the Convention for the first time. I hope all of you will have an enjoyable stay in Cambridge, allied to an interesting and stimulating Convention. The challenge, I believe, is to capture the attention of delegates in preference to distractions such as Wimbledon – a daunting task, but I am sure that we are up to it. However, I am sure there will be a few fast balls flying over the net during question time.

The numbers this year are, not unexpectedly, down, as the building industry in the UK is staggering through a recession the likes of which we have not seen for some 50 years. Having said that, numbers are only marginally down, and there will be more this year at the Conference Dinner, a sure sign of the health of the Association, although I am not sure if it is good for the waistline of the delegates!

Whilst recession can be an excuse for inertia, this is certainly not the case with the Association. The committees have been beavering away on a wide range of issues, having bedded down well following the merger, and thankfully we have had a year with few media distractions. I guess that if a retired preserver, or indeed a preserved preserver, returned today he would be entitled to believe he had arrived in the wrong lecture theatre or at an unrelated conference. Who a few years ago had heard of NVQ, BATNEEC, CEN, QA, COSHH, NAPD, DG11, to name but a few? Yet they now dominate our thinking and will be referred to more than a few times during this Convention.

The BWPDA will be taking the lead for the industry on Vocational Qualifications, and you will be hearing more of that later. Quality assurance to BS.5750 is now the hallmark for manufacturers and treaters, and of course, European Standards are about to descend on us, where the BWPDA has had a significant influence. COSSH and the Control of Pollution Act are major pieces of legislation which acknowledge our environmentally aware society. The Non-agricultural Pesticides Directive will shortly be a reality, and DG11 is definitely not the Dog and Gun Soccer Team!

So the Covention programme is one that I hope will have interest for all of you. and accordingly I have pleasure in opening the Convention.

PRESERVING THE PAST, PROTECTING THE FUTURE

by DR. MARTIN G. BIGG
Her Majesty's Inspectorate of Pollution

BRIEF BIOGRAPHY

1. Martin Bigg graduated in chemistry from the University of Bristol in 1977 after following a subsidiary course in environmental chemistry studying Bath water. In 1980 he completed a PhD at the University of Salford in organic chemistry and joined May and Baker in Norwich and Dagenham. He then moved to Teeside in 1985 as a plant manager for a new Laporte Industries subsidiary.
2. Following several dealings with the local inspector he joined HMIP at its Darlington office in 1987 before moving to Cambridge and then the Luton offices as a principal inspector.
3. In 1988 he established the HMIP local authority unit in Birmingham which now includes 3 environmental health officers. The unit is currently producing a variety of guidance notes and preparing for the new local authority air pollution control powers in the Environmental Protection Act. In addition he is also co-ordinating the production of technical guidance for HMIP and heavily involved with HMIP's other preparation work for the implementation of the Environmental Protection Act.

ABSTRACT

The Environmental Protection Act 1990 provides the basis for a new system of pollution regulation operated by Her Majesty's Inspectorate of Pollution from 1 April 1991. At the heart of this is a new concept called Integrated Pollution Control which requires the use of 'best available techniques not entailing excessive cost' to prevent or minimise and render harmless releases from the most polluting industrial processes and aims to ensure that releases are optimised between air, water and land to secure the Best Practicable Environmental Option. In line with the Government's commitment to the principle that the polluter pays, a simple and practical charging scheme will also be introduced by HMIP to cover its costs in implementing and enforcing the new controls. This paper outlines HMIP's new regulatory approach with particular emphasis on what it means for industry in terms of resource commitment and cost.

HMIP'S ROLE IN INTEGRATED POLLUTION MANAGEMENT

The UK Government is in the final stages of creating new institutional arrangements for the protection of the environment from pollution caused by operating industrial processes, in particular those with the potential to cause most harm. The Environmental Protection Act 1990 (1) introduces, in Part 1, a new system of integrated pollution control (IPC). In Part 2 it increases controls over the disposals of waste on land, and in Part 5 it modifies the regulation of the handling and disposal of radioactive substances under the radioactive substances Act 1960. These provisions together with certain responsibilities under the Water Act 1989 provide the main legislative basis for Her Majesty's Inspectorate of Pollution's regulatory responsibilities. To meet these responsibilities HMIP has developed a new regime called integrated pollution regulation (IPR) which began operation in April this year. Preparations for IPR began in April 1987 when HMIP was formed by combining: Her Majesty's Industrial Air Pollution Inspectorate, Her Majesty's Radiochemical Inspectorate, the Hazardous Waste Inspectorate and a new Water Pollution Inspectorate. In October 1989 HMIP's field inspectorate was reorganised into three regional divisions, based in Bristol (West Division), Leeds (North Division) and London (East Division). April 1991 represents the next major milestone for HMIP when the provisions of Part 1 of the Environmental Protection Act began to be phased in. But IPR is not just about new legislative innovation, it is about a radical shift in the Inspectorate's thinking and approach.

Integrated Pollution Regulation – HMIP's Raison d'etre

Integrated Pollution Regulation can be summarised as follows:

i. carrying out all its work within the framework of what HMIP has defined as *Integrated Pollution Regulation;*
ii. *a preventive approach,* designed to avoid problems arising, through rigorous assessment of plant design and waste management proposals, authorisation and monitoring, backed by enforcement action and prosecution where necessary;
iii. a postiivee but *structured* relationship with operators;
iv. provision of information and guidance to industry, through publication of *Chief Inspector's Guidance to Inspectors – "IPR Notes";* and
v. a systematic *targeting of resources* to the highest priorities.

From April 1991 the statutory framework of control for non-radioactive processes will reflect the cross-media philosophy. IPC and HMIP's other main functions – regulation of premises under the Radioactive Substances Act 1960, audits of the new Waste Regulatory Authorities, and regulation of discharges of Red List substances to sewers – will be dealt with in an integrated way, through *Integrated Pollution Regulation.*

THE PREVENTIVE APPROACH

From an environmental standpoint, prevention is normally better than cure. For operators, it is more cost effective and less disruptive to design effective controls and operating procedures into a plant, rather than face later remedial action and reactive adaptation. It is also better to minimise the creation of waste at source and to encourage recycling wherever practicable and to dispose of remaining wastes in the most environmentally acceptable way. This thinking lies behind HMIP's preventive approach.

The three elements in the preventive approach are:-

i. *guidance* on process design and operation, in particular, through IPR Notes;
ii. *avoidance* of pollution risk, by rigorous scrutiny and process design and operating arrangements, and *reduction of waste creation at source,* through the authorisation process; and
iii. *deterrence,* by using authorisations to set up monitoring regimes which will bring lapses in performance quickly and reliably to the attention of the operator, HMIP and the public; and by effective monitoring, inspection and enforcement regimes.

RELATIONSHIP WITH INDUSTRY

The traditional approach to pollution regulation in Britain has been one of informal working together between operators and enforcing authorities. This is a legitimate approach, and one which has been productive and effective in achieving high standards. However, IPR Marks a shift to a more structured approach to regulation. In line with this, HMIP's relationship with the individual operators whom it is charged with regulating, will become more formal, and the provision of company and plant specific technical advice will become less necessary.

This does not mean that there will not be dialogue with industry. HMIP will continue to provide general technical guidance through publication of the Chief Inspector's IPR Notes and other formal guidance to inspectors. More than 180 such notes are planned for preparation over the next five years. HMIP also maintains close links with trade associations and bodies representing relevant sectors of industry such as the Confederation of British Industry and the Chemical Industries Association.

Technical Guidance Material – IPR Notes

Ministers have undertaken that the introduction of IPC will be accompanied by technical guidance on the operation of each process under IPC. Formally, these will have the status of guidance to inspectors, but will be published for the benefit of applicants.

Draft guidance on industry sectors has already been prepared for the following categories:-

- fuel and power industry (2);
- metal industry (3);
- mineral industry (4);
- chemical industry (5); and
- waste disposal industry (6).

These will be followed over the next five years by full IPR notes covering all processes prescribed for IPC; beginning shortly with the publication of an IPR Note on large combustion processes. Annex 1 gives an indication of the latest timetable for the preparation of Chief Inspector's Guidance to Inspectors for industries and processes.

Cost Recovery Charges

Reflecting the "polluter pays" principle, the Environmental Protection Act contains provision for HMIP to charge fees for the determination of IPC applications and for the holding of an IPC authorisation (subsistence charge), to meet its ongoing costs of oversight and enforcement. A fee will also be charged to cover the costs of considering an application for a substantial variation of an authoristion. Processes which involve releases to controlled waters (estimated to be about one in six of IPC processes) are subject to monitoring by the National Rivers Authority. To cover the cost of this, the annual subsistence charge for such processes will additionally include the amount payable under the NRA's charging scheme.

These charges do not represent a "pollution tax" – they are by statute limited to the recovery of HMIP's regulatory costs, although the recent White Paper on the Environment states that the Government will be considering a form of incentive charging very soon.

To ensure that the level of charges on individual installations will fairly reflect the amount of regulatory effort involved in dealing with them, planned charges will be linked to the number of specified "components" which the installation contains (7).

There will be a lower application fee for existing installations, being converted from an existing statutory approval, to IPC.

For example, a combustion process which comprises three boilers of more than 50 MWth, three gas turbines of more than 50MWth, and a waste gas treatment plant would contain 3+3+1=7 components for charging purposes.

Charges will commence from April 1991 – but are payable only when an application for authorisation is required. HMIP has consulted industry on the details of the charging proposals, and will take comments into account in framing the final scheme.

The Act also introduces a charging scheme for premises regulated under the Radioactive Substances Act 1960 from April 1991. The scheme will apply to all premises holding existing registrations and authorisations.

Public Register Of Pollution Information

The Environment Protection Act requires that all information directly related to applications, and issuing new authorisations and to compliance requirements be placed on a public register. This will be a major innovation and will require:-

i. applications for IPC authorisations to be advertised;
ii. third parties may make representation to HMIP about these applications, and any changes must be made public;
iii. authorisations and monitoring data;
iv. the information must be held on public registers, copies of which will be held by the local District Council and HMIP; and
v. authorisations including discharges to water, to be copied to the National Rivers Authority's registers so that they hold a complete record.

Part 1 of the Environment Protection Act provides for the introduction of integrated pollution control, which covers processes responsible for the majority of releases to air, land and water with the greatest polluion potential (Schedule A). Prior authorisation will be needed by those wishing to operate prescribed processes. The Secretary of State for the Environment (in England) specifies the processes to be prescribed for IPC: HMIP's responsibility is to operate the regulatory system (8). At present it is envisaged that about 105 types of process will be prescribed, involving at least 5,000 installations in England and Wales. IPC processes fall into three main categories:

i. process currently regulated for air emissions under the Health and Safety at Work etc Act 1974;
ii. processes giving rise to significant quantities of special waste;
iii. processes giving rise to emissions to sewers or controlled waters of Red List substances.

The Environmental Protection Act requires HMIP to have in regard to setting IPC authorisation conditions. These include:-

i. a general duty on the operator to use of *"best available techniques not entailing excessive cost" (BATNEEC)* to prevent or minimise releases of prescribed substances, and to render harmless substances which are released;
ii. application of the *"best practicable environmental option" (BPEO)* to minimise pollution to the environment as a whole; and
iii. *compliance with limits, plans, quality standards and objectives* set by the Secretary of State for the environment.

IPC Authorisations

An IPC authorisation will be required before a prescribed process may be operated. The applicant will have a right of appeal to the Secretary of State against refusal of an authorisation, or against conditions attached to it. HMIP will be required by the legislation to determine an application within a prescribed period of time, or such longer period as may be agreed with the applicant. Otherwise, the applicant can appeal to the Secretary of State as if the application has been refused. The prescribed period may vary for different categories of application, but it is likely to be about 4 months. HMIP Must consult the Ministry of Agriculture, Fisheries and Food, sewerage undertakers (for discharges to sewers), the Health and Safety Executive, and the NRA on applications for authorisation involving releases to controlled waters, and must incorporate conditions as to the release not less stringent than those which the NRA may require.

Implementation procedure And Timetable

It is not feasible to issue IPC authorisations immediately for all existing installations and the Act allows for staged implementation. Implementation will be by class of process, every firm operating a particular class of process will require an IPC authorisation – and will start to pay IPC charges at the same time as operators of similar processes elsewhere in England and Wales.

However, all new installations and existing installations undergoing major change will require an IPC authorisation from April 1991. Moreover, the Act, reflecting in part an EC Directive requirement, provides that IPC authorisations will be subject to review at least every four years. In practical terms this makes it desirable to implement IPC within four years from April 1992 so that HMIP will have completed all initial authorisations before having to start on the first round of reviews.

HMIP will aim to implement IPC On the following timetable:-

i. regulations will be made shortly to prescribe the IPC processes, and will require all new installations and substantially changed existing installations in Schedule A to be subject to authorisation, as from 1 April 1991, unless approved under an existing statutory system by that date;
ii. from 1 April 1991, all large combustion plants (those over 50 MW th) will become subject to IPC. Operators will be required within one month to submit an application for IPC authorisation;

iii. IPC will be progressively extended to other existing installations from April 1992 with the target of completion by April 1996 see Annex 1, subject to resources.

Local Authority Air Pollution Control

Part I of the Act also establishes a parallel local authority air pollution control regime. The controls apply to a range of what can best be termed 'medium-polluting' processes – or 'Part B' processes as they are commonly known as, because of the heading in the Environmental Protection (Prescribed Processes and Substances) Regulations, SI 472. The new functions will be exercised by district or borough councils and by port health authorities.

Part B processes have a significant potential for air pollution, but are not so complex as to require the cross-media approach of IPC. It is estimated that the local authority controls will apply to some 12,000 such plant, together with between 10,000 and 15,000 small waste oil burners in garages and workshops.

The implementation of the local authority controls will be in three stages. The processes have been divided into three blocks. For those processes in the first block, new processes and substantial changes to existing processes may not be carried on without an authorisation after 1 April 1991. Operators of existing processes must apply for authorisation between 1 April 1991 and 30 September 1991. For processes in block 2, the dates are 1 October 1991 for new processes and substantial changes, and 1 October 1991 to 31 March 1992 for existing processes. The three blocks are set out in Schedule 3 to SI 472.

It is intended that Secretary of State guidance on BATNEEC for each category of process will also be issued in three blocks. The first block of 25 notes was published by HMSO in February this year. The other two blocks of notes will be issued before 1 October 1991 or 1 April 1992, as appropriate.

Local authorities will be required to levy an application fee and an annual subsistence charge, as for IPC. The charging scheme is, however, different: notably, the Part B processes are not subdivided into components and the fees and charges are lower. The application fee will in most cases be £800 per process, and the annual charge will be £500.

General guidance notes on the working of the local authority air pollution control system will be published by HMSO at the end of April.

Waste Regulation Functions

HMIP's waste regulation functions are to be placed on a statutory basis by the Environmental Protection Act, which places a statutory duty on the Secretary of State to keep under review the regulation authorities' discharge of their functions. Waste Regulation Authorities will be created as separate entities from the Waste Disposal Authorities under the provisions of the Act. There will be 63 Waste Regulation Authorities in England (at County and Metropolitan District level) and 37 in Wales (at District level). HMIP will assist the Secretary of State to discharge this duty by reporting to him on their periodic audits of each authority and continuing general oversight of regulation standards in the country. HMIP will also comment as necessary on WRA Annual Reports.

HMIP's new role will come into effect three months after the relevant provisions for separating waste regulation authorities from waste disposal authorities are enacted. It is likely that this will be in the first quarter of 1991 and the authorities first annual reports will cover April 1991 to March 1992, to be published in Autumn 1992.

HMIP's Audit And Oversight Of WRAs

The prime responsibility for standards at individual waste management facilities will rest with the Waste Regulation Authorities. HMIP will audit the authorities' capability, methods, systems and performance. Inspection of a sample of sites will also be carried for background information. HMIP's audit reports on WRAs will be published and HMIP may also publish interim reports on any authority as necessary.

Coordination Of Waste Regulation Authorities

HMIP will play an active part in the promotion of higher standards by working with voluntary regional groups set up by the waste regulation authorities to help to ensure consistency of licensing policy, procedures and standards within their committee areas. HMIP will report to the Secretary of State on the operation of the groups. HMIP's role will include:-

i. discussion/presentation of new guidance, procedures and initiatives;
ii. providing guidance on the interpretation of codes of practice and other guidance material and its application to individual cases;
iii. advice on good practice, for example on waste management licence conditions, inspection regimes, enforcement etc; and
iv. disseminating information on good and bad practice to authorities.

Radioactive Substances Act 1960 – Authorisation, Registration, Inspection And Enforcement

There are nearly 9000 premises regulated by the Radioactive Substances Act 1960. There has been an increase of about 30% over about the last 5 years. They can be split into four basic categories as shown below:

TABLE 2
Categories of RSA60 Premises

1:	BNFL Sellafield	1 premises
2:	Other sites – CEGB, SSEB and UKAEA sites licenced under the Nuclear Installations Act 1965 – Amersham International	30 premises
3:	Other nuclear and UKAEA sites and sites authorised under RSA 60 to dispose of radioactive wastes	1100 premises
4:	Registrations under RSA60 to keep and use radioactive materials	7000 + premises

With the introduction of Integrated Pollution Regulation (IPR) it has been decided that disposal authorisations under RSA60 will be reviewed every 4 years. This is a substantial task and will be phased over 4 years starting in 1991.

Water Act Notice: Red List Discharges To Sewers

HMIP is already responsible on behalf of the Secretary of State for the Environment for regulation of discharges of Red List substances to public sewers under the Water Act 1989. HMIP estimates that around 2,000 discharges are from processes which will remain outside IPC control ie those not prescribed under IPC. Under EC requirements, Water Act consents, like IPC authorisations, are subject to review at least every 4 years.

Supporting Research

HMIP is developing its portfolio of information about the techniques available for pollution abatement of industrial processes with a view to providing its inspectors with guidelines on internationally recognised standards of good practice. HMIP is also planning a research programme to establish methods of characterising and quantifying the impact of pollutants on air, land or water to allow comparative evaluation of cross-media process options. This is in addition to an extensive programme of research to assess the impact of alternative radioactive waste disposal systems.

Future Developments

The Environment White Paper, published on 25 September announced two new initiatives of particular importance to HMIP. The first was that HMIP should be a candidate to become a "Next Steps" agency (ie a separate agency within the

Department of the Environment) as soon as possible. HMIP would thereby have a clearly separate identity in discharging its new regulatory responsibilities under the Environmental Protection Act. The second initiative involves the setting up of an independent committee to advise HMIP on all its responsibilities. Membership would be drawn from industry, public bodies and independent members. It will ensure that views and advice from a wide range of informed opinion would be available to HMIP in implementing IPR.

Conclusion

In this paper a broad overview is given of the future role of HMIP in regulating industrial pollution in England and Wales. Until each of HMIP's new responsibilities under the Environmental Protection Act is phased in during the next five years, existing single medium controls will remain in force. HMIP and industry faces many challenges over this period, and there is much to learn but we believe that Integrated Pollution Regulation provides the basis for coherent and fully effective industrial pollution control.

References

(1) Environmental Protection Act, HMSO, London 1989.

(2) Chief Inspector's Guidance to Inspectors Fuel and Power Sector Guidance Note (Consultation Paper), HMIP September 1990.

(3) Chief Inspector's Guidance to Inspectors – Metal Industry Sector Guidance Note (Consultation Paper), HMIP, September 1990.

(4) Chief Inspector's Guidance to Inspectors – Mineral Industry Sector Guidance Note (Consultation Paper), HMIP, September 1990.

(5) Chief Inspector's Guidance to Inspectors – Chemical Industry Sector Guidance Note (A Consultation Paper), HMIP September 1990.

(6) Chief Inspector's Guidance to Inspectors – Waste Disposal Industry Sector Guidance Note (Consultation Paper), HMIP September 1990.

(7) "Pollution Regulation: Cost Recovery Charges: A Consultation Paper", HMIP July 1990.

(8) The Environmental Protection (Prescribed Processes and Substances Regulations.

Annex A
TIMETABLE FOR IMPLEMENTING INTEGRATED POLLUTION CONTROL

EPA Sched. 1 Ref	*Process*	*Comes within IPC*	*Apply Between*	*Chief Inspector's Guidance Note Issues*
	Fuel & Power Industry			
1.3	Combustion (50MWth)	1.4.91	(1.4.91) & 30.4.91	1.4.91
1.1	Gasification	1.4.92	1.4.92 & 30.6.92	1.10.91
1.2	Carbonisation	1.4.92	1.4.92 & 30.6.92	1.10.91
1.3	Combustion (remainder)	1.4.92	1.4.92 & 30.6.92	1.10.91
1.4	Petroleum	1.4.92	1.4.92 & 30.6.92	1.10.91
	Waste Disposal Industry			
5.1	Incineration	1.8.92	1.8.92 & 31.10.92	1.2.92
5.2	Chemical Recovery	1.8.92	1.8.92 & 31.10.92	1.2.92
5.3	Waste Derived Fuel	1.8.92	1.8.92 & 31.10.92	1.2.92
	Mineral Industry			
3.1	Cement	1.12.92	1.12.92 & 28.2.93	1.6.92
3.2	Asbestos	1.12.92	1.12.92 & 28.2.93	1.6.92
3.3	Fibre	1.12.92	1.12.92 & 28.2.93	1.6.92
3.5	Glass	1.12.92	1.12.92 & 28.2.93	1.6.92
3.6	Ceramic	1.12.92	1.12.92 & 28.2.93	1.6.92
	Chemical Industry			
4.1	Petrochemical	1.5.93	1.5.93 & 31.7.93	1.11.92
4.2	Organic	1.5.93	1.5.93 & 31.7.93	1.11.92
4.7	Chemical Pesticide	1.5.93	1.5.93 & 31.7.93	1.11.92
4.8	Pharmaceutical	1.5.93	1.5.93 & 31.7.93	1.11.92
4.3	Acid Manufacturing	1.11.93	1.11.92 & 31.1.94	1.5.93
4.4	Halogen	1.11.93	1.11.93 & 31.1.94	1.5.93
4.6	Chemical Fertiliser	1.11.93	1.11.93 & 31.1.94	1.5.93
4.5	Inorganic Chemical	1.5.94	1.5.94 & 31.7.94	1.11.93
	Metal Industry			
2.1	Iron and Steel	1.1.95	1.1.95 & 31.3.95	1.7.94
2.3	Smelting	1.1.95	1.1.95 & 31.3.95	1.7.94
2.2	Non-ferrous	1.5.95	1.5.95 & 31.7.95	1.11.94
	Other Industry			
6.1	Paper Manufcturing	1.11.95	1.11.95 & 31.1.96	1.5.95
6.2	Di-isocyanate	1.11.95	1.11.95 & 31.1.96	1.5.95
6.3	Tar and Bitumen	1.11.95	1.11.95 & 31.1.96	1.5.95
6.4	Uranium	1.11.95	1.11.95 & 31.1.96	1.5.95
6.5	Coating	1.11.95	1.11.95 & 31.1.96	1.5.95
6.6	Coating Manufacturing	1.11.95	1.11.95 & 31.1.96	1.5.95
6.7	Timber	1.11.95	1.11.95 & 31.1.96	1.5.95
6.9	Animal and Plant Treatment	1.11.95	1.11.95 & 31.1.96	1.5.95

THE PRESIDENT: Ladies and gentlemen, the question is do we want to work with the gorillas, and Martin this morning has been very thought-provoking and has introduced to us what is surely the most important legislation in our industry that there has been for a long, long time. I have a sneaking feeling that his talk will have stimulated a lot of thought, and you would like to ask a number of questions, so for the next 25 minutes the floor is yours. When you raise questions would you please give your name and your company or association.

MR. M. CONNELL (Hicksons): Thank you, Dr. Bigg, for such clear guidance on the Environmental Protection Act. My question relates to new timber treatment processes. The existing processes come within the scope of IPC. I am talking about Chapter 6 processes in 1995. The IPR Notes, which will detail the requirements for compliance, will also not be published until 1995 but, as I understand, new processes actually come under this control immediately. As a manufacturer and a treater, we are in some difficulties, both with the regulators, in interpretation of the application of IPC to new processes, because the IPR notes are not available. My question is what interim arrangements for Chapter 6 processes apply or are actually in existence to assist the authorisation process until 1995?

DR. BIGG: Thank you, Mike. That is obviously a very important point. We are conscious that, much as we have the best intentions to get the preparation for the implementation and integrated pollution control sorted out, there is no way we can provide comprehensive guidance for every process as of 1st April or soon after, so what we have done is to produce industry sectors guidance notes, and they are available through HMSO at about £5 each. They lay out basic principles.

If you have a particularly novel and unique process that the local inspector cannot advise on, we have also got a system whereby that inquiry can be addressed direct to the Chief Inspector, and my collegues and I in London will endeavour to deal with it as a one off. We also have topic groups specifically targetted with drafting guidance and assisting on an application in advance of the programme date for the production of specific guidance. However, although that programme for the specific guidance does not come to fruition until four years hence, we have already started discussions with the Association with a view to making it available well in advance of that date. As far as we are concerned, they are the latest dates that the guidance should be available, and we are certainly working hard to get as much prepared as soon as possible, because it is not only in the interests of the industry but also in the interests of the Inspectorate.

DR. CHRIS COGGINS (Rentokil): Dr. Bigg, thank you for a clear and unequivocal presentation of the laws we now face. The industrial timber preservation industry is a mature industry. There are quite a large number of treatment plants in the UK which have been operating, quite a number of them, for many years. The original capital investment in those of course will today be rather small in today's terms, and so my question really relates to BATNEEC and the interpretation of the term "excessive cost". Even a new treatment plant today perhaps would not exceed a couple of hundred pounds, one with a large capacity, and some of the latest facilities – certainly not in the field of the millions of pounds that you mentioned in your presentation. So I wonder if you can comment.

DR. BIGG: Thank you, Chris. Obviously we are very concerned about existing plants but we do believe that there is no reason why we should turn a blind eye to existing plant and simply allow them to continue to current standards or in the absence of any standards. What we believe is that everyone should have at the end of the day a level playing field, consistent standards across the industry. So, particularly with regard to BATNEEC, the NEEC part of it we believe should reflect a timetable for the upgrading of this existing plant to the new plant standards, and that timetable should reflect the capital investment required. If, as you point out, the costs are reasonable, then I sincerely hope we could look for and see a fairly short timetable for the improvement in the industry. On the other hand, what we do not want to do is to get such a short timetable that it distorts the industry, ie the large operator can afford the expenditure and it puts the smaller operator out of business. That has also to be taken into account, but at the end of the day we would want to see everyone coming up to what we believe to be appropriate standards for the whole of the industry sector.

DR. COGGINS: So what we want is an absolute definition of "excessive cost" rather than a relative one.

DR. BIGG: What we are looking for, as you are probably aware, in the Air Framework Directive, is taking into account the costs for the industry sector concerned, but that also is taking into account the costs bearing in mind the scale of the operation, but what we will not take into account is the costs of an inefficient or ineffective operator.

MR. G. EWBANK (FOSROC): Thank you very much for your paper. I have a comment and a question. Firstly the comment: as we understand it, most light organic solvent treatment plants will come under Part A classification, and this does have implications for the authorisation of timber manufacturing processes on site, which otherwise would be Part B and, as I understand it, would actually come under the control if HMIP as well, and therefore the authorisation date would be different. Perhaps you would like to comment on that.

Secondly, during your presentation you specifically used the example of CCA treatment plants and, as I understand it, with the criteria in the regulations at the moment, these are not actually affected because they do not use Red List substances or organic solvent based preservatives. Perhaps you would like to comment on that as well.

DR. BIGG: Yes. Where you operate a timber process that contains plants which are under Part A, e.g. using pentachlorophenol, or you produce large amounts of special waste and you are just cutting up or sawing up a large amount of timber which in its own right would come under Part B, local authority control, then by the interpretation of the rules the whole operation is considered as a Part A process, coming under central inspectorate control. This is all part of the attempt to the keep the system as simple as possible, so you do not have different inspectors and different authorities traipsing through your gate.

As far CCAs are concerned, what we are talking about here are plants which treat timber using CCA and which go over the 500 m^3 a year threshold. Although CCA is not a prescribed substance for release to water, because of the release of particulate material, dust, etc, and solvents which are prescribed substances for air, will come under local authority control.

MR. EWBANK: If I can come back on that, CCA is a water-based process, so you will not get solvent emissions. As far as particulates are concerned you might have some dispute as to whether a significant amount of particulates come out of a CCA treatment plant.

DR. BIGG: Yes, but the important thing is the release to air of any prescribed substance. If it is more than trivial, then the process which is prescribed will come under in this case local authority control.

MR. EWBANK: Do you have a formal definition of "trivial"?

DR. BIGG: Something which is not capable of causing harm. At the end of the day, it will have to be settled on a case by case basis.

MR. M. COLE (Wickes Europe Ltd): Going back to what Gordon was saying with regard to the local environment, I have spoken to about a dozen local environmental health officers, and where we have sawn timber and machined timber and treatment, they are separated. We only have a few months left, and I am finding I am ringing up individually every single environmental health officer to see what they are going to take on. This is not the correct way of going about it. Environmental health are only just getting their act together; no-one can tell me what is going on. We have 120 outlets and we have only two or three months left to make application. We need to get a clearer definition on it.

DR. BIGG: I am concerned to hear you have been experiencing problems with the local authority implementation of Part I. I can only emphasise that it states very clearly in the regulations – SI 472 Schedule 2, I think it is Rule 3 – that where you have got two processes which fall within the same description in the schedule, ie timber processes, then if one comes under Part A and the other will normally come under Part B, the whole lot is a single process and comes under central control. Similarly, if you have two spearate timber treatments, both of which come under local authority control, they are treated as one process, so you need one application and one authorisation.

We have tried to make local authorities aware. We have run training courses. We are now running training courses for training their trainers. We have 457 in England, Wales and Scotland. In the majority of cases the message has got through and they are prepared, but at the end of the day local authorities are autonomous organisations. We cannot tell them exactly what they have to do. We can only guide them and if one or two are ignorant or unaware of what they need to do, probably the best thing is if we can identify the local authorities to have a diplomatic word with them.

DR. D. ASTON (Hickson): I have a comment rather than a question. We have spent an awful lot of time on the telephone, talking to local authorities and offering them guidance.

DR. BIGG: Thank you very much for offering them guidance; they obviously need it. I have to say that we have given presentations to the various local authorities associations, but they come over with perhaps a slightly different emphasis, particularly the Institution of Environmental Health Officers, which has also come over as being well aware of what is going on and they are only too keen to pick up the powers but there will be some who are less prepared than others. We draft as much guidance as we can. If you think we need to put out more guidance, if you have a word, we will see what we can put out to them.

DR. COGGINS: President, may I have a second bite at the cherry here? Dr. Bigg, you mentioned the definition of "significant change" was in one of the documents. Is that right, because I have not seen a definition yet?

DR. BIGG: We have two levels of definition. First of all, in the Act itself it lays out general principles. In "Integrated Pollution Control: A Practical Guide" we have laid out more clearly what we interpret as a singificant change, which is really where you have an increase in releases to any of the environmental media. Then when we come down to specific processes, and we are giving clear examples. For example, for large boiler plants we talk about change in reference systems, change in fuel, as all being categorised as significant change. We want to make that as clear as possible.

DR. COGGINS: If I can cite a specific circumstance, the industry, because of a change in the status and approval of a tributyltin compound is having to change, for example, from tributyltin phosphate to tributyltin napthanate, and in principle the only change in formulation is the change in fungicide from phosphate to napthanate, but I have had a letter from one of your colleagues suggesting that that may be a significant change. If we are looking at simple change from one tributyltin to another being a significant change, that indictes to me that almost if you undo a nut and bolt or change a nut and bolt you are looking at creating a significant change and thereby bringing lots of existing plants under HMIP control in the very near future and in the absence of the immediate guidance in that area, think it will cause the industry quite a lot of difficulty if that constitutes a significant change.

DR. BIGG: I cannot really comment on individual correspondence from one of our inspectors, but as a general principle I would think it is quite likely that if the active ingredient is changed chemically, they are considering that as a significant change, but at the end of the day the onus has been left to our regional offices to make individual decisions on the individual cases put to them in the absence of the guidance, which we are obviously trying to draft as quickly as possible. It all demonstrates that we all have a vested interest in getting comprehensive guidance for this particular process sorted out as soon as possible.

MR. EWBANK: This is a particularly important point Chris has raised, and we need to establish some policy decision from HMIP at the national level, because it will be relevant over the next few months. Would Don Litten or somebody like that be the man we should go to?

DR. BIGG: I am sure he would be able to help you. Having had the question raised, I can go to him and get an answer.

MR. EWBANK: I have a second question. As I understand it, obviously our industry has to use hazardous substances. We need to use biocides that protect the wood. These regulations are intended to eliminate or minimise risk to the environment, and to do that by control of emissions and control of standards. Somebody from your organisation actually passed the option to me that they did not want in 1995 to be looking at applications for the use of Red List substances in timber treatment plants. That seemed to me not to be consistent with the philopsophy of the legislation for the control of emissions. It should not matter too much what active ingredients we are using in the process.

DR. BIGG: The timetable is very clear, such that if there is no significant change, the existing process is continuing, then yes, an application would not be required until 1995, unless there is a change in the regulations. We envisage in most industries, because things do change, some processes, a proportion of that industry, will come under control earlier.

MR. EWBANK: I am sorry. No. I have not made it quite clear. What he was saying was that when 1995 came round he would not be keen to be dealing with applications for timber preservation plants where Red List substances were being used. In other words, he was putting pressure on us to move away from those substances. That seems to be taking it outside his remit.

DR. BIGG: I have to agree that we are not in the business of making policy as to what material can and cannot be used in any particular process. Provided an operator adheres to the requirements in the Act in terms of assessing the environmental consequences and using best available techniques, that is what we are required to adhere to. If it turns out particular materials are highly toxic, release levels will be correspondingly tight, but the policy on materials and whether particular industries can or cannot operate is outside our remit.

THE PRESIDENT: We have time for two more questions, preferably from the non-manufacturing industry.

MR. G.R. CLAYDON (NRA): At the moment the NRA are bringing in the charging for discharge also on their side of the monitoring and pollution control aspects. You mentioned that HMIP will be introducing this charging scheme. Could you give us some idea what the monitoring aspect of that charge will be?

DR. BIGG: How much of that charge will cover monitoring?

MR. CLAYDON: Yes.

DR. BIGG: I have no idea. It very much depends on the individual process. We are looking at a fairly simple charging scheme to cover the cost of all the relevant activities, be it inspection or monitoring, and we cannot very easily in each process category break it down into how much is for monitoring and how much is for the other activities.

MR. CLAYDON: Can you see any dualising of monitoring in the future?

DR. BIGG: As we both have responsiblities for discharges to water, then although one does not want duplication, there will have to be an overlap in responsibilities to ensure that the processes are fully regulated.

DR. COGGINS: Red List substances: is the list of substances prescribed for water tied in directly to a European Community list or is it a UK list, and how is its future likely to be determined in terms of addition, presumably rather than subtractions?

DR. BIGG: That is an important key point. Although we have had numerous lists floating around in terms of European directives and UK proposals in terms of Red Lists, at the end of the day what we have here is a unique list to this particular piece of legislation, which is generally based on what was previously described as the Red List, with one deletion. What I do envisage happening is that over the years materials will be added to those lists as they are identified as giving cause for concern. I would not want to say at this stage what substances or even what processes we are likely to be adding, but certainly the whole system is intended for flexibility so that substances can be added when they are identified.

THE PRESIDENT: Thank you, Martin. We have had, ladies and gentlemen, a fascinating insight into the development of environmental protection and how that legislation has been implemented. We have had this morning a very lucid presentation and one which, as far as I am concerned, has made a very complex subject into a rather more simple one. Having said that, it does sound as if there are many loose ends that require to be tidied up. I am sure that does not apply to Martin and his colleagues in the HMIP, but it does strike me that there is a need for continuing the very close co-operating. The ideas of setting up working museums and buying schools in an interesting option. I am sure it will give us all much food for though! Thank you again, Martin, for a most interesting talk this morning, and I would ask the delegates here to show their appreciation in the normal way. ***(Applause)***

IMPROVEMENTS IN SAFETY AND ENVIRONMENTAL PROTECTION AT TIMBER TREATMENT PLANTS – ACCELERATED FIXATION AND OTHER NEW SYSTEMS

by DR. C.R. COGGINS
Rentokil Ltd., Felcourt, East Grinstead, West Sussex RH19 2JY

INTRODUCTION

Much progress has been made in the design and operation of industrial timber treatment plants through the activities of preservative and plant suppliers and timber treaters.

The BWPDa itself has always encouraged a responsible attitude to health, safety and environmental protection. The most recent initiative is the development of training standards and vocational qualifications. This will provide a national framework of standards for training providers such as the major preservative manufacturers. Formal National Vocational Qualifications are the ultimate aim of the inititative. The BWPDA Code of Practice for Safe Design and Operation of Treatment Plants was first published in July 1989 and is soon to be reissued in revised form following consultation with the Health and Safety Executive, Her Majesty's Inspectorate of Pollution and the National Rivers Authority.

Self-regulation is, however, a system which is perceived to fail to deliver the required standard of health, safety and environmental protection not only in the timber preservation industry but across the spectrum of industrial activities. As a consequence, we have been faced in the UK in recent years with a raft of new regulations which bring the force of law to the management of these issues.

Two of the most recent sets of regulations require significant improvements in health, safety and environmental protection at treatment plants. These are:

- The Control of Substances Hazardous to Health Regulations (COSHH) 1988
- The Environmental Protection (Prescribed Processes and Substances) (EPA) Regulations 1991

These regulations have brought two important principles for plant managers to follow. These are:

1. Assessment of the risk to health arising from work and what precautions are needed.
   Following the assessment appropriate measures must be introduced to prevent or control the risk. First priority must be given to removing the hazardous substance by changing the process or substituting a safer one. Where this is not reasonably practicable then exposure must be controlled by, for example, engineering changes such as enclosure of the process, the introduction of ventilation and the use of safe systems of work and handling procedures. The use of personal protective equipment (PPE) may only be considered where other measures cannot adequately control exposure.
2. The use of best available techniques not entailing excessive cost (BATNEEC) to prevent the release of harmful substances to the environment or, where that is not practicable, to reduce such release to a minimum and to render harmless any such substance which is released.
   When certain prescribed substances are used at treatment plants, an authorisation to operate will have to be obtained from either Her Majesty's Inspectorate of Pollution (in respect of releases to air, land and water) or the local authority (in respect of releases to air) depending on the substances used. It will be a condition of the licence that BATNEEC has been implemented or plans made for implementation within a defined time frame.

This paper reviews some of the developments in plant design and operation which will help timber treaters to meet their obligations under these new regulations.

HANDLING OF WOOD PRESERVATIVES

The BWPDA Code of Practice requires that preservatives should only enter the treatment site in sealed and properly labelled containers, conveyed in appropriate vehicles, and leave it in treated timber. The revised version will be rather more specific in the controls required over the delivery and handling of bulk deliveries by tanker.

Most treatment plants using light organic solvent preservatives (LOSP) take delivery by tanker of ready-for-use solutions or concentrate for dilution in solvent. The plant operator should not be required to handle or be potentially exposed to such preservative solutions until the treated timber emerges from the plant. Operators of vacuum-pressure plants using copper-chromium-arsenic (CCA) preservatives in the UK, however have normally had to carry out a mixing and dilution operation carrying a risk of exposure to concentrated product and diluted solution.

The supply of CCA preservatives began with powder formulations in bags which had to be opened and handled manually. The risk of exposure and the pollution potential were rather high. A major improvement in exposure risk and pollution control came with the introduction by Rentokil of paste formulations in drums in the late 1960's. This brought the benefit of in-drum mixing which has continued to the present day. Nevertheless drums have to be opened and mixing equipment handled. The rigours of a COSHH assessment should lead managers to question as to whether this risk can be eliminated through some engineering measure rather than PPE.

The supply of CCA preservatives in bulk (as paste or liquid concentrates) has been a feature of treatment plant practice for a long time in North America and, more recently, in Scandinavia. Now the system is to be made available in the UK. Bulk delivery finalty eliminates the involvement of the plant operator in handling concentrates and the mixing and dilution process. A simple coupling of the bulk container to the plant mixing system is all that is required. For existing plants some engineering modifications to the plant are necessary to allow for measuring 'doses' of concentrate or paste but these are certainly reasonably practicable.

Bulk containers are refillable and robust and have a long life expectancy, being usable for several years. A useful benefit is the elimination of drums which may be returnable or may have to be disposed of. In either case a pollution potential exists which is avoided by the use of bulk containers.

CONTROLLED FIXATION

In the context of the COSHH regulations control measures to prevent or reduce exposure to liquid preservative on the surface of freshly-treated timber are a necessity.

Anderson[1] has reviewed the published experimental work on fixation mechanisms of CCA preservatives and systems of controlling it. A detailed review is therefore unnecessary here but an understanding of the processes is essential to appreciating the benefits of controlled fixation. Fig. 1 shows the essential elements of the fixation process.

It is clear from this that the Primary Fixation Period is the most important phase since once this is completed the performance of treated timber and the resistance of the chemicals to leaching is assured. This means that the timber will neither compromise health and safety nor present a risk of environmental pollution.

For any given timber species the length of the Primary Fixation Period is essentially a function of temperature. It should be emphasised that it is not a function of moisture content. The reactions proceed regardless of this unless the wood is frozen or has been dried to a very low level. The effect of temperature on time to completion of this phase has been established for several CCA preservatives. The relationship between time and temperature for Rentokil Celcure A is shown in Fig. 2.

Now these times represent those needed to go to full theoretical completion of the Primary Fixation Period. Clearly if these times had to elapse before the treated timber could be used then the very long holiday periods would make the process impractical. For reasonably practicable purposes, therefore, the wood must be able to be handled and used before full theoretical completion. Coggins and Hiscocks[2] showed that the reduction in available chromium at the surface of freshly-treated timber and the proportion of hexavalent chromium in that total proceeds at a rate which makes the surface of treated timber safe to handle before completion of the Primary Fixation Period. Nevertheless the rate of fixation and the handling of treated timber should not be left to chance or the vagaries of the weather.

The health, safety and environmental protection implications of the treatment process need to be quantified together with the benefits which accrue from using controlled fixation methods. The need to hold CCA-treated timber on site for a period to allow drying and fixation reactions to occur has always been an industrial standard plant operating procedure but the requirement became formalised when the Pesticides Safety Precautions Scheme (PSPS) was introduced for wood preservatives during the 1970's. Members of the BWPDA adhered to this voluntary scheme from its inception and labels carried the advice suggested by the Health and Safety Executive. This included the phrase:

Treated wood should be held for 48 hours, or until dry, before despatch or erection

The PPS was replaced by the Control of Pesticides Regulations in 1986 and since then this and other precautions have been statutory requirements.

If we look at the way in which plant design and layout and plant operator safety have developed until now we will see that in many respects controlling fixation is the last link in the chain of process control seen as proper in today's health and safety conscious and environmentally aware climate.

Treatment plants themselves are now frequently delivered to site in a fully prefabricated and tested condition. Safety devices and systems eliminate much of the risk of operator exposure and environmental pollution. Foundation and site layout with bunded areas control liquids within the plant boundary and the enclosure of plant areas within buildings helps to reduce the risks of flooding associated with heavy rainfall. Carefully selected and tested personal protective equipment coupled with information, instruction and training provide a good framework for safe and effective operation of the plant. All these measures and more are incorporated in the BWPDA Code of Practice for the Safe Design and Operation of Treatment Plants already referred to.

Even with all these measures the treated timber still emerges from the treatment plant carrying fresh preservative solution and precautions must be taken to contain any which drips from the timber and plant equipment and to protect those who may be required to handle the timber before it is dry or the fixation reactions have proceeded far enough.

There are several ways in which this can be achieved. Freshly-treated timber can be held on a drip pad, perhaps under cover, at the treatment site until it is suitable for despatch. Ambient conditions vary greatly, however, during the year and present some difficulties with this approach. In Denmark, for example, this has been recognised by the adoption of a regime which requires timber to be held for 6 days in summer and 14 days in winter with days below 5^{0}C not counted. A further development expected to be implemented soon is the use of a technique to measure soluble chromium and arsenic compounds in a sample of treated timber which allows a definite end-point to be determined rather than a predetermined time period (Sheard 1991[3]). Should this approach be adopted here in the UK, and we should remember that the conditions of approval for CCA preservatives will be reviewed in the near future, then greater emphasis will fall on artificial drying systems.

One of the approaches which has great merit is to heat the timber after the impregnation process but before it is removed from the treatment vessel. This can be achieved in a variety of ways – even the use of microwaves is possible – but the use of steam or hot liquids has received most attention in recent years. Interestingly it seems that the use of steam to accelerate the fixation of copper/chromium mixtures – the forerunner of CCA preservatives – was mentioned in a 1927 patent by Gilbert Gunn the inventor of the original Celcure process. However it wasn't until the 1980's that interest in the use of steam for accelerating fixation really took off in response to environmental protection concerns. As a result, various steaming systems have been developed and brought into commercial use.

The use of hot liquids has also attracted considerable attention. The Swedish inventor Bror Hager has patented the use of hot oil which can also be used to colour the wood and impart water repellency. Special oils must be used to avoid degradation by the copper in the preservative and the process is rather costly. Perhaps appropriately the limited commercial use of hot oil has been under the title of 'The Royal Process'.

Hot water is the alternative and is of much greater interest commercially. A considerable amount of work was carried out in the Forest Products Laboratory at Mississippi State University in the 1970's using heated water to fix CCA-treated timber. This became known as the MSU Process. Commercial exploitation has been limited even in the USA. The Danish Wood Treating Company (DWT) hot water system differs from the MSU process in detail but the principle is the same using the transfer of heat from water to treated wood as the means to accelerate the fixation reactions.

The benefits are clear from a comparison of fixation time against temperature based on work by DWT (see Fig.3). Treated timber emerges from the treatment vessel surface-dry and with the Primary Fixation Period substantially complete. This is, therefore, an example of a reasonably practicable approach to controlling exposure to liquid preservative at treatment plants. The additional benefits of avoiding the holding time before despatch (and the temptation to release treated timber too early) and in reduced run-off of preservative by dripping or rain-washing bring the process much more in line with today's requirements for worker safety and pollution control.

CONTROL OF AIR POLLUTION

Amongst the substances prescribed for release into the air in the EPA regulations are organic compounds and metals and their compounds. Treatment plants using these substances (which are not otherwise prescribed for release to water) and where throughput is likely to exceed 500m^3 in any 12 month period are 'Part B' processes subject to local authority air pollution control through the system of authorisations.

Treatment plants using CCA preservatives could therefore be construed as being subject to local authority control. The EPA regulations, however, make provision for processes where there is no likelihood of release except in a quantity which is so trivial that it is incapable of causing harm or its capacity to cause harm is insignificant. Rentokil has carried out extensive monitoring of, particularly, arsenic in air at treatment plants. The results from this survey (Table 1) indicate that releases are very low and transient. The metal compounds have no practical vapour pressure and so are not released to air by evaporation. Although a test case has not yet arisen (and the official interpretation of the terms "trivial" and "insignificant" not yet seen) it would seem reasonable to assume that the exemption applies.

A process guidance note has been issued under the EPA regulations for chemical treatment of timber and wood-based products. This provides guidance to local authorities on appropriate techniques for the control of air pollution at treatment plants subject to their control. It covers the use of LOSP and creosote products. (LOSP's using pentachlorophenol, lindane or tributyltin compounds as active ingredients are 'Part A' processes subject to HMIP control. However, treaters using such products are not required to apply for authorisations until 1995 unless the existing process is replaced or substantially changed).

Application for local authority authorisations for existing treatment plants must be made before 30 September 1991. New, replacement or substantially changed processes will need to be authorised before operation begins.

The guidance note specifies emission concentration limits. These are:

Volatile organic compounds (VOC) (excluding particulate matter) expressed as carbon	100mg/m^3
Total particulate matter	50mg/m^3

The aim should be that all emissions are free of offensive odour outside the process boundary, as perceived by the local authority inspectors.

Most VOC arising from use of LOSP's will be the organic solvents used as the carrier for the active ingredients. These are typically of the white spirit type with a flash-point above 32^{0}C and with other characteristics as defined in BS5707: Part 1:1979[5]. Typically they contain about 80% carbon.

Measurements of VOC levels at treatment plants indicate that significant improvements in emission control will be needed at all LOSP treatment plants. The following are indicative of the scale of the problem:

	mg carbon/m^3
Background level	100-145
Vacuum pump exhaust	1600-2400
Drier vent	13000-32000

Various forms of arrestment equipment can be fitted to reduce emissions to the required level. The guidance note itself refers to the use of a carbon absorption cartridge to minimise odour arising from emissions from vents of storage tanks during filling. Equally this is likely to be needed during return of preservative to storage tanks at the end of the treatment process.

Emission limits are, it seems, to be applied only where measurements can be made in vents or exhausts. There would therefore, appear to be little incentive to install drying equipment for freshly-treated timber since this automatically introduces a vent or vents where measurements can be made. However, discussions are already underway at European and UN level on commitment to reduce VOC emissions. One proposal is to reduce by 30% by 1998[6]. In such circumstances some means of collecting the evaporating solvent from treated timber will become necessary. It may be that the EPA regulations will, in any case, make some form of controlled drying and emission control necessary. The UK usage of industrial LOSP's amounts to about 22 million litres per annum[7]. At present most of this evaporates into the atmosphere. There is clearly a case to reduce this to a much lower level.

Limits on VOC emissions in Sweden have been applied for some time and this has led to the development of drying systems with solvent recovery. The system developed by Rentokil will be available in the UK soon.

The principle of the system is to introduce freshly-treated timber into the drying chamber which is constructed on a modular system so that the capacity can be matched to individual treatment company requirements. Post-installation expansion in capacity is also possible.

Over a period of eight hours batches of treated timber are held in a high velocity warm (37^{0}C) air. Only 300m^3 of air are used per hour for a typical 4m^3 charge. The process is characterised by:

- recirculation of air
- recirculation causes a balanced and regular evaporation from the treated timber without affecting the condition or moisture content of the wood
- heat transfer is by air circulation
- with solvent recovery a proportion of the recirculating air is bled off to the recovery system. This is controlled automatically by monitoring the solvent concentration in the air and bleeding off only when the concentration is optimal for recovery.

Fig. 3 shows the VOC emissions from such a drier. It is anticipated that peak emissions can be reduced to around the guidance note maximum emission limit by the use of solvent recovery systems currently under development.

CONCLUSION

The guiding principles for the selection of engineering improvements at treatment plants to meet the requirements of the COSHH and EPA regulations are:

- what is reasonably practicable?
- what are the best available techniques not entailing excessive cost?

Clearly decisions of this nature must reflect the circumstances of the particular treatment operation and the opinion of government inspectors and local authorities. Further information is available in the series of guidance notes accompanying the COSHH and EPA regulations.

The techniques and systems described in this paper are presented as examples of the type of improvements now or shortly available to the treatment industry in the UK, each offering distinct and quantifiable benefits in terms of health, safety and environmental protection.

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Figure 1

Fixation Reactions of CCA in timber

Instantaneous reactions of copper and chromium with wood substance (reversible)	Primary Fixation Period Reactions of chromium with cellulose and lignin in wood cell walls and with copper and arsenic, to form insoluble 'fixed' compounds Cr6 ⟶ Cr3 Reduction in acidity	Secondary Fixation Period Very slow rections resulting in changes in the nature of compounds present in the wood
⟷ seconds	⟷ hours/days	⟷ weeks/months

↑ **First contact of preservative with wood**

Figure 2

Time to completion of fixation for CCA treated timber (determined by chromium leching procedure)

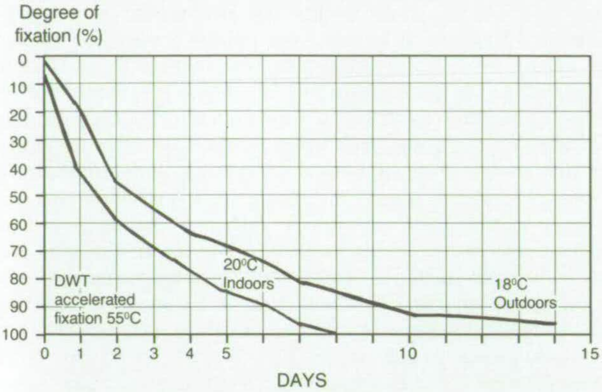


Figure 3

VOC emissions from drier for LOSP – treated timber

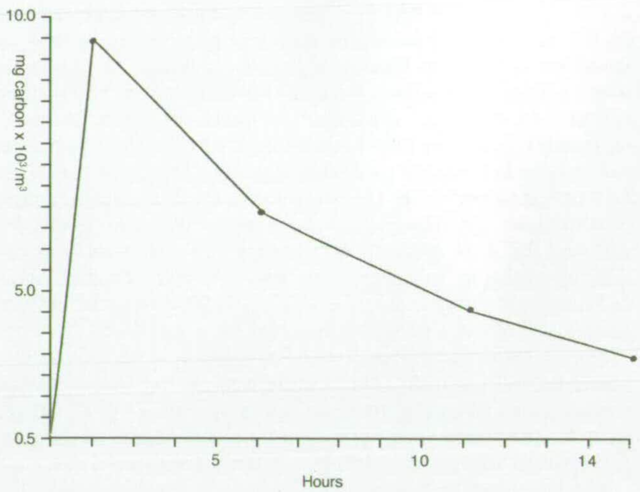


TABLE 1
Arsenic in air at treamtent plants

Sampling location	*period*	*mg arsenic/m³ air*
Treatment area background	15 mins	0.002 - 0.0007
In-drum mixer	15 mins	0.00 - 0.04
Vacuum pump exhaust	15 mins	0.009 - 0.12
Operator personal sampler	8 hours	0.005*

*Maximum Exposure Limit 0.1 mg/m³ (from HSE Occupational Exposure Limited EH40/91)

DISCUSSION ON PAPER 2
Chairman: Mr. T.C. Chiddle

THE CHAIRMAN: We have some time for questions now. Can I invite the first question please for Chris or Bror?

MRS. J. CORNFIELD (Hickson): I have a comment and a question. The comment is: I am not quite sure what temperatures you are referring to when you talk about "high" temperature steam fixation. We have successfully used in Holland temperatures of around 90°C to get good fixation. However, my question related to comparison of information given on the slides that you have shown. In the first part of the paper you described how lab work on wood flour gave long times to achieve 100 per cent of the primary fixation in Dahlgren's work, but then you followed that by a more practical test, showing that after 50 hours at 20, the level of chrome which could be removed from the treated timber was minimised, and also the proportion of chrome VI was minimised, and that gave broad agreement with the UK legislation. I could not really correlate that with the information given in the paper in Figure 3 and shown on your slide from the work by DWT, where 8 days where shown as necessary for fixation indoors at 20. I have two questions about that really. Was the work in Figure 3 lab work, like in Dahlagren's test, and what would you get if you did the more practical test that you described? Also, in Figure 3 the degree of fixation is shown as varying from 0 to 100 per cent and the figures were stated as being relative. What would the actual values be? They would not be 0 at 0 time when the first test was done, and presumably it would not go right up to 100 per cent. How would these compare with practical use?

DR. COGGINS: Thank you very much. If I can tackle points first, Bror, then you can say anything you want to afterwards. I think difficulties arise because of different techniques that have been used, Judith really. As you say, Darbrin's work was essentially on wood flour and he was seeking to establish how long it took to go right to the end of the primary fixation period, and the work that we did on surface chromium was to pick up using a non-absorbent and non-cellulosic wool swab to pick up chromium from the surface of treated timber, so it was essentially aimed at demonstrating what sort of exposure risk there would be to a plant operator during the period immediately after treatment and up to hours or days afterwards, whereas I think the work that I showed on the slide of degree of fixation related to what you can wash from treated timber, cores from treated timber, but Bror did the work so perhaps I can ask him to expand on that. So it is different criteria, or different ways of measuring the thing giving you perhaps a different interpretation.

BROR MOLDRUP: First of all, to your comment about the temperature for accelerated fixation, there are basically three systems being employed. The system which you are describing has been used first in Germany, where you take steam at either 110 to 120 degrees or 90 degrees, but that is the temperature of the steam, and of course not the temperature of the wood. If you go and employ your high temperature steam at 90 degrees and heat your wood to 90 degrees, then you will get a whole range of problems, but what you do in most cases in Germany and, as far as I am informed also in Holland, is that you actually only heat the wood up to 50 to 60 degrees Centigrade.

On your question regarding the degree of fixation in Figure 2, I was fearing these questions, because it is something which needs to be defined. What we are usually trying to do in our company is to look at it from a practical point of view and not from the point of view of a laboratory. What we have done here, and what we are proposing to do, is to take cores of either 10 mm penetration or 5 mm penetration, but that has to be decided, and then leach those cores for a period of time, which also has to be decided, and then from the leached water decide the amount of chromium that you have in the water. Then for the degree of the fixation you have to decide whether, if you talk about percentages, you are talking about percentages of the amount of chromium that you have brought into the wood or if you are talking about the amount of chromium which can be leached from the wood after the end of the treatment process, so there are a number of questions where there are no standards, and we have been asking for and making proposals for standards for quite some time now, but there has been some foot-dragging also from the preservative suppliers unfortunately on this issue. So when you look at many different works you will find different methods being employed which make it very difficult really to compare these, and I would say once again, as I have said many times, that this is an area where the industry needs to sit down and find a proposal for a standard.

MRS. CORNFIELD: Thank you very much. I think that has answered the question. Just a comment on the timber surface temperatures. We get timber surface temperatures of 80 degrees with no problems with spruce, but on the degree of fixation, perhaps if it was given in some quantitative measured units ...

MR. MOULDRUP: You are qualifying, you are now saying "on spruce", and 80 degrees, but are you talking about 80 degrees on the surface, which certainly you will be getting if you are using steam at 90 degrees, but what about the timber in-depth? That depends of course on the length of time that you put your wood in the treatment cylinder. So we have to be very exact when discussing these matters.

DR. D.J. DICKINSON (Imperial College): Chris, can I ask a question about any changes of biological efficacy with these sort of processes? You know that when doing an experiment in the laboratory with light organic solvents, the standards lay down very clearly how slowly the samples should be dried to prevent any redistribution of the active ingredients. Do you get different distribution patterns after accelerated drying?

DR. COGGINS: Of LOSP treatments? I cannot tell you. There may be some work available on that, but I am not sure.

DR. DICKINSON: And of course the same with accelerated fixation at high temperatures. Are we getting the same reaction products? Are we getting the same micro-distribution, which leads on to the question are we then going to get the same long-term biological performance from wood which is fixed in this way?

MR. MOLDRUP: Some work has been undertaken in Germany to study this question in lab tests. The Germans have been looking at possible decay problems with wood fixed at high temperatures in this case. It was established that with the exception of CCA and soft rot there would be no change to the results obtained for wood fixed not at high temperature.

DR. DICKINSON: That is what I would predict, I would have thought. There is just this question of long term effect.

DR. COGGINS: Coming back quickly to your point about organic solvent treated timber, David, of course, at the moment there is not, in British Standards anyway, a requirement for any particular drying schedule or indeed penetration or loading pattern, but with the change in standards looking for particular penetration and loading patterns, those will have to be complied with and clearly if drying is used, one would need to look at the whole process, and the end point, before determining what is the best way of drying.

DR. DICKINSON: Did you say 50 per cent recovery?

DR. COGGINS: Yes, typically about 50 per cent can be recovered.

DR. DICKINSON: At those levels probably that would have a minimal effect on redistribution.

MR. A.J. BUIJS (Flexichemie): I have a question on the accelerated fixation. I wonder when you are using hot water for the fixation if not a lot of the salts at the outside of the wood will dissolve into the water and be leached out before fixation takes place. So will not too much of the salts be dissolved into the water and no longer be available for fixation?

MR. MOLDRUP: I am not quite sure I understood the question, but it appears to relate to the use of liquids or water for accelerated fixation. It is true, and I think we will be back to that during a paper this afternoon, that especially in the case of spruce you can have an amount of surface preservative which has no connection with the wood, and also that preservative will bleed out for quite some time, maybe days after treatment, and this preservative of course cannot fix with anything, so it will turn into sludge in hot water, but provided that you design your treatment schedule in such a way that there is no surplus preservative on the surface of the wood, the hot water fixation will not leach out preservative from the surface to make the retention smaller. We have done some tests on this, and it is fantastic to observe the influence of temperature and chromium based preservatives with wood. There will be an instant fixation of your preservative right in the surface, which will not leach out when you continue with your process for in-depth fixation.

MR. G.A. EWBANK (Fosroc): Thank you, Chris, for a very interesting paper. A comment on the rather alarming figures for the VOC emissions from air dryers: I think this is an issue the industry obviously has to address, but the practical implication at the moment is maybe not that significant, because in practical terms most timber is dried in the open air, and you cannot apply a limit on emissions that relates to a vent if there is no vent. I am not trying to skirt over the problem; it is obviously something that needs to be looked at. Secondly, a question on the accelerated fixation with CCAs. Is there any adverse effect on the additives, like colorants, dyes, pigments, to the solutions because of the temperature?

DR. COGGINS: Picking up your point about the effect on additives, this is one of the reasons why the plant at Blenheim has both steam and hot water fixation systems. With, for example, brown coloured CCA treatments, they use steam for that, and the results have been excellent. In fact, there is a suggestion that the steam fixation improves the permanence of the colour.

MR. H.W. HISLOP (Maljon Timber): Purely as a user and a practical question, as we all know, timber is shaped by heat and steam. What problems are you incurring in wide boards in particular as regards twisting and warping?

MR. MOLDRUP: That is a quite simple question to answer. If you have no drying as part of your fixation process, there will be no dimensional changes in the wood, and you will not have a problem, and most fixation processes are designed only to fix and not to dry the wood except in the outer limit of the wood, so you will not have any problems with twisting or warping.

MR. M. CONNELL (Hicksons): Just one final comment perhaps on chromium fixation. Speaking as one of the groups of preservative manufacturers that were suppossedly dragging our feet in Denmark on chromium fixation, as Bror Moldrup explained, it is very, very difficult to establish meaningful standards in this respect and one of the problems of the core and squeeze test as it has been defined is how in fact it relates to a practical risk for the person handling the treated timber, and the work goes on, I think, to identify a satisfactory method. The core and squeeze test does appear a very artifical way, I think, of determining risk, but the question I have is completely different, nothing to do with chromium fixation. It relates to the integrity of bunds. Both your paper and Dr. Bigg's this morning identifieid the importance of bunding as an integral part of pollution control. The question I would like to ask Bror is what recommendations he would give to ensure the continuing integrity of the bund on an ongoing basis. A bund, or its integrity, will not last for every, so what kind of maintenance checks would he recommend?

MR. MOLDRUP: One would almost think I had paid you to ask that question. On the question of bunding – my English is not that good – on bunded areas, I and my family have started a number of treating companies in Denmark and abroad, and we have had for many years bunded areas for holding treated timber, and what we do establish unfortunately is that these bunded areas do not last for ever. They last unfortunately for a very short time. After a few years we see cracks in concrete, we see asphalt or tarmac not being impermeable, which means that the preservative solution pollutes the ground underneath the bunded area, and that is one of the reasons that we, or I personally only believe in accelerated fixation as an integrated part of the treatment process. You should never move your treated wood out of the treatment vessel before the primary fixation has been concluded.

THE CHAIRMAN: I must apologise to the President for allowing this session to run 15 minutes over time, but of course, I must thank both Bror and Chris for a fascinating and well-illustrated paper on this most critical subject. Equally, may I thank them for conducting such an interesting question session, and I invite you, this morning's audience, to show your appreciation to Dr. Coggins and to Bror Moldrup. *(Applause).*

ADDING VALUE TO CCA TREATED TIMBER

by J. A. Cornfield
Hickson Timber Products Ltd., U.K.
R. Sturgis
Hickson Corporation, U.S.A.

Introduction

CCA has a 55 year history of commercial use. It is often regarded as a mature product by timber treaters, but market research in the U.S. has shown that retailers do not think the market is saturated (Resource Information Systems Inc, 1990). We believe that there are opportunities for growth in the U.K., the U.S. and in Europe and this growth will result from the development and promotion of high quality, value added, treated timber products.

The economic benefit associated with CCA treatment of timber is most easily shown by comparing the cost of treatment with the cost of repair or replacement incurred by failure of untreated timber. The cost to preserve timber can be as low as 5% of the value of the untreated timber, whereas the replacement cost is around 500% of this value. In this paper we examine new developments in additives for CCA and alternative processing techniques and how these can be used to further add to the value of CCA treated timber.

The durability of CCA treated timber is well established with a service life of 40 years in ground contact specified in BS5589. The perception of quality in treated timber depends not only on the preservative chosen for treatment, but also on: timber species; appearance; country of origin; seasoning regime; moisture content; preservative retention; uniformity of colour and shade; resistance to leaching and weathering; freedom from mould and efflorescence; treatment by quality assured treaters and use of leading preservative brands.

These factors are taken account of in the marketing of high value preserved outdoor wood products. Adoption of the highest specifications for timber, preservation and design yields building products with aesthetic appeal and enhanced durability. Such quality products can be promoted on the basis of quality, guaranteed performance and treatment with a brand name preservative.

Use of leading brand of CCA will assist treaters in receiving orders against specification. Market research has shown that the majority of specifications for preservative treated timber in the U.K. are written by reference to the brand (INDAL, 1991). In many cases this is also backed up by quotation from the relevant British Standard. Certain branded products also offer guarantees that extend for decades. These reinforce the British Standard Specifications and give increased confidence in the use of preservative treated timber.

Targeting unique custom designed products for specific end uses has proven a successful marketing strategy in the case of supply of sound barrier timbers in Holland. CCA treatment is followed by drying and oil treatment which gives an attractive coloured water repellent finish. The timber barriers are designed, treated and assembled to a very high technical specification and provide an improved visual and aural environment over that which can be obtained by use of less sympathetic materials. By demonstrating what can be achieved with well preserved, well designed timber structures, the use of timber and timber preservatives are thus promoted.

A notable success story in the marketing of preservative treated timber with added value has been that of water repellent CCA treated timber in the U.S.A. Because of consumer desire for such a product, pressure treated water repellent formulations quickly gained acceptance within a one year span (1989-1990) and captured 6-8% of the overall U.S. CCA market. Substantial growth in the water repellent category is forecast for the 90's.

Another CCA additive – an oil emulsion – was recently introduced in the U.S. The emulsion improves the climability of CCA treated poles. This new development is being exploited in the U.S. to better position CCA as a viable alternative to traditional oil penta and creosote formulations.

Colour additives for CCA increase the value of the treated timber. In the U.K. these have been successfully exploited in the competitive fencing market to gain increased margins. In certain regions of the U.S. where consumers prefer the colour of cedar and redwood, colour additives have enabled pressure treated wood to compete successfully.

Other additives for CCA are available to fill market niches, and allow the use of CCA under adverse local conditions. In Africa and Australia grass fires are common. In these countries CCA treated timber is popular but it can suffer from the phenomenon of afterglow, where burning of poles continues after the fire has passed. CCA additives are available which minimise the damage caused by afterglow and allow use of CCA in areas prone to fires.

Mouldicides are available for use when prompt drying of CCA treated timber does not occur. Wet CCA timber is susceptible to unsightly mould growth. In the U.S. 20-30% of the overall CCA market utilises mould inhibitors. These should not, however, be used in an attempt to treat green or partially seasoned timber. Under these conditions treatment will be of a poor quality, with untreated timber in the centre susceptible to decay, and the potential for mould growth will not be completely eliminated.

Kiln drying and controlled fixation of CCA treated timber can reduce drying defects and promote a uniform timber appearance. Drying, in particular, adds value to the treated timber eliminating the problems of working wet timber and allowing immediate use for construction. Both drying and controlled fixation reduce the environmental impact of treatment plants. Results from research work carried out on these methods are presented. The benefits to the user of drier, consistently well fixed timber must be actively marketed in order to capitalise on the benefits of adding value to treated timber by these methods.

Water Repellent Additives

Water repellency, surface appearance and resistance to weathering of CCA treated timber can be enhanced by incorporation of a water repellent additive into the treatment solution. This feature has been promoted successfully in the U.S. where there is a large market for treated timber in the construction of timber decks, or raised wooden patios, around private houses. Homeowners recognise the harmful effects of weathering on the appearance of wood, either from their own experience or from the extensive advertising of brush-on water repellents.

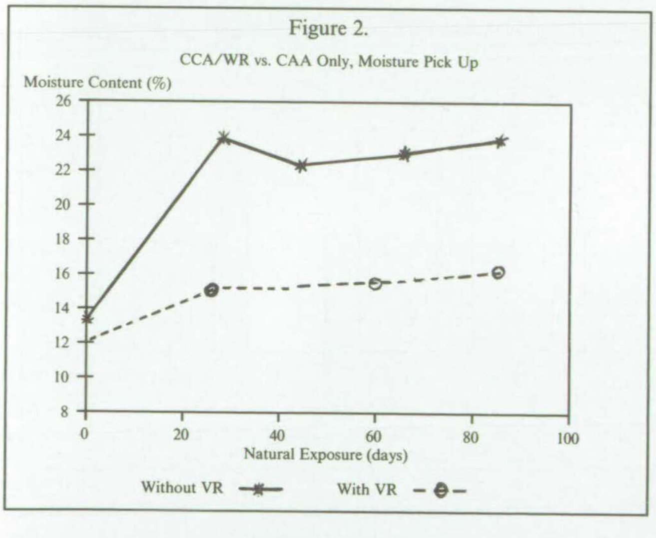
The marketing success of Wolmanized Extra weather resistant lumber – wood pressure treated with CCA and water repellent – is directly linked to the market research conducted prior to the product's introduction. The research not only assessed the perceptions and attitudes relative to the use of pressure treated lumber for residential projets but also examined the desirability of pressure treated lumber with water repellent. The research results were unanimous in confirming that consumers want pressure treated lumber with water repellent and are willing to pay more for the added benefit of long lasting appearance.

All levels of distribution benefit by offering water repellent pressure treated wood. Treaters are able to make more money on their finished goods and better position themselves within the marketplace by offering product differentiation. Retailers benefit by introducing an innovative product that provides better margins, less inventory loss and fewer customer complaints. Consumers benefit because their projects look better longer and their expectations are met. Pressure treated lumber with water repellent fulfills the needs of the marketplace.

Rain falling on water repellent treated timber exhibits a pronounced beading effect, as can be seen in Figure 1. This high level of surface hydrophobicity and beading persists for around twelve months depending on conditions, internal protection remains indefinitely. Weathering tests showed that after three years outdoor exposure, water was only absorbed very slowly from water repellent treated timber. Timber treated with CCA containing no water repellent additive soaked water up rapidly from the start of the exposure. The water repellent present deep in the timber was, therefore, still acting as a barrier to moisture pick-up and resisting weathering.

Fig. 1. Water beading on water repellent treated timber

Matched samples of timber were treated with 2% CCA Oxide C with and without the water repellent additive. The samples were dried, then exposed to natural weathering. The moisture pick-up was determined by periodic weighing. The results are shown in Figure 2. The difference between the moisture uptakes is very pronounced, and it demonstrates the effective performance of the water repellent treatment.

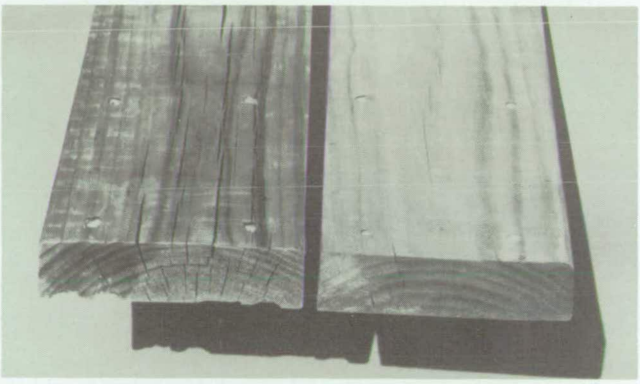


Natural Exposure (Days)

Fig. 2. CCA/WR vs. CCA Only, Moisture Pick Up

The effect of reducing the rate and extent of moisture uptake is to minimise the extent of checking, warping and grain raising of the water repellent treated timber. The overall appearance is thus enhanced as shown in Figure 3. The reduction in checking is particularly important where uncontrolled air drying is used after treatment; incorporation of the water repellent into the CCA treatment solution protects the timber during the critical period when it is drying from a fully saturated condition to equilibrium with atmospheric humidity. The presence of the water repellent also improves the workability of treated wood, making it easier to saw and nail.

The water repellent additive is a water based emulsion. It is easily mixed with the CCA solution and applied to wood using a single stage treatment. No changes are required in treating procedure using Baltic Redwood. Commercial treatments have been done for four years using CCA Oxide C. Stability of the treating solution is maintained indefinitely, provided it is used frequently and prevented from freezing. No problems are encountered when the solution remains unused for periods of up to two weeks. Use and addition of fresh solution agitates it sufficiently to prevent any separation.



CCA only *CCA plus water repellent*

Fig. 3. Water repellent treated timber after weathering

The stability of the water repellent emulsion was tested with a range of preservative formulations under more severe static laboratory conditions.

TABLE 1

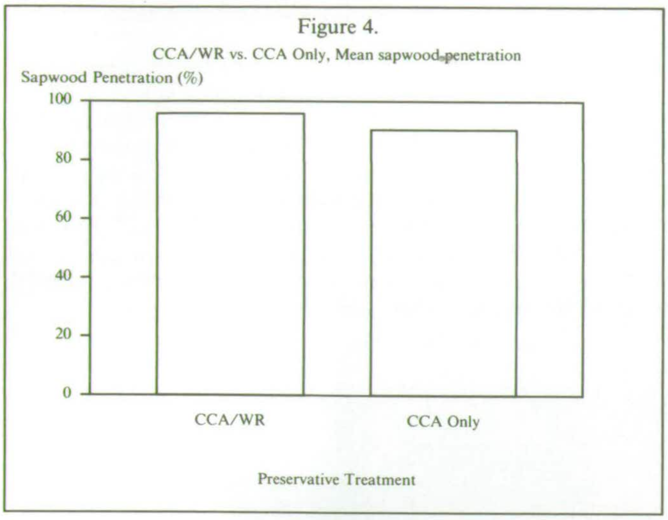
Stability of water repellent emulsion with a range of preservative formulations under severe laboratory test conditions.

	Shelf Life of Undisturbed Sample (weeks)			
	CCA Oxide C	*CCA Salts* Type 2	*CCA* Oxide B	*CC* Oxide
5°C	> 16	> 16	> 16	16
20°C	3	5	> 16	> 16

All formulations are at least as compatible with the water repellent as CCA Oxide C which has given indefinite stability in commercial use. In the laboratory test greater stability was shown at the lower temperature, because oxidation of the emulsifier system which leads to eventual breakdown of undisturbed samples occurs more slowly at lower temperatures. Stability is greater in practice than in this laboratory test, because under normal conditions of use solution is taken up by timber and replenished with freshly mixed CCA and water repellent.

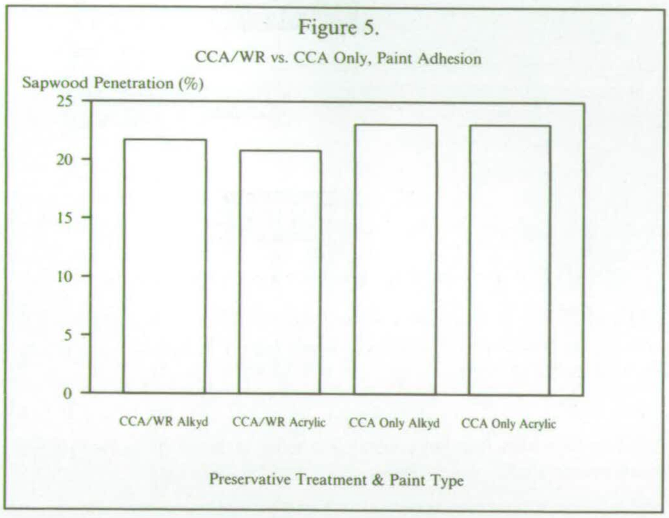
Timber treatment trials were done on Baltic Redwood using a full cell cycle. Matched samples were end sealed and treated with 2% Oxide C with and without water repellent present. The results are shown in Figure 4.

No reduction in uptake of treatment solution or depth of sapwood penetration occurred when using the water repellent additive. Drying trials on Baltic Redwood have shown no significant difference in air or kiln drying times for timber treated with CCA only and with CCA plus water repellent additive.



Preservative Treatment

Fig. 4. CCA/WR vs. CCA Only, Mean Sapwood Penetration.



Preservative Treatment & Paint Type

Fig. 5. CCA/WR vs. CCA Only, Paint adhesion

Using Southern Yellow Pine treated to a modified full cell cycle penetration is maintained but overall uptakes are increased slightly with the water repellent additive present. Commercial drying trials in the US have shown that drying rates are not significantly different but, due to the slight increase in uptake, overall drying times may be slightly longer when the water repellent additive is present.

A laboratory evaluation of the effect of the water repellent additive on the paintability and paint adhesion was done. Baltic Redwood treated with 2% CCA Oxide C only and CCA Oxide C plus water repellent was overcoated with three coats of solvent based or water based microporous coating. The pull-off adhesion test described in BS 3900 Part E10 was used. The results are shown in Figure 5. The mean adhesion values are similar for all systems. External weathering tests have shown that coatings perform as well over water repellent treated timber as over timber treated with preservative only.

Further details of all the experimental work described have been given by Warburton, Cornfield and Fox (1991). Work on alternative water repellent system for CCA has been described by Zahora (1991), and Fowlie, Preston and Zahora (1990).

The main potential for the use of a water repellent additive in the U.K. is in outdoor decorative applications where use of timber is in the ascendancy. In these applications cracks which appear in timber due to shrinkage and swelling are detrimental to both the appearance and function of the timber. The water repellent additive minimises this effect and is particularly suitable for timber destined for gardens, parks, and local authority amenities such as playgrounds.

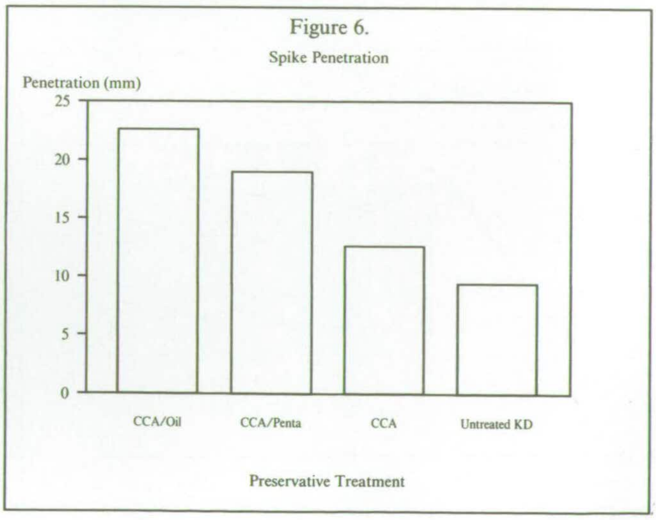
AN OIL FOR POLE TREATMENTS

In the U.S., electric utilities use approximately three million treated wood distribution poles annually. The market share for each of the major preservatives roughly breaks out as follows: pentachlorophenol 60%, creosote 20% and CCA 20%.

The primary reason for the low rate of CCA usage in the utility industry is pole climability. Maintenance work is often done by climbing the poles, utilising spikes or gaffs on the lineman's boots. Linemen do not like to climb CCA poles because they are harder than poles treated with pentachlorophenol in oil or creosote, and gaffs do not penetrate as well. When gaffs don't adequately penetrate, linemen risk falling from the pole.

An oil additive for CCA has been developed to eliminate the climability concern.

Details of six month and one year climbing evaluations and strength, corrosion, conductivity, migration, fixation and biological testing have been given by McIntyre and Fox (1990). Maintenance workers climbed CCA/oil treated poles, CCA only and oil/PCP treated poles which perform similarly to poles treated with creosote. The depth of penetration of the climbers spikes was measured, the results are shown in Figure 6. The average depth of penetration of spikes was ranked in the order CCA/oil 22 mm > oil/PCP 19 mm > CCA only 13 mm, this demonstrates the improvement in climability with emulsified oil. During these trials the maintenance workers also expressed a clear preference for the CCA/oil treated poles over the oil/PCP and CCA only treated poles.



Preservative Treatment

Fig. 6. Spike Penetration

Research and development work on Wolmanized ET™ (emulsion treated) poles started in the late 1980's. Pilot plant trials were followed by full scale commercial tests which concluded in 1990. Commercial introduction commenced in November of 1990 and the product was approved by AWPA in May of 1991.

This value added product strategically positions CCA as a viable alternative to oil based formulations for the utility industry.

High Quality Wood products

An outstanding success in the promotion of CCA treated timber was initiated in 1974 with the first major promotional campaign for 'Wolmanized' wood aimed at D.I.Y. enthusiasts in the U.S. The 600% growth in production of treated timber in the U.S. between 1974 and 1988 is due to the establishment of a retail market for treated timber.

Details of technical and marketing approaches which have resulted in high value treated wood products which also appeal to the specifier are drawn from our experience with 'Hickson Leisure Developments' in the U.K. and 'Soundwood' and 'Weerbaar Hout' in Holland. Particular emphasis is given to preservative selection and the preservation techniques used.

Production of these premium quality products has relied on a holistic approach whereby only the highest quality option has been chosen in every aspect which contributes to the final product. In this way, value is added at every stage in the design, production and construction process. The resulting systems are promoted to consumers and specifiers on the basis of their high quality and by reference to the intrinsic advantages of timber. Namely, that it is a natural, environmentally sympathetic material with a pleasing appearance which is flexible and easy to use. This is backed up by the technical specification which includes use of high quality timber treated with a leading preservative brand and performance guarantees. This overcomes the most cited disadvantages of timber, which are poor timber quality, susceptibility to decay and cost of maintenance.

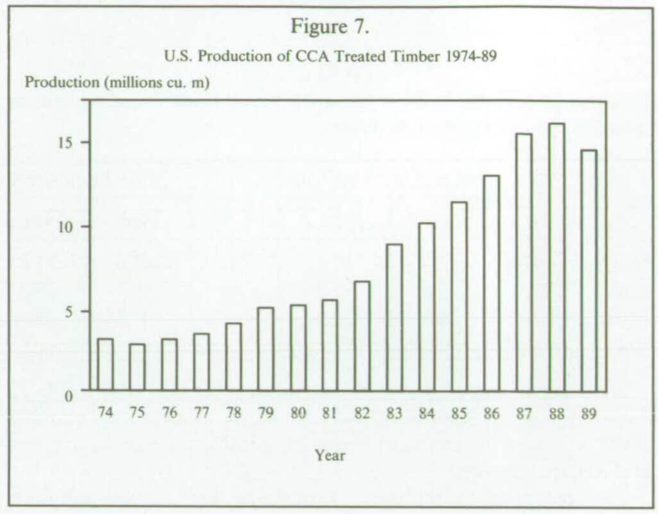
Outdoor[R] wood is a premier type of Wolmanized wood aimed at the D.I.Y. deck construction market in the U.S. It is made only from top appearance grade lumber which is dried after treatment and contains a water repellent. Retail sale of timber for deck construction is of vital importance to the U.S. preservation market; it is responsible for more than three quarters of the CCA usage. This accounts for the difference in per capita consumption between the U.S. and the U.K. with usage of treated timber being ten times higher in the U.S. whilst the population is only four times higher. The rapid growth of the U.S. market shown in Figure 7, is due to promotion and adoption of treated timber for deck construction. Comparative growth figures for the U.K. and U.S. for the years 1983 to 1988 are 25% and 80% respectively over the five year period.

The oustanding growth of pressure treated lumber between 1974 and 1988 can be attributed to successful marketing and promotion campaigns capitalising on the outdoor living trend. Over 20% of all U.S. homes have decks (NFO 89/90) and new deck construction is forecast to grow 10% for the next three years (NFO 89/90).

Homeowners have been able to expand their living space in an affordable and aesthetically pleasing manner. Decks are desired as decorative and functional extensions to the home which enhance its value and can be used for entertainment. They are preferred over patios for their beauty and adaptability to the terrain. Quality of the treated lumber used is important to consumers; structural stability, resistance to rot, durability and product safety also rank highly. the average size deck is 350 square feet and the average cost is around £1,000 per deck.

While projected growth of the deck market is positive, the CCA lumber market in the U.S. is entering the highly competitive mature phase. Product differentiation is one of the keys to economic survival for treaters, therefore quality value added products are extremely important for the 1990's.

Timber engineering systems products in Holland and the U.K. are designed to high aesthetic and engineering standards. Custom design for specific projects is available. Northern Scandinavian Redwood is selected for its strength and permeability properties, and pith wood is excluded. the timber is kiln dried and fully machined prior to treatment to give complete sapwood penetration and ensure that all exposed faces are well preserved.



Year

Fig. 7. U.S. Production of CCA Treated Timber 1974-89

'Weerbaar Hout' is a system for production of timber for high hazard uses such as bridges and dyking timbers which are installed along canal banks and provide bank stability and resistance to erosion. Due to the risk of decay and susceptibility to checking associated with this environment, the timbers are incised to a depth of 3-8 mm prior to treatment. This increases the overall uptake of preservative and improves the treatment given to less permeable heartwood areas. It also minimises the checking that would otherwise occur due to differential moisture contents in the portions of the timber above and below the water line.

For all these treated wood systems the selection of CCA preservative type is very important in determining the quality of the surface appearance. CCA wood preservatives are available with different ratios of preservative elements and can be prepared from salts or oxides. These variables affect the sodium sulphate content of treated timber, and the level of fixation of the preservative.

AWPA Standard P5 defines three oxide formulations, two of which are used commercially today. CCA Oxide C is the single most widely used CCA preservative, it accounts for 80% of the world market, the bulk of which is used for treatment in the U.S.A.

Usage of CCA Oxide B which corresponds to 'Boliden K33' is much lower at 5% of the world market and predominates in Northern Scandinavia. These two formulations which are prepared from copper oxide, chromic acid and arsenic acid are given in Table 2.

TABLE 2

Percentage of chromium oxide, copper oxide and arsenic pentoxide in AWPA CCA Oxides B and C.

	Oxide B	*Oxide C*
$Cr0_3$	35.3	47.5
Cu0	19.6	18.5
AS_20_5	45.1	34.0

In the U.K., CCA Salts Types 1 and 2 which conform to BS 4072 are commonly used. These formulations account for 15% of the world market with the U.K. using approximately half of the salts tonnage. CCA salts formulations are prepared from sodium or potassium dichromate, copper sulphate and arsenic acid. The formulations are given in Table 3, expressed in the usual way as hydrated salts. Equivalent metallic ratios are also expressed as oxides for comparison with AWPA Types B and C.

TABLE 3
Percentage of Salts in CCA BS 4702 Types 1 and 2 and equivalent metallic ratios expresed as oxides.

	UK Salts Formulations			*Oxide Equivalents*	
	Type 1	*Type 2*		*Type 1*	*Type 2*
$Na_2Cr_2O_7.\ 2H_20$	4.10	45.0	$Cr0_3$	45.3	51.5
$CuSO_4.5H_20$	32.6	35.0	$Cu0$	17.1	19.0
$As_20_5.\ 2H_20$	24.6	20.0	As_20_5	37.6	29.5

By comparison of Table 2 and 3 it can be seen that the U.K. Types 1 and 2 Salts formulations most closely approximate AWPA Type C in terms of ratios of metallic copper, chromium and arsenic present.

The presence of sodium dichromate and copper sulphate hydrates in the salts formulations affects the level of the soluble non-preservative component, sodium sulphate, in the treated timber. This harmless by-product is formed after evaporation of the water carrier for the preservative. It can effloresce as a whitish deposit on the surface of freshly treated timber. These soluble deposits are washed away on exposure to weathering but nonetheless can detract from the appearance of CCA Salts treated timber at the point of sale.

Oxide treated timber has a cleaner more attractive appearance and gives good adhesion of surface coatings applied to the freshly treated and dried timber. Oxides have been selected as the CCA preservatives of choice for treatment of D.I.Y. deck construction timber and landscaping elements for which aesthetic appeal is a fundamental requirement. In the U.S. approximately 95% of the CCA treaters use oxides rather than salts.

In deciding which CCA formulation will give the best quality product not only the question of salts or oxides but also that of the optimum ratio of preservative elements to use must be considered.

Much research work has been done to determine the best ratio to minimise leachability in service. This has been reviewed elsewhere (Connell and Nicholson, 1990). The work shows that the composition of CCA preservatives significantly affects the type of complexes formed during fixation and hence the ultimate leach resistance of the product. Several studies have shown that Type C Oxide formulations and Types 1 and 2 Salts formulations which are close to the Oxide C formulation in copper: chromium: arsenic balance, are optimised for maximum permanence. No differences between oxides and salts have been detected. A significantly greater level of arsenic leaching is found for Oxide B formulations. This has recently been confirmed (Cornfield, Bacon, Lyman, Waldie, Gayles, 1991).

Oxide C was, therefore, selected as the optimum CCA preservative in terms of minimising environmental impact and is used for treatment of all 'Outdoor' wood, 'Wolmanized' lumber, 'Hickson Leisure Developments', 'Soundwood' and 'Weerbaar Hout' systems marketed by Hickson.

The retention level of CCA Oxide C reflects the high exposure hazard for timbers which may be used in aquatic environments. Typical treatments are to refusal with loadings of 12 kgm^{-3} of Oxide C being obtained, this is equivalent to 16.5 kgm^{-3} CCA Type 2 Salts. These products are guaranteed for up to 25 years. For certain hazards such as non aquatic ground contact, out of ground contact and marine exposure lower and higher retentions are used respectively to ensure the guaranteed service life.

The environmental impact of preservation is further minimised by adoption of controlled fixation techniques. These ensure optimum conditions of fixation of preservative, a pleasing and uniform colour and a low tendency for checking.

For 'Soundwood' sound barriers treated by the unique 'SWAGA' process the timber is kiln dried after treatment to below 20% moisture content. It is subsequently impregnated by a double vacuum process to a retention of 30 lm^{-3} of Restol-oil a pigmented oil and resin based product. This gives an attractive appearance in a range of colours. The oil treatment stabilises the timber by minimising checking and reducing water absorption. The timber is assembled into panels prior to delivery and after installation a final coat of Restol is applied. This process gives a very high quality durable product with a particularly attractive surface appearance. As well as the preservative performance guarantee, the surface finish is also guaranteed for five years. 'Soundwood' has gained ground in the market as the usage of metal sound barriers, a lower cost option, dwindled for various reasons from a dominant position to virtually zero. Market share has also increased at the expense of hardwoods in recent years due to their decline in acceptability on environmental grounds.

Marketing of all these products as high quality, added value preserved timber has allowed a substantial premium price to be obtained over that for CCA treated timber.

COLOURED CCA

The green colour of CCA treated timber signifies durability. In the outdoor fencing and leisure market, however, an even brown colour is often preferred. Market research in the U.K. has shown that the demand for brown fencing is such that customers are prepared to pay a premium price for coloured treatments, and that golden brown colours are usually more desirable than dark brown. Colour additives for CCA were first used commercially in the U.K. in the late 1970's. Their development and impact in the market place is reviewed.

In the U.S., little if any price premium can be gained by adding colour to treated wood (Welling 1987). However, colourants are commonly used in certain areas of the country and for certain products where the normal CCA green is not desired. In those regions where redwood and cedar are popular and abundant, consumers are accustomed to darker coloured wood and will not accept greenish material. Coloured wood is also preferred for some treated specialty products such as fencing and roofing shingles.

Though unable to generate higher margins, coloured CCA treated wood enables U.S. treaters to compete where otherwise they would be excluded and to differentiate themselves from other producers.

Combined colouration and preservation formulations have been developed which can be applied in a single pressure treatment. These are more economical to use and the colour penetrates more deeply than when stains are applied to timber after preservative treatment by dipping. Alternatively, the colours which are compatible with CCA can be applied by a consecutive treatment in the pressure cylinder after the preservative treatment. This minimises the uptake and the cost of the colourant.

Colours which will resist one to three years weathering, depending on the exposure are currently in commercial use in the U.S. and in the U.K. By selection of appropriate dye and/ or pigment combinations a balance of good initial hiding power, good durability of colour and economy of operation can be obtained.

Natural weathering tests on timber treated with 2.5% CCA Type 2 Salts solution and a range of colour additives were done using severe exposure conditions with the timber inclined at an angle of 45°C to the vertical facing south. These showed that the greater the intrinsic light fastness of the dye or pigment used the greater the durability of the colour of the treated timber after exposure to weathering. Durability of colour was also related to the strength of colourant in the treatment solution. In particular use of high pigment dispersion strengths gave a very deep and long lasting colour to the treated timber.

The colourants are easily added to the CCA solution and applied to the wood by single or dual treatment processes. Commercial practice has shown that stability of the combined CCA and colourant solutions can be maintained indefinitely with an appropriate solution usage and top-up rate, irrespective of the CCA formulation type.

Timber treatment with dye additives has no effect on CCA penetration. The following work was undertaken to test the effect of pigment additives on treatment properties. Pine fence posts and mixed softwood stretchers and laths were treated using 3% CCA Type 2 Salts containing a 0.5% pigment dispersion. The following treatment cycle was used:

25" Hg initial vacuum held for 30 mins

12.6 kg cm^{-2} pressure held for 90 mins

25" Hg final vacuum held for 15 mins

Eighteen charges were treated over a period of 100 days with top-ups as required. Absorptions varied depending on the timber species, section and heartwood content. For posts, absorptions were in the order 390-490 $1m^{-3}$ for each charge.

Using stretchers and laths absorptions were in the range 230-675 $1m^{-3}$ for each charge.

Full sapwood penetration was obtained with Redwood posts. Dispersion stability was good. Evenness and intensity of colouration were good over the whole period of testing with very little difference in colouration being observed on different species and with different absorptions treated at different times for a given pigment strength.

These findings have been borne out with good product performance during commercial treatments.

Use of consecutive preservation and colouration treatments in a single treatment cylinder gives full sapwood preservative penetration of permeable species, and concentration of the colour in the visible surface zone. This results in a greater depth of shade which is more resistant to the effects of weathering for a given colour usage than when a 'one-shot' coloured CCA treatment is done. Such consecutive treatments require an increase of only 15% in the cycle time over that for a single treatment with CCA including a colour additive.

Commercial use of colourants in the U.K. has been concentrated in the fencing and garden products sector. This sector currently accounts for around 20% of the pressure impregnation market. There is significant opportunity for growth in sales of CCA preservatives and preservative treated timber for these end uses which accounted for over 800,000 m^3 softwood consumption in 1989 (Northern, 1989). The demand for pressure preserved timber fencing could be increased to account for the lions share of this consumption by promotion of coloured products with enhanced visual appeal, and by greater emphasis on marketing of the preserved wood product as a natural and durable material.

Controlled Fixation And Drying Of Treated Timber

Under traditional vacuum pressure impregnation processes the timber leaves the vessel in a wet condition and the time taken to achieve full fixation of the CCA chemicals varies considerably from season to season throughout the year. This can give rise to on-site pollution if insufficient covered concreted drip dry areas are available for storage of the timber until fully fixed. If the fixation process occurs under controlled conditions, then any concerns about the environmental acceptability of CCA can be significantly reduced. These benefits can be promoted to allow differentiation of fixed pressure treated wood in the market place.

The environment benefits are threefold: there is less risk of contamination of the treatment site since the potential for rainwater leaching and run-off pollution is drastically reduced; production of an environmentally safe treated wood product is ensured; and treating processes comply with all current regulatory controls in the U.K. and Europe relating to post treatment holding periods and fixation. Treaters benefit by reduced stock financing and increased convenience: extensive drip dry areas and civil works are not required; the stockholding and storage time of treated timber prior to despatch can be reduced; and no special precautions are required for handling the timber. The benefits to the user are that the surface appearance and uniformity of colour is improved, and physical damage such as splitting, checking and warping can be reduced.

Drying of treated timber gives further benefits to the user. The timber can be used immediately for construction purposes without risk of shrinkage, or problems associated with working with wet timber.

Fixation of CCA preservatives depends principally on the temperature and time of the fixation process as can be seen in Figure 8. Accelerated fixation techniques are based on the principle that the controlled exposure of treated timber to a heat source after impregnation will speed up the reactions in the timber. The literature on controlled fixation of CCA treated timber under drying and non-drying conditions has been reviewed elsewhere (Warburton, Cornfield, Lewis, Anderson, 1990). This shows that humidity control is important during fixation.

Because of the great variation in the equipment and operational requirements of CCA treaters there is no single controlled fixation process that will universally meet all needs,

The timber species being treated and the surface appearance which is required are important factors to consider when selecting a suitable process temperature. Resinous species, such as Baltic Redwood, have a maximum temperature above which resin bleed may occur, 40°C in this case. Southern Yellow Pine can be fixed at 70°C with no problems and woods of low resin content such as Spruce can be heated to 90°C. Where surface appearance is not an important criteria, then the maximum temperature quoted for a particular species may be exceeded, for instance, Larch can be fixed satisfactorily at 80°C with a low level of resin mobilisation.

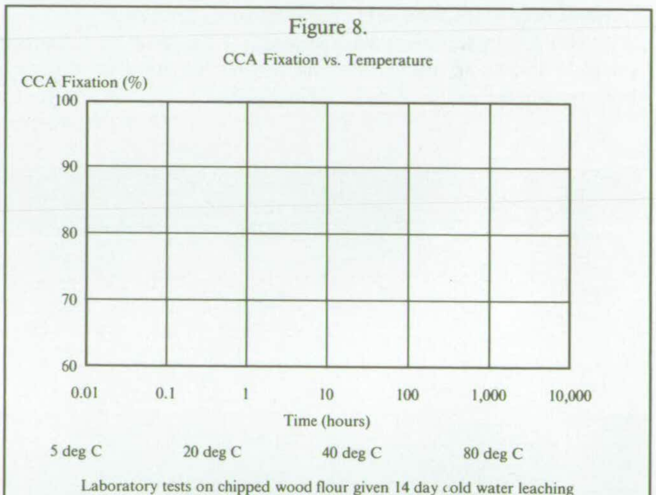


Fig. 8. CCA Fixation vs. Temperature

The time for the fixation process depends on several vessel design parameters: the type of heat energy used; the heat distribution system; and also on the wood dimensions and stickering configuration adopted. Maximum efficiency of accelerated fixation will occur with maximum heat flow. Thus timber rounds and fully stickered packs can be fixed more quickly than block stacked material. Time is required for heat to diffuse to the centre of individual pieces of timber, therefore, small section material can be fully fixed more rapidly than large section material. Where timber dimensions dictate that bundles must be fixed, or wood must be fixed with only minimal stickering then the schedule must be extended to allow for wood at the pack centres to warm up. Alternatively, a period in the fixation vessel may be followed by a hold time with the pack intact to allow heat to permeate to the centre of a pack and bring about fixation. In this case pollution due to rainwater is reduced since the surfaces of the packs are fixed.

A range of process techniques are available from which the most suitable can be selected to meet a particular treaters requirements. These are steam fixation, kiln fixation and drying, warm chamber fixation and heated room fixation.

In the steam fixation process the extra energy for accelerated fixation is provided by the use of steam. This has the advantages of being relatively inexpensive and provides optimum conditions for maximum fixation to occur.

Timber, pre-dried to 28% moisture content, is treated with CCA Salts or Oxide in a suitable stickering configuration to suit the steam fixation schedule required. The vessel is emptied of preservative solution and a final vacuum applied to remove excess solution from the timber, this is then returned to storage. The wood is then subjected to live steam so that the appropriate temperature, which can range from 40°C to 100°C, is maintained for the correct length of time. Condensed steam is pumped to a settling tank. The liquors are used for dilution of CCA treatment solution, settled sludge is disposed of as hazardous waste. In practice 1 kg of sludge is produced for every 100 m^3 of timber treated. Steam fixation may take place either in the same vessel as treatment or, more usually, in a separate chamber.

Depending on the schedule selected, the wood may be held in a stack under cover on a hard standing area for a specified period before despatch to customers, or alternatively may be despatched from site immediately.

Surface drying by evaporation occurs on removal of timber from the vessel. The extent varies dependant on the fixation temperature and species.

The steam fixation process has been used commercially in Holland for several years. A typical schedule for Spruce rounds is 90 minutes at 90°C. For unstickered packs the steaming period would rise to four hours with residual heat in the pack contributing to fixation after removal from the vessel.

A HIFIX installation with a single treatment and fixation vessel is shown in Figure 9. The first U.K. plant of this type was commissioned in March of this year.

Fig. 9. Accelerated fixation installation

In the kiln fixation process the extra energy is supplied by heated air. It is important, however, that sufficient humidity is provided in addition to the heat in order to prevent a reduction in the extent of fixation. Humidity should be typically 90% to maintain a good environment for fixation to occur. Timber treatment is the same as for steam fixation. The kiln should be equipped with air recirculation and heat and humidity controls. As with steam fixation, schedules depend on the species and end-use of wood.

Kiln fixation can be followed by drying. Experimental details of research work done on kiln drying of fully stickered treated Baltic Redwood have been published (Warburton, Cornfield, Lewis, Anderson, 1990).

The data presented showed the suitability of the kiln drying schedule given in Table 4 for use with Baltic Redwood. This schedule has been used commercially for three years.

TABLE 4

Kiln drying schedule for CCA treated Baltic Redwood

Time	*Dry bulb*	*Wet bulb*	*Relative humidity*
4 days	40°C	35°	70%
4 days	40°C	32°	55%

The humidity in the kiln is closely controlled so as not to interfere with fixation and to ensure that no surface or dimensional degrade occurs during drying.

The final moisture content of treated timber dried commercially to this schedule is 10-12%. The level of fixation of CCA Type 2 Salts is 98%, for CCA Oxide C it is 99%.

Research work has shown that certain cycle modifications can reduce the solution uptake whilst maintaining full sapwood penetration with Baltic Redwood. By using these modified cycles, the drying time can be reduced by two days and drying costs for CCA treated timber can be reduced. Treatment cycle times can also be reduced thereby increasing the throughput of the plants. Treatments to different preservative retentions can be obtained by using a full cell or modified full cell cycle with a single solution strength. Adjustments of solution strength, or provision of an additional storage tank is not required. It is necessary to intersperse modified full cell cycles with occasional full cell cycles to maintain solution stability.

Use of Lowry cycles, in which no initial vacuum is applied, were known to cause post treatment dripping and to increase sap levels and potential for sludge formation in the treatment solution. In addition, some treatment plants utilise an intial vacuum to fill the vessel and cannot be operated according to the Lowry process. Therefore, research work on modified cycles was directed towards minimising these potentially deleterious effects and to ensuring that processes developed could be operated on all plant types.

Matched samples of Baltic Redwood were end sealed and treated using 2.5% CCA Salts Type 2 solution by full cell, modified full cell and Lowry processes. The preservative uptakes were recorded. Further matched samples were sealed on all but the tangential face so that the maximum depth of radial penetration of sapwood could be recorded. The results are given in Figure 10.

Figure 10.

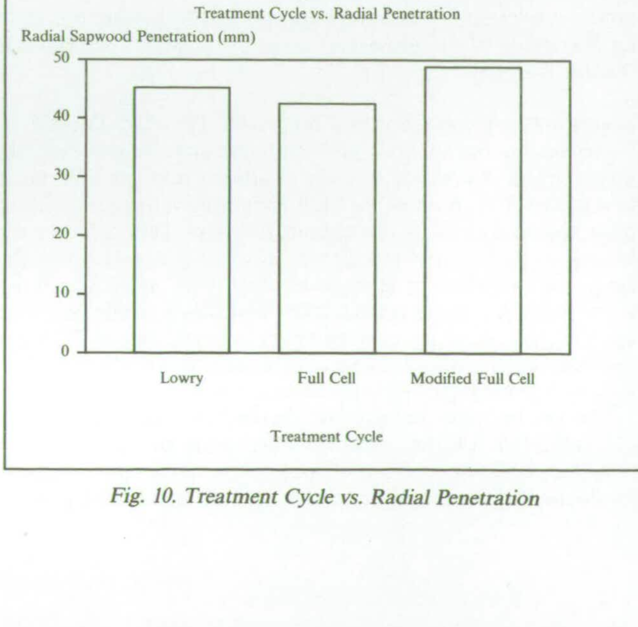


Fig. 10. Treatment Cycle vs. Radial Penetration

Analysis of the preservative salt gradient and balance of copper, chromium and arsenic at depths 0-10mm, 10-20mm and 20-30mm in the treated timber by X-ray fluorescence spectroscopy showed no significant differences between the treatments.

This showed that a reduction in preservative uptake of 30% could be obtained using a modified full cell cycle whilst maintaining the radial penetration of the treated timber compared to when a full cell cycle was used. Using the Lowry cycle it was found that repeated treatments would eventually bring about sludge formation irrespective of the number of treatments done between top-ups. The modified full cell cycle did not cause the same extent of build-up of wood extractives in the treatment solution. By use of a suitable sequence of treatment cycles and top-ups the solution stability could be maintained indefinitely.

Appropriate modified full cell cycles and treatment sequences can be specified for particular plant designs and customer requirements. This will allow timber treaters the advantage of drier treated timber and lower kiln drying costs, whilst maintaining the penetration and retention of preservative chemicals during timber treatment.

Controlled fixation can also be achieved by storing treated timber in a warm room. This prevents changes in the fixation time due to seasonal weather variations. The length of time the treated wood needs to be held in the warm room environment depends on the temperature maintained and whether the wood is block stacked or stickered. Typical fixation periods recommended would be two days at 20°C. The treatment vessel and warm room storage racks may be housed in the same building. Several benefits are available using this route: the timber is protected from the effects of rain and ultra violet light; the treatment site is protected from pollution; a better standard of fixation is assured during the winter months; and the working conditions would also be improved.

In order to choose the most cost effected controlled fixation system for particular operational requirements careful analysis of a wide range of factors is required. These include the reasons for considering the technology: environmental; regulatory compliance; improved handling; or market acceptability. Other variables to consider are: timber species; end use; throughput requirements; existing practices; site facilities; and future plans.

Marketing of high value preserved timber products relies on the promotion of timber as an attractive and durable material. In order to obtain a marketing edge for preserved timber which has undergone controlled fixation the product must be differentiated. One way of achieving this is by linking controlled fixation to other quality aspects of timber treatment such as the preservative brand, adoption of the quality management systems BS5750 by the treater, and promotion of performance guarantees for construction timber. Marketing in this way will link the name of the treater with high quality preserved timber products and allow a price premium to be obtained for a product with added value.

Conclusions

The main selling point for CCA treated timber will always be based on the usefulness of timber as a versatile, aesthetically pleasing construction material, and the necessity of preservation by a vacuum pressure process to insure against decay or insect attack thereby increasing the expected service of life.

However, there are opportunities for promoting additional benefits, particularly relating to treatments which give a more attractive appearance. Many of the 'added value' products and processes described have considerable technical benefits both to the timber treater and the user of treated timber. These developments are the results of an on-going research programme to improve the properties of CCA treated timber. They have all been commercialised and are used by timber treaters throughout the world as a means of adding value to their CCA treated timber.

We hope that we have introduced the technical work behind the developments and the way these have been used to give a marketing advantage to a wider audience.

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DISCUSSION ON PAPER 3

Chairman: P.D. North

THE CHAIRMAN: Thank you very much, Judith. I have been able to persuade Judith to answer a few questions from Dr. Coggins and from anybody else who would like to ask a few.

DR. L. D. A. SAUNDERS (Fosroc): Judith, thank you very much for a very clear paper. I have a question in relation to Table 1. You demonstrated that Oxide B and Oxide C contain very similar chemical species. The only real difference is the ratio between them, yet in Table 1 the water repellent additive, whatever it was, that was tested in that situation, you got quite dramatic difference in stability. My question is did you make up the Oxide B and Oxide C from the same batches of raw materials, that is to say, does the stability difference arise solely as a result of the difference in ratios of molecular species, or is there some more subtle effect of different impurities or whatever in the batches used?

MRS. CORNFIELD: The preservatives were made up from the same batch of raw materials and were made up according to the ratios of Oxide B and Oxide C, and it was found that the Oxide B formulations were much more stable than the Oxide C, and I think that is because of the higher level of chrome in the Oxide C, compared to the arsenic, with the copper level being the same. It is the hexavelant chrome that is doing the damage, because that is the strong oxidising agent which is causing the emulsifiers to be oxidised, and it causes the emulsion to break down.

MR. B. MOLDRUP (DWT): I am not going to ask you about the extent of your shareholding in Hicksons. I appreciate your presentation very much, but being also a wood treater, a number of things mentioned sounded too good to be true. Certainly on the question of using pigments directly in the preservative solution and obtaining a uniform and long-lasting colour, I find that a bit difficult to believe. Of course, uniform and long-lasting are relative words, but what I was going to ask regards the modified full cell process. This is quite important for the wood treaters. We have been proposing the modified process – we have called it modified intercell process – for a number of years, and for those who do not know – and correct me if you do not use the same system – it implies using a smaller initial vacuum and a longer final vacuum. It is quite true that it gives a very good result on Scots Pine, but we have been using it for 20 years and it has serious modifications if you go to Scots pine as with your leisure timber from northern Scandinavaia or on Spruce. On both of those timbers, as has been reported by Dr. Peck, regarding the pressure differences in wood, the creation of vacuum or pressure is so slow in northern Scandinavian pine or in spruce that you get exactly the opposite result of what you want to obtain if you use the modified full cell process for those two species. In both cases you create a surplus pressure in the wood because of the low initial vacuum, which is only released very slowly, and it is released so slowly that you will have your northern Scandinavian Scots pine or your spruce bleed for hours and in some cases for days, so you have to make a very serious limitation to the use of this process, but for normal Scots pine, it gives enormous advantages.

MRS. CORNFIELD: Thank you. Was that a question?

MR. MOLDRUP: If you want a question, I could put it this way: have you experienced the same thing?

MRS. CORNFIELD: Thank you for your contribution. We have found that, by using the particular process, you have to tailor the process to suit the treatment plant and suit the species that the treater is treating. We do this already with the full cell cycle, with different treatment cycles for spruce and redwood, so it is important to consider all those aspects, and to develop the cycle exactly to suit the treatment plant, but we have found that we can develop suitable cycles.

DR. K. J. ARCHER (Laporte Timber Division): Judith, in Figure 4 you illustrate the penetration of CCA and CCA water repellent as being fairly even. Does the water repellent component penetrate as far as the CCA? Do you know that?

MRS. CORNFIELD: We have not measured the exact level of penetration of the water repellent in this work on redwood, but the level of water repellent penetration in southern yellow pine has been measured and found to be suitable, the same as CCA. What we found here is that you get a difference when you treat the European species in the UK from that which you get with southern yellow pine, in that you do not get the increase in absorption with the European species using the normal cycle that you get with southern yellow pine using the low weight process.

DR. ARCHER: One other short question. Have you looked at the penetration spikes into the CCA water repellent poles at all? I notice in the paper you only talk about the CCA, but have you looked at CCA water repellent?

MRS. CORNFIELD: No. We have developed the oil for the pole treatment, and the water repellent is more for surface appearance, so the trials that have been done on spike penetration have been done on the oil-containing formulations for preference.

DR. ARCHER: We have done some work with our CCA water repellent emulsion, and it appears that the penetration of spikes is superior with the water repellent formulation.

MRS. CORNFIELD: Superior to CCA or superior to creosote?

DR. ARCHER: Superior to CCA.

MRS. CORNFIELD: Yes, but not superior to creosote as the oil emulsion is.

DR. R. MILLER (BRE): I was interested in your slide of the adhesion tests to the CCA water repellent products, in which you showed that both solvent-borne and waterborne paints showed good adhesion. Even indifferent waterborne paints would adhere quite well to dry wood, which is why the BS5082 primer standard requires a blister box test. I just wondered if you had checked the adhesion under wet conditions, where there might be slightly more sensitivity.

MRS. CORNFIELD: No. First of all we did the initial lab tests, which we were then quite happy to proceed with, and we have gone straight to external weathering exposure tests. We think the blister box test is most suitable for situations where condensation occurs such as joinery timber, whereas we think that with the CCA treated timber we are better going to natural exposure with rain and sunlight.

DR. A. BRAVERY (BRE): I just wanted to clarify, Judith, in the work that you did with spike penetration, have you looked at the combination with the high temperature improved fixation system? I wonder whether the slight embrittlement that tends to be associated with CCA treatment is markedly less with high temperature fixation because the period of exposure to more acid conditions is so much shorter, and therefore whether the spike penetration improvements might be even greater with that combination. Did I understand that you have not looked at the combination of water repellent and high temperature fixation? Are they incompatible?

MRS. CORNFIELD: We have no reason to believe that they are incompatible. With the oil formulation, we did the spike penetration tests without accelerating the fixation, because that is the normal method that is used at the moment with pole treatments.

MISS J. CARMO (Anglo-Portuguesa): Thank you very much, Judith, for your presentation. It managed to keep us awake after lunch. I would just like to say that at a time when treating with CCA is such an emotive issue, it is very nice to see enhanced its advantages and have an opportunity to air its value.

MRS. CORNFIELD: Thank you.

DR. COGGINS: Judith, thank you for a super paper on what can be achieved with CCA treatments. I have a couple of questions, first of all about water-repellent additives. As you know, your company, and indeed mine, did a lot of work on water repellent additives 20 years ago, when the demand for something like that really was not there. Our work over that period indicated that the life of the sort of products that we used then was rather limited, and given that we are looking at timber which has a life measured in terms of decades, I wondered what sort of life you are expecting from the water repellent additives used now, and in that context, what their costs are, what sort of added cost is involved in getting the added value, and also whether you were able to give any information on whether there is reduced loss of components to water in service, so that sort of life costs and effect on loss of components with water repellent additives. Secondly, if I may, on the question of guarantees: guarantees are an emotional issue for the BWPDA, particularly for the remedial treatment side of the industry. I wonder what the consumer is actually getting with the performance guarantees that you mentioned. It is an important element in future for pre-treated timber, but what is the consumer actually expecting and getting.

MRS. CORNFIELD: I made that four questions. The life of the water repellent additive: it depends what you mean. You get two main effects with it. One is the beading effect, and that depends a lot on the exposure conditions, but you get from about one to three years of the beading. However, that is not really the main benefit. The main benefit is in the reduction to checking, and the process has been used commercially for four years, and after that period you do see an improvement in the appearance of the timber. What we find a lot, particularly in timber that is treated for a good appearance, like the decking market, is that it is not when the timber decays that it is replaced; it is when it warps and checks and does not look nice any more, so we find that there you are increasing the life of the appearance.

The next question was the cost. I think you would be looking at round about 15 per cent.

The third question was loss of components. If you have an oil or water repellent additive in the formulation, it does reduce the loss of any components which would normally be washed out in field performance such as boron, but of course, here we were talking about CCA and with CCA the preservative is fully fixed.

DR. COGGINS: I was talking about the environmental impact.

MRS. CORNFIELD: Okay. It does result in a reduction in rate of loss of components of systems, and from the point of view of guarantees, all the guarantees do really is reinforce what is already written into the British Standards, and they are really saying that we, the treaters, have confidence in our product and we are prepared to say so.

THE CHAIRMAN: Ladies and gentleman, we have run out of time. Before thanking Judith, can I make a genuine comment about microphone technique. I am sure everybody will agree that Dr. Coggins' technique – I know this sounds like the beginning of a joke, but it is not – is probably exemplary, and I notice that he held it horizontally and at about that sort of level. I found listening to his questions easier than listening to anybody else's, and I think it is important that we should get this question of technique correct. I am just passing this on as a free tip, and I am sure that Dr. Coggins will not mind sharing his great experience in these matters with the rest of us.

As to the paper, I thought it was a most refreshingly commercial paper. I think most of us at this stage are very glad of any kind of a commercial edge, and this paper was, as the charming young lady said, extremely welcome and very timely. I am sure you will appreciate what has been done for us, and join me in thanking Judith. Thank you very much indeed. (applause).

ADVANCES IN THE PRESERVATIVE TREATMENT OF COMMERCIALLY IMPORTANT TIMBERS

by R. J. ORSLER and G. A. SMITH

1. INTRODUCTION

Methods used for the industrial pretreatment of timber in the UK are currently prescribed in certain key documents (codes of practice), such as the British Standards BS5268: Part 5 and BS5589, and the BWPA Manual, which are the practical result of research and development in this area carried out over a considerable period. Twenty years ago it was usual to define preservation requirements in terms of the results expected from the various treatment processes (Anon 1972a, BS 4072:1974), but changes in commercial practice, such as the routine preservation of timbers that are relatively difficult to treat, together with the introduction of legislation governing trading practices led to the development of specifications in terms of the process itself.

When codes of practice first appeared and only a few timber species were routinely treated, it was practical to list those processes that were appropriate for specific timbers, for example BS5589 of 1978 listed only European redwood, European whitewood and hemlock in the section dealing with the treatment of exterior joinery. However, as more species appeared on the market this approach became unwieldy and a generalized system was introduced in which recommendations for treatment were based upon a natural durability and treatability classification (Anon 1985) rather than a reference to the needs of specific timbers.

Recently, when using this sytem, it has been found that some timbers, often those of relatively recent commercial importance, do not receive the expected level of treatment when the relevant recommendations within the codes are carried out. Problems of both under-treatment and over-treatment have been observed in the industry. Such problems usually derive from the treatability characteristics of the wood species themselves, from the practicalities of timber drying or from the commercial practice of supplying timber in parcels of mixed species having different treatability and natural durability characteristics.

In recent years BRE has addressed several problems relating to the response to treatment of certain commercial timbers under the sponsorship of particular government departments, sometimes with co-sponsorship from industry. In this paper the detailed results of three such studies will be presented. In all cases, the processes recommended as suitable for the production of treated timber for specific end-use was brought into question, either by the specifier in seeking assurances of quality of treatment or by the producer in claiming that the recommendations would lead to excessive uptake of preservative fluid with all the attendant complications (extended drying periods, bleeding, high costs).

The most recent investigation concerned the use of Douglas fir for motorway fencing posts. Timber is the preferred material for motorway and trunk road fencing, as can be seen during any journey along the principal roads of the UK. Latest figures show that the total volume of sawn produced annually in the UK is 1882K m^3 of which 34% is used as fencing (Anon 1991). During 1990 specific problems arose with some batches of timber when inadequate penetration levels of copper/chromium/arsenic (CCA) preservatives were identified. BRE was commissioned to investigate a number of these instances. Several wood species were involved in these early investigations, and conclusions as to the origin of the problem rested on the hypothesis that drying before treatment had been inadequate. However, it became apparent that the situation was more complex than originally envisaged and a reappraisal of the treatability of Douglas fir was required.

The other two studies to be presented here involved the use of organic solvent preservatives for the treatment of timber destined for use as exterior joinery. In both instances the timber, as sold commercially, contained more than one wood species of differing treatability characteristics and was, therefore, likely to be difficult to treat satisfactorily under the system laid down in the codes of practice.

The hardwood known variously as lauan, seraya, meranti or Philippine mahogany derives from several species in the genus *Shorea*. The commercial classification of this timber is complex, usually involving the country of origin together with an assessment of density and colour. Details of the accepted classification system appear in BS881. As a practical response to concern over the durability of *Shorea* used for exterior journey, it was acepted that joinery grade *Shorea* contains sufficient timber of low durability for treatment to be recommended. However, there was some doubt as to the adequacy of the treatment levels achieved by the double vacuum schedules used and, as an alternative, the option of establishing a system of selection to exclude the less durable timbers was suggested. The existing system using colour and density was thought inappropriate for these properties can vary markedly within a species, allowing several different species to be included in a single consignment selected on this basis. Unfortunately, individual species can show differences in other important timber properties, such as resistance to fungal attack (natural durability) and treatability with wood preservatives. These latter properties are important in the approach to obtaining satisfactory performance for exterior joinery timber.

Timber referred to as hem-fir is also regarded as insufficiently durable for use in exterior situations without the advantages of preservative treatment. However, since the western hemlock component of the mix is classified as "resistant" to treatment (Anon 1985) in the current codes of practice it is recommended that the preservatives are applied by treatment schedules reserved for the more refractory timbers, although there is a derogation when hem-fir is used in door construction. Recommendation of the more severe treatment schedule was seen as a disadvantage by the Council of Forest Industries, British Columbia (COFI) who consider this timber suitable for the construction of exterior joinery. Their experience indicated that the use of organic solvents with the more severe treatment schedules led to over-treatment of hem-fir with the associated problems for protracted drying and effects on subsequent coatings. It was therefore felt that an appraisal of the treatability of hem-fir would be appropriate, possibly leading to the development of a treatment schedule specifically designed to treat this timber.

It is clear from the continuing demand for this sort of work that issues of durability and treatability of commercial timbers remains important to both specifiers and treaters. Achievement of economic treatment processes leading to acceptable levels of performance is a continuing objective so that non-durable timbers can continue to provide the advantages of a natural renewable material for the construction market.

The investigation presented here have been completed during a period of great activity within Europe in drafting standards to support the move towards a single European Market. The relationship between treatment processes and the resulting penetration and loading characteristics for different timber species has assumed new signifance in the UK as a consequence of the appearance of the draft European standards. The basic approach to wood preservation specification that has been adopted for Europe is based upon penetration and loading requirements (a results specification) rather than the current UK approach of defining the treatment methods (a process specification). From the data presented here for the three treatability studies it can be clearly seen that particular penetration values cannot be associated precisely with a particular treatment process. the great variation in response to treatment that certain timber species continue to demonstrate has to be acknowledged in the relevant European Standards and careful consideration will have to be given to the methods used to define penetration if the proposed system is to be both workable and acceptable to the industry. The development of performance standards for wood preservatives and preservative-treated timber within Europe can only succeed if a sound data base which demonstrates the treatability characteristics of commercially-important timbers can be established and used. The final section of this paper summarizes the recent developments in Europe specifically related to the production of preservtive-treated timber.

2. Douglas Fir And Motorway Fencing

2.1 Nature of the problem

Motorway fencing, and most other trunk road fencing, is treated to the Department of Transport (DTp) specification (1986). In Part 1 of this specification, Clause 311 covers preservation of timber and states that the timber shall be treated at a moisture content of 28% or below in accordance with the requirements of sections 1 and 6 of the British standard BS5589 for compliance with Category A (desired service life of 40 years). The clause lists several requirements additional to the British Standard including the crucial point in paragraph (iii) that "In all species having permeable or moderately resistant sapwood, the sapwood shall be completely penetrated with preservative when treated with CCA formulations".

The current DTp specification refers to the 1978 edition of BS5589 in which Douglas fir is named as an allowed species for Category A if appropriately treated. The 1989 edition of BS5589 retains the same provision but expresses it differently. No timber names are included, but Douglas fir, if selected for such use, requires treatment for Category A performance because it is rated as "moderately durable". The recommended treatment schedule using CCA is the same as in the 1979 edition because Douglas fir motorway fencing posts would be in the sawnwood category having a resistant/extremely resistant rating. In both cases the recommended schedule involves an initial vacuum for 1 hour followed by a pressure period for 3 hours using a 30 g/L solution of CCA and the vacuum and pressures values given in BS4072: part 2.

Samples of motorway fencing posts were sent to BRE for examination of the depth of penetration of CCA and these showed that in a number of instances the levels stipulated in the DTp specification had not been achieved. The subsequent rejection of particular offending fencing consignments by inspectors, understandably caused major concern in the fencing industry. Accordingly, BRE was commissioned to examine the response to treatment of current Douglas fir fencing stock. The agreed investigation essentially assessed the levels of penetration that could be achieved at different timber moisture contents.

2.2 Experimental Approach

In total BRE received 100 home-grown Douglas fir *(Pseudotsuga menziesii)* posts, each 2000m x 150mm x 75mm, supplied from two different sources (Suppliers 1 and 2) as unkilned, green material. From these 100 samples, 60 were selected by rejecting those that contained the smallest amounts of sapwood. The 60 posts were divided into 3 batches (A, B and C) of 20, each containing 10 from each supplier. Twenty post samples from previous enquiries, comprising part-lengths which had been treated commercially, though to unsatisfactory levels, were also examined (batch D). Batches A, B and C were conditioned individually to different moisture content levels. Moisture content measurements throughout this exercise were determined using an electrical resistance moisture meter. The meter used had, in addition to the usual 0-30% range, a range of 40% to 60% moisture content. A reading recorded as off-scale would therefore imply a moisture content in excess of 50%. For each post, three determinations were taken on each sapwood face, approximating to two end and one central zone readings, from which the average moisture content of the sapwood zone was calculated.

Batch A posts were kiln-dried to about 16% moisture content by a schedule created by modifying Kiln Schedule K. The modification involved reducing the dry bulb temperature by 10°C (see table 1).

Batch B posts were allowed to air dry under cover to a moisture content of less than 40%, generally in the range 25% to 35%.

Batch C posts were dried in a kiln running constantly at 30°C and almost 100% relative humidity so that a range of moisture contents between 22% and off-scale (ie above 60%) were attained. Not only did these samples show large variations in average moisture content between individual samples but the individual moisture content readings showed that posts also varied in moisture content along their length. Consequently the three moisture content readings were taken on each face at the same three distances from a designated reference end of the post. In this way a disc could be cut from the treated post adjacent to the points at which the moisture content readings were taken and which would represent closely the lateral penetration of preservative associated with the measured moisture condition.

Batch D comprised approximately one metre lengths of previously-treated posts which had been supplied as conforming to the Department of Transport specification and had been the subject of the earlier investigations at BRE which led, in part, to the study described here. This fourth batch was not entirely Douglas fir, but contained 5 lengths of pine. These samples had been examined in the earlier work only for the penetration patterns of the preservative within them. They had subsequently been stored in the laboratory during which time they had dried down to about 16% moisture content. These samples were treated with the other experimental batches as space allowed in the treatment plant.

After drying, all posts were cross-cut at their mid-point and one half of each post was selected for preservative treatment. These halves were each sealed at one end with two coats of a pitch epoxy compound, weighed, and impregnated with a 30g/L CCA solution using the schedule recommended in BS5589 for Category A performance (60 minute vacuum period, 180 minute pressure period with a 30g/L CCA solution). Following treatment, they were reweighed, close-stacked for two days and then open-stacked to air dry under cover for 3-4 weeks before examination.

Each of the dried samples was cross-cut and one of the exposed end-grain surfaces sprayed with chrome azurol-S solution (Theis 1955) which reacts with the copper component in the CCA to give a blue colour on a red background from which the penetration pattern of the preservative through the lateral surfaces can be measured. The other exposed end-grain of each section was used to identify the boundary between the heartwood and sapwood. For Douglas fir this entailed painting the exposed surface with a bromophenol blue solution to give a brownish colour for heartwood and a blue-green colour for sapwood. For the differentiation of heartwood and sapwood in the pine samples, the method described in BS5666: part 2 was used.

Tracing paper was placed over the exposed end-grains of the samples and the outline marked on the paper of (i) the cross-section, (ii) the boundaries of the heartwood and sapwood, and (iii) the boundaries the preservative-treated areas. These areas were cut from the paper and the proportions of heartwood, sapwood and treated sapwood calculated from the weights of the appropriate pieces of paper.

2.3 Results and Discussion

The results are presented in tables 2-4 inclusive, in batches and according to the respective supplier. However, statistical comparison of these results failed to reveal any significant differences between the two sources of supply of the original posts. The data, therefore, have been treated as a single sample population.

Table 2 lists the uptakes and penetration details for the Batch A samples, ie those that had been dried to approximately 16% moisture content. Expressed as averages, the samples contained 26% sapwood, absorbed about 360 kgm^{-3} and showed that 88% of the sapwood was penetrated by preservative. Sapwood penetration was variable, ranging from 55% to complete. This variation was not related to the quantity of sapwood present in the sample, more than 90% penetration being recorded for samples with as little as 12% of their volume as sapwood up to those with 57%. Overall, 10 samples showed 100-95% penetration, 5 showed 94-80% and 5 showed 75-55%. The patterns of penetration in the sapwood of incompletely penetrated samples did not reflect any natural feature of the wood (eg annual ring patterns) but were characterized by their irregularity.

Purslow and Redding (1978) in a study on the comparative resistance of timbers to CCA and creosote treatment, calculated that Douglas fir sapwood could take up 720 kgm^{-3} when completely dry. From impregnation experiments they found that at approximately 18% moisture content the sapwood absorbed 600 kgm^{-3} and the heartwood 225 kgm^{-3}. Using these figures as a basis for assessing the results of the Batch A treatment suggests that in most cases the absorption of the individual samples exceeded that which might have been expected, even in those samples where the sapwood was not completely penetrated. Unfortunately, Purslow and Redding, in general, concentrated on heartwood penetration, but they did note that "sapwood, where present, was also generally completely treated in all timbers".

Table 3 lists the uptakes and penetration details for the Batch B samples, ie those that had been dried to moisture contents in the range 23-35% (one sample exceptionally had a moisture content of 40%). Although the average amount of sapwood present (25%) was similar to Batch A, the samples absorbed markedly less preservtive (average 240 kgm^{-3}). However, penetration was improved, and less variable; 15 samples achieved 100% penetration and 5 samples 80-90% penetration. Even the sample with a 40% moisture content showed 90% sapwood penetration. Again, untreated zones did not follow any obvious natural feature of the wood. Compared with Batch A it would appear that a lower overall absorption of preservative fluid has resulted in increased overall penetration.

It is difficult to explain the marked difference in absorption between these two batches. Both were, in general, at or below the fibre saturation point so blockage of available pathways by free water should be at a minimum. Using the Purslow and Redding figures (720kgm^{-3} at 0% moisture content and 600kgm^{-3} at 18%) the amount of preservative absorbed by the cell wall at Batch A and Batch B moisture contents can be calculated. This suggests that the difference in moisture content can account for about 66% of the difference in absorption and may well provide the principal means of explanation. However, the differences in penetration run counter to that expected from the absorption values. A possible explanation for this may again derive from the difference in moisture content. Posts with higher moisture contents may provide a greater opportunity for post-treatment penetration by diffusion. Clearly, further work would be required to resolve these puzzling results and, in addition, to discover whether an optimum moisture content can be defined which allows maximum penetration and loading.

Table 4 presents the penetration and uptake details for Batch C. Here three values for sapwood content and penetration are given for each sample, representing the effect of moisture content variation along the length of the sample. The results from 60 sections can therefore be appraised. It can be seen that 33 sections had a moisture content of 28% or less, of which 27 achieved a minimum sapwood penetration of 90%. The remaining 27 had a moisture content of 30% or more of which 18 failed to achieve 80% penetration. A histogram of the penetration levels achieved is presented in figure 1. However, even at these relatively high moisture contents only four samples returned a sapwood penetration of less than 50%. No apparent relationship could be seen between the amount of sapwood present and penetration, although those samples with 10% or less sapwood invariably were treated to the 90-100% level. Similarly no relationship was identified between the moisture content and the penetration level although it was clear that higher moisture contents tended to produce lower penetration levels. Unfortunately no sample had a moisture content so high as to demonstrate almost complete preclusion of preservative under such conditions.

The results for the samples from BRE stock retreated after drying are presented in table 5. For the 15 Douglas fir samples retreatment after drying increased the sapwood penetration from an average of 45% to 72%. However, there was some variation in response to retreatment, nine of the samples achieving 80% or better but four failing to achieve 50% sapwood penetration from an even lower original value. Again, the unpentrated zones did not necessarily follow any obvious natural feature of the wood. Although it is clear that retreatment has increased penetration it still did not necessarily result in complete penetration. This would indicate that only in some of the samples were the original low values due to inadquate drying. Samples 72D and 41R were treated a third time, but with little additional improvement. Overall, these results show that retreatment of a previously rejected consignment after further drying will improve the quality of treatment but not necessarily to the level currently required. Certainly the four posts which still revealed a sapwood penetration of less than 50%, even after retreatment, indicate an unresolved problem.

Retreatment of the five pine posts gave more uniform penetration results, four showing 100% penetration and one 90% penetration, not of the sapwood only but of the whole cross-section. It was noted that these samples were extremely wet when first received for inspection. Thorough drying to a moisture content below the fibre saturation point and retreatment using a schedule normally used on resistant timbers has shown that both the permeable sapwood and the more refractory heartwood can be treated. The response to treatment of the pine posts after proper drying has provided an indication that this timber may offer an alternative to Douglas fir for fencing posts, even though the natural durability of its heartwood is inferior to that of Douglas fir heartwood. If the more severe treatment schedule is used, complete penetration of the whole cross-section of a pine post can be achieved, thus producing what should be a durable commodity. Purslow (1975) reported no failures with either pine or Douglas fir stakes treated with a CCA-type preservative after 40 years in ground contct.

The whole trial was carried out on only a limited number of posts and therefore must be interpreted with care. A simplistic comparison of the effects of moisture content can be made by using the average values obtained from the results of the treatment of batches A, B and C (see table 6). In general, the average penetration of Douglas fir sapwood decreased in the order.

(i) Batch B timber at 25 - 30% moisture content;
(ii) Batch C timber at 22 - 28% moisture content;
(iii) Batch A timber at 16% moisture content;
(iv) Batch C timber at 30 - 60+% moisture content.

However, the penetration values for (i), (ii) and (iii) above were very similar and in the context of this limited experiment their differences may not be signficant. No clear advantage was seen in kilning to 16% moisture content nor did it provide the required 100% sapwood penetration. This was a little unexpected for the kiln schedule is not considered severe and was followed by conditioning to relieve drying stresses. However, kiln drying may be seen as the only practical solution to achieving a controlled moisture content before treatment. It seems clear that the choice of kilning schedule could well affect the treatability of the dried stock, and this warrants further investigation because of its influence in turn on the ultimate durability of the fence posts.

The level of 28% moisture content in itself does not appear to be an absolutely critical threshold for good penetration since moisture contents up to 35% achieved by air-drying still permitted good penetration. However, in general, moisture content levels above 30% did indeed lead to inferior penetration.

The effectiveness of a preservative treatment in service depends on the amount of preservative present in the treated zone as well as on the depth of its penetration. In some instances a balance has to be struck between these two values for economic and practical reasons. Posts dried down to 16% moisture content absorbed 40% more preservative than those dried to higher moisture contents even though the amounts of sapwood were broadly similar, although penetration was lower in the former. However, the moisture content, the amounts of sapwood between individual posts and the dispostion of the sapwood within each post is likely to vary along each post, and since sufficiently detailed measurements were not made in this experiment it was not possible to relate moisture content precisely and quantitatively to uptake of preservative. The uptake relates to the whole metre-long sample, whereas the moisture content values relate to a specific point along the post. However the overall results do confirm that, as expected, moisture contents well below the fibre saturation point permit higher uptake of preservative than do those above this point.

2.4 Conclusions

Treatment with CCA preservative of the sapwood of a sample of Douglas fir fencing posts, dried to a moisture content of 28% or below according to the requirements of the DTp specification, did not achieve 100% penetration in all of the materials.

Marked variations in the penetration levels were observed even with timber dried to below 28%.

Douglas fir posts which had been previously treated, dried and re-treated appeared to be less treatable than new, untreated posts. Pine posts put through the same cycle were completely treatable using the schedule normally applied to Douglas fir.

This limited study has identified a number of factors which have an influence on compliance with the existing requirements for Department of Transport specification for motorway fencing. However, more work is needed to define the limits of the variability in these factors in order to define an improved specification which is both realistic in expectation and practical in operation.

3. Selection Of Shorea Spp For Exterior Joinery

3.1 Nature of the problem

Commercial consignments of joinery grade *Shorea* contain some species whose natural durability is seen as too low to guarantee adequate performance of the whole consignment when put into service; these cannot readily be selected out before use. Fougerousse, in a study of the performance of various *Shorea* species concluded that preservative treatment was necessary to ensure adequate durability in service. This was accepted by the UK specifier, although it was argued (Brooks 1984) that only a relatively mild double vacuum schedule need be used as this would give adequate protection to the vulnerable timber while not including the practical difficulties associated with over treatment. Current specifications for the quality of timber for exterior joinery (BS1186) require that supplies of *Shorea* for this purpose are treated according to BS5589 (the BWPA Manual makes the same recommendations).

Since the treatment of *Shorea* was introduced specifically to give protection to the less durable timber within a consignment, there have been attempts to exclude this timber and thus avoid the need for treatment. It has been suggested that this may be done by assuming the following:

i. The denser timbers are more durable than the more lightweight timbers and therefore do not need treatment.
ii. The dark timbers are more durable than the pale timbers and do not need treatment.

Certain specifiers already include a minimum density among their requirements. In addition it has been suggested that treatability may be related to density and colour, thus allowing a screening process to reduce the need for treatment. The work which BRE carried out was designed to identify relationships between various measurable properties of the timber in order to assist in the more effective use of *Shorea* through selection and preservative treatment.

3.2 Experimental approach

Two consignments of *Shorea* timber, with approximately equal numbers of planks in each and representative of the current imports into the UK, were purchased from different joinery manufacturers, to give a total of 195 samples. Each plank was converted to give samples of the appropriate size and condition for a series of tests to determine basic timber characteristics. The tests were as follows.

1. **Density.** Samples 100 x 50 x 43 mm were oven dried to constant weight according to the general drying procedure described for moisture content determination in BS5666: part 1 (1987). Density was calculated from the original volume of the sample and the oven dry weight.
2. **Hardness.** The Janka identation test was carried out according to BS 373:1957. This measures the load necessary to force the hemispherical end of steel rod into the test sample to a measured depth. The results were recorded as the guage readings in Newtons.
3. **Reflectance value (colour).** This was determined using a Pye-Unicam SP 8-200 spectrophotometer incorporating an integrating sphere, measurements being made of the amount of light reflected from the wood surface at 10 nm intervals between 750 and 380 nm. Summation of the CIE tristimulus values, X, Y and Z, obtained by using the D65 spectral energy distribution coefficients gave the value defined here as the 'reflectance value', R, (Judd and Wyszecki, 1963). A high value indicates a light colour.

   A limited comparison of the ranking of reflection values obtained by the spectrophotometer and observed by the human eye was also carried out.
4. **Uptake and penetration of preservative.** Planed samples of timber, 300 x 95 x 40mm were sealed at one end with two coats of a PVA adhesive and treated by the schedules described in table 7 using a solution of a copper carboxylate in white spirit (copper concentration equivalent to 0.4% m/m).

   Uptake of preservative was measured by weighing the samples immediately before and after impregnation. The samples were then open-stacked and allowed to air dry under cover for about one month.

   After drying, each sample was cut across the grain 50mm from the sealed end to reveal lateral penetration and the remaining 250mm length ripped along its centre to reveal the longitudinal penetration from the unsealed end. The exposed surfaces were sprayed with chrome azurol-S, as described in the motorway fencing post study, to reveal the distribution of the preservative. The depth of penetration was measured with a ruler, measurements being taken at 10mm intervals around the periphery of the exposed surfaces.
5. **Resistance to decay.** Both field and laboratory tests were employed. Laboratory tests measured mass loss of timber blocks when exposed to basidiomycete attack. This was determined by placing the blocks in contact with a selected fungus growing on agar, as described in Timberlab paper 50-1972. The test fungi used were *Coniophora puteana* (FPRL 11E) and *Coriolus versicolor* (FPRL 28A).

   In the field test, stakes were placed in the ground and tested as described in BRE CP6/76. All stakes were 600mm in length, either duplicates 20 x 20mm in cross-section or single stakes 40 x 40mm. When stakes 50 x 50mm were obtainable these too were exposed.

3.3 Results and discussion

The results from all the completed tests are presented in table 8 where the distinction between timber from the two commercial suppliers has been retained. The very wide ranges in the values of all of the properties examined demonstrate the problem of variability within the source material used in this work. Statistical analysis of such results is difficult. The ratio of the variances often shows that further testing, e.g. a t-test to determine the significance of the differences between two means, is not valid. Similarly, range tests give no valid results and the mean is often distorted by a few extreme values. The median gives a better basis for comparison under such circumstances.

It is generally accepted that timber can be used for exterior joinery without preservtive treatment if its natural durability is at least "moderately durable" as defined in the 'Handbook of hardwoods' (1972b). If the durability is lower than this rating, treatment is recommended.

The results from the basidiomycete test for resistance to decay can be related to the standard ground-contact natural durability classification as defined in table 9 (Timberlab Paper 50 - 1972).

Table 10 gives the proportion of the *Shorea* samples falling within each category. Approximately 25% of the timber samples tested gave mass loss values associated with a non-durable or perishable classification (ie greater than 10% mass loss) and would therefore require treatment when used as exterior joinery. Conversely, the results indicate that at least 75% of the timber within the samples taken would not require treatment under current recommendtions.

The ground contact trials will clearly take much longer to produce significant results. However, after 27 months almost 25% of the total number of 20 x 20 mm stakes have failed with 50% of the original test planks having at least 1 stake failure. Using the approximate relationship that ground contact life is directly proportional to the smaller cross-section of the stake under test suggests these failure would be classified as non-durable. Microscopic examination of failed stakes showed attack by both basidiomycetes and soft-rot. Since this trial is not complete, reference will be made only to the basidiomycete laboratory test for natural durability in the discussion section.

The mean and median values for the uptake and penetration of preservative are very different and have large relative standard deviations (see table 8), showing that these properties do not have a normal distribution. It should be noted that the dimensions of the samples made it impossible to measure a lateral penetration greater than 20mm or a longitudinal penetration greater than 240mm. The median values, together with the cumulative frequency (table 11) give a better representation of the results.

In order to assess the level of treatment achieved, some criteria must be adopted. For double-vacuum and immersion treatments, Watson (1970) proposed that 3mm at any point across the grain and 40mm along the grain should be the intended objective of pretreatment with organic solvent preservatives. Such penetration must be achieved without excessive uptake of preservative, for this renders the process uneconomic and creates subsequent processing problems in drying, handling and surface coating. In considering the absorption of preservative by the *Shorea* samples, an overall level of 50 kg/m^3 was selected arbitrarily as the target absorption since this approximates to the uptake expected from the treatment of a timber such as Scots pine containing principally sapwood.

Using schedule VI only a minority (about 10%) of the samples achieved an average cross-grain penetration of 3mm or better (table 11) and an even smaller number achieved 40mm penetration along the grain. The severe schedule V4 increased the numbers achieving the preferred penetration, but at the same time increased absorption fourfold (table 8).

Density, hardness and reflectance were selected as properties that could be easily measured and that might provide some indication of the durability and treatability characteristics of the timber without the need for more time-consuming or complex testing. Examination of table 8 shows that the two consignments A and B were virtually identical in density. The two groups would therefore have satisfied the same density specification. It is usual for hardness and density to be closely correlated; in this study the correlation coefficient was 0.961 (figure 2). However, the correlation between density and colour was poor (figure 3) the two properties having a correlation coefficient of -0.4.

An assessment of colour carried out by two human observers on 13 samples showed that they rated samples with a value of 70 or less as dark and those with a value of 100 or more as pale. There was excellent agreement between the humans and the spectrophotometer in ranking timbers outside the 70-100 limits, the correlation coefficient for this range being 0.90. Within the 70-100 range there was little agreement.

Graphic comparison of other pairs of properties (figures 3-6) shows little correlation and clearly a precise method predicting durability and treatability from the selected properties of density, hardness and reflectance is not possible. However, the signs of the correlation coefficients (+ or –) indicate that there is a tendency for the heavier, darker timbers to be less treatable and more resistant to decay than the less dense, paler timbers. Thus by using the broad trends that link the various properties some advantageous selection may be possible.

In considering the long-term performance of a timber when used for exterior joinery, its inherent durability is of prime importance. Only if this is deemed insufficient is the option to treat with preservatives considered and then the ability of the timber to take up preservatives has to be addressed. In the absence of service or field trial data, natural durability is assessed by considering the mass loss caused by basidiomycete attack, since this is the principal cause of decay in joinery. It has already been shown (table 10) that 25% of the present samples tested fell below the level of natural durability normally required for exterior joinery. A reduction in this quantity of vulnerable timber would clearly be an advantage.

Table 12 illustrates the relationships between the various physical properties and the sensitivity to decay as determined by the basidiomycete laboratory test. It can be seen that as the weight-loss increases so the average uptake and penetration of preservative increase, the timber tends to become paler and the density decreases. However, such trends can only be defined in general terms for the ranges within each group are considerable.

Table 13 demonstrates the consequences of selecting by density and colour, and also of carrying out a preservative treatment. The colour value of R 100 is arbitrary and is intended to reject a large proportion of those timbers that a person would class as 'pale', as previously described. Selection for colour by eye is a quick process, but selection by density is much more difficult unless all the timber is at the same moisture content.

Exclusion by density alone reduces the amount of vulnerable timber. For instance, excluding timber with an oven-dry density of less than 480kg/m^3 allows the retention of 37% of the original quantity supplied. Of this timber, 8.3% is vulnerable to attack as judged by the basidiomycete test criterion. Additionally excluding pale (ie R 100) timber reduces the acceptable timber to 32% of the original, of which 6.3% is at risk. If the exclusion were by colour alone (rejecting only timber with R 100) then 81% of the timber would be retained, of which 20% would be vulnerable.

For the purposes of this paper, satisfactory preservative treatment of timber vulnerable to decay is achieved when a mean lateral penetration of 3mm is obtained when treated by schedule VI. If this criterion is taken to represent the minimum threshold for satisfactory performance, the process provides only a marginal improvement, reducing the amount of vulnerable timber from 8.3% to 6.9% for that selected by density and from 6.3% to 4.8% for that selected by both density and colour.

Clearly there is balance to be struck from these figures. If the rejection of 63% of current *Shorea* exterior joinery stock on the basis of a limiting density of 480kg/m^3 is unacceptable and a lower density is to be specified, the advantages of preservative treatment is increased. For instance, selecting timber of minimum density 430kg/m^3 results in only 28% of timber being rejected; preservative treatment of the acceptable portion results in 11% of that portion being vulnerable to decay as defined in this paper. This issue will have to be resolved by economics and user acceptability.

3.4 Conclusions

1. This work gives some support to the suggestion that the natural durability of *Shorea* timbers increases with increasing density and with darkening colour, density having the greater effect. There are, however, many exceptions to this principle because of the variability inherent in the timber and high levels of density and colour would have to be set to exclude all susceptible timber.
2. Although the most dense samples are amongst the darkest, samples can be found which are comparatively dark yet have relatively low densities. Exclusion of the palest coloured timbers (reflectance value 100) would show a slight benefit, reducing the amount of timber to 81% of the original, of which 20% would be vulnerable to attack.
3. Treating *Shorea* joinery timber by the preservation process currently recommended decreases the amount of susceptible timber, but does not eliminate it as there is a proportion which is not treatable but is non-durable. Initial selection by density can reduce the benefits of subsequent preservation.
4. As density and hardness correlate strongly either could be used as the selection criterion, but hardness is more affected by small changes in moisture content than is density.

4. The Treatability Of Hem-Fir

4.1 Nature of the problem

British Columbia contains extensive forest stands comprising a mixture of western hemlock *(Tsuga heterophylla)* and amabailis fir *(Abies amabilis)*. These are harvested, processed and marketed without segregation as hem-fir. However, the commercial timber can be identified as deriving from two geographical regions, the low altitude coastal plain (coastal grown) and the high altitude interior (mountain grown). Joinery-grade hem-fir derives entirely from the coastal grown timber. It has been shown (Cooper and Ross, 1977) that the coastal grown timber is easier to treat than that from the mountain region when using CCA-type water-borne formulations and that the timber exhibited marked variability in response to treatment. It was thus necessary to appraise the variation in response to treatment that current commercial timber gave when treated by the double vacuum schedules recommended in the UK codes of practice and, if necessary, to suggest alternative schedules that would produce acceptable levels of penetration.

Although the work described here covers the assessment and development of schedules for the treatment of hem-fir for use in exterior joinery, the results could equally be applied to the treatment of hem-fir for constructional purposes, eg timber-frame studding.

4.2 Experimental approach

Two batches of hem-fir were supplied, both representative of current commercial stocks. The first batch contained samples 5000 x 200 x 48 mm and 3500 x 100 x 48 mm. These were identified by microscopy and separated into the two species, providing 74 western hemlock samples and 57 amabilis fir. All samples were kiln dried to about 15% moisture content. Each of the longer samples was converted into nine pieces 535 x 140 x 48 mm and each shorter sample into six pieces 535 x 100 x 48 mm. One end-grain face of each piece was sealed with two coats PVA adhesive.

The second batch was supplied at a later date and contained samples of varying lengths, between 2000 and 3500 mm, with cross-section 150 x 50 mm. Segregation by species and kiln-drying were carried out as before to yield 25 western hemlock samples and 10 amabilis fir. Each sample was cut and planed to yield four pieces 500 x 143 x 43 mm. One end-grain face of each piece was sealed with two coats of PVA adhesive.

Batch 1 pieces, one from each sample were submitted to double vacuum schedules using a solution of a copper carboxylate in white spirit (equivalent to 0.4% m/m copper) as the preservative formulation. Schedules A, B and C were used (see table 14).

These schedules are to be found in BS5589, section 2 which covers external wood work above the damp-proof course in buildings, although schedule C has a less severe final vacuum than that required in the standard.

Two experimental schedules (D and E in table 14) were used following consideration of the results from the first three schedules.

Following appraisal of the overall results from the five schedules, two further schedules (X and Y in table 14) were examined, first using batch 2 and then batch 1 timber.

Each piece was weighed immediately before and after treatment. After treatment, the pieces were open-stacked under cover to air dry for 6-12 weeks. After drying, each piece was cross-cut to remove a 50 mm length from the sealed end to reveal lateral penetration and the remaining length rip-sawn down its centre to reveal longitudinal penetration from the unsealed end. As before, the exposed surfaces were sprayed with chrome-azurol S reagent to enhance the preservative penetration patterns. Measurements were carried out using a ruler at 10 mm intervals along the edges from which penetration originated.

A limited study of selected pieces by electron microscope was carried out in order to ascertain whether there were clear anatomical differences between treated and untreated zones.

4.3 Results and discussion

This study is essentially concerned with the quality of treatment that can be achieved using the variables available within the double vacuum schedule. As in the *Shorea* study the criterion adopted for assessing adequate penetration was that suggested by Watson (1970) of 3 mm lateral and 40 mm longitudinal penetration.

The results for schedules A-E inclusive are summarized in Table 15. Timber size is not included in this appraisal for statistically no significant difference could be discerned between the results from the various dimensions of timber. In all cases amabilis fir gave better penetration and loading values compared with western hemlock. It is therefore necessary only to ensure that the western hemlock component of the mix is treated adequately; the amabilis fir will then automatically be treated to a higher level. In this discussion reference will be made to amabilis fir only where it emphasizes the point being made.

It was concluded that schedule A, commonly regarded as the "redwood schedule", was inappropriate for hem-fir because it only achieved a mean lateral penetration of 1.8 mm with the western hemlock. Even those mean values that appear satisfactory, such as the longitudinal penetration of western hemlock and the lateral penetration of amabilis fir, could not be accepted as adequate because of the high degree of variability. Longitudinal penetration of western hemlock showed a range of 23 mm to 220 mm, and over half the samples of amabilis fir showed lateral penetration less than 3 mm.

Schedule C, approximating to the one recommended in the codes for the treatment of resistant timber species, produced a level of treatment far in excess of that generally accepted, thus confirming the doubts that launched this work. Most of the specimens tested were completely saturated with preservative and it was clear from this result that in practice most joinery components up to a metre long would be in a similar condition if treated by schedule C.

The intermediate schedule B, sometimes referred to as the "severe redwood schedule", appears satisfactory if assessed using the mean values, all being above the criterion set. However, the variability in response to treatment again reduces the effectiveness of the apparent penetration. For western hemlock, the analysis of 396 individual lateral measurements showed that 70% of them were 3mm or less (63% were 2mm or less) and although the longitudinal penetration had a mean of 175mm, the high level of variation meant that, overall, large volumes of timber remained untreated.

The results from these three schedules strongly suggest that it is inappropriate to treat hem-fir by any of the recommended schedules defined in the codes, and that a schedule in between the two extremes, but closer to the schedules recommended for permeable timbers, would produce an acceptable level of treatment. The schedules D and E represent this intermediate approach. An experiment to compare these two schedules demonstrated that there was no significant difference between the results achieved by the two schedules but that a higher proportion of the samples treated by either schedule achieved lateral penetration values in excess of 3mm (55% were recorded as 3mm or less compared with 70% for schedule B). End-grain penetration was almost double that of schedule B, with all pieces achieving the minimum 40mm. Confirmation that schedule D was an improvement over schedule B was obtained by running the two schedules on matched pieces (ie adjacent pieces taken from the same samples). Statistical analysis showed that the difference between the two schedules was significant at the 1% level for western hemlock and at the 2.5% level for amabilis fir.

Clearly schedules D and E provide advantages in penetration over the schedules in the current codes of practice for the treatment of hem-fir. However, the absorption is somewhat high and the schedules requires 40-45 minutes for completion as opposed to 30 minutes for the "severe redwood schedule" (schedule B). In an attempt to maintain the level of penetration achieved with schedules D and E but to decrease the absorption and overall treatment time, schedules X and Y were suggested. Batch 2 pieces were treated by schedules X and Y with schedule B being included in the experiment to provide comparison between batch 1 and 2. Results appear in table 16. It is apparent from the schedule B results for batch 1 and batch 2 pieces that the latter timber is markedly the more permeable. Thus the lateral penetration of western hemlock shows an increase from 6.2mm to 14.2mm, while for amabilis fir the mean has gone from 10.9mm to almost complete (18.4mm) penetration. The penetration patterns in general do not follow any anatomical feature such as earlywood/latewood boundaries of heartwood/sapwood differentiation. This ease of treatment compromised the validity of the results from schedules X and Y. However, the results once again demonstrate that variations in penetrability within a timber species present great problems when seeking to define a required treatment in specific penetration terms.

Assuming that such a difference in treatability could be identified by an examination of the anatomical features of the wood, samples of batch 2 timber were examined by electron microscopy, both in the treated zones and in adjacent untreated zones. There were no obvious differences. In both cases the bordered pits were intact and there was no sign of cell wall damage: bacteria, which sometimes are associated with increased porosity, were not observed. Schedules B, X and Y were repeated on batch 1 material. The results are presented in table 16. Significance testing concluded that there was no difference in penetration achieved between schedule X and Y. However, they gave a significant improvement in penetration over schedule B with a lower absorption. Certainly the time taken to complete schedule X or Y and the absorption achieved would appear more acceptable than that for schedules D and E without any associated significant loss in penetration.

4.4 Conclusions

The existing recommended schedules for the double vacuum treatment of hem-fir are unlikely to give acceptable penetration and absorption values.

Varying the pressure and time parameters of the double vacuum process has shown that such a process can be used to treat hem-fir to an acceptable level.

Over the three treatment experiments incorporated in this study, the variability in response to treatment of western hemlock has complicated attempts to rationalise the response of hem-fir to double vacuum treatment.

Of the schedule tested, schedules X and Y appear the most appropriate for the treatment of hem-fir if adequate penetration is to be achieved.

5. Wood Treatments And European Standardization

The publication of the Construction Products Directive (CPD) and the associated drive towards the establishment of the 1992 Single European Market has demanded the creation of a great many European Standards to provide a rational agreed basis for future trade unrestricted by national barriers. The production of preservative-treated timber is but one of a large number of topics which have been addressed in this exercise. Since the initiation of the programme to put in place a unified set of European Standards covering the durability of wood and wood-based construction materials on a performance basis, the BWPDA has been kept abreast of developments through presentations given at this Convention (Brooks 1989, Bravery et al 1990). These presentations have described the current position at the time, but the speed of development and changing attitudes justifies an annual account. Since the context of this present paper is the treatment of commercially important timbers with wood preservatives, it is appropriate to relate this issue to the developments in Working Group 3 of CEN/TC38 which is concerned with the performance of treated wood.

The plenary meeting of CEN/TC38, held in Vienna at the beginning of 1990, agreed that the drafts of the proposed standard (prEN351) developed by Working Group 3 should go forward for public comment. The standard was in three parts:

prEN351 Durability of Wood and Wood-based Products – Preservative-treated solid wood.

Part 1 Requirements for preservative-treated wood according to hazard class.

Part 2 Sampling and analysis of preservative-treated wood.

Part 3 Identification of preservative-treated wood.

Comments on these three parts were submitted to the CEN/TC38 Secretariat by the end of August 1990 for action at the next CEN/TC 38 plenary meeting.

The key part to the standard, part 1, received seven negative votes (Belgium, France, Norway, Portugal, Spain, Switzerland and The United Kingdom) reflecting the lack of confidence in the presentation and approach taken in this document. Meetings of the Working Group held in 1991 have attempted to revise the drafts to provide a more acceptable and workable form.

The basic European approach to wood preservation specification has not changed and continues to be based on penetration and loading requirements (a results specification). However, the current draft has altered markedly compared with the proposals put forward by the Working Group in 1989. Reference to hazard classes and the treatability classification of timber have disappeared from the principal table which now lists only a series of penetration classes (table 17). It is intended that the specifier choose from this list in order to define timber treated to the level appropriate to his intended requirements. Because service conditions throughout Europe can vary dramatically as can the desired working life of a wooden component, no attempt has been made to prescribe levels of treatment in relation to service conditions (hazard classes) in the draft standard. It is expected that an appropriate body of each nation will make general recommendations as to which penetration class is generally acceptable for each hazard class within its borders and thus provide necessary assistance to the specifier. By using the standard as a common document to underpin these recommended levels of treatment, barriers to trade should be removed.

Table 17 also includes reference to an analytical zone. This defines the zone of treated timber in the component that must contain the required concentration of preservative. This concentration is referred to as the retention requirement and is derived from the so-called critical value. The critical value will have been obtained by testing the preservative formulation according to the performance standard for preservatives developed by another CEN/TC38 working group, Working Group 4. In this standard a series of biological test methods are applied depending on the hazard class in which the wood preservative is to be used and the organisms against which it is to provide protection.

Minimum requirements for each hazard class are listed in prEN351. These are presented in terms of the treatability of the timber in question (permeable or resistant) and the general method of application (superficial or penetrating treatment processes). This inclusion has caused some difference of opinion in Working Group 3. The UK is in favour of the removal of minimum requirements for such a list can only give the lowest level of treatment of all those used for a particular hazard class amonst the nations of Europe and will not give the minimum level that is acceptable and used throughout Europe. This not only devalues the concept of a minimum requirement but misguides the casual reader. Specific clauses have to be included in prEN351 to address points of difficulty. For instance, it requires that heartwood and sapwood must be distinguisable if a penetration requirement specifically for sapwood is to be met and be verifiable. If, however, the boundary between sapwood and heartwood cannot be distinguished, the whole piece must be processed and assessed as though it were sapwood otherwise there could be no assurance that the sapwood part of the timber was treated to the appropriate level.

Variations within a charge of treated timber are of particular concern when addressing the level of compliance with the requirements of the specification that can be expected within a charge of treated timber and the potential problems in checking that compliance. Permeable timbers can be expected to achieve a high level of compliance but less permeable species are likely to show considerable variation in their response to treatment, as demonstrated by the accounts in the earlier part of this paper. Any penetration requirement, therefore, must acknowledge this and define acceptable limits in the technical specification. The draft standard attempts to deal with the concept of tolerances by defining a proportion of individual components within a charge or batch of treated timber that may be accepted as conforming to the standard even though some individuals might fail to reach the minimum criteria laid down in the standard. Currently, Working Group 3 has in mind maximum tolerances of 15% for permeable timbers (ie 15% of the components in the charge may fail to reach the minimum requirements) and 25% for the other (resistant) timbers. These are to be maximum tolerances with allowance included in the standard for lower tolerances to be agreed between treater and customer.

The implication of accepting that a proportion of the treated timber will not reach the minimum requirements of the specification is still being debated. However, it may well be that the accepted or agreed level of tolerance will vary depending on the intended end-use of the timber. Those timbers that perform a highly critical or important structural function may be required to achieve a higher level of compliance, or even total compliance, with the standard. Those whose function is less critical in that their failure will not compromise the integrity of the building, or that can easily be replaced, may be accepted with a lower level of compliance. Such a suggested interpretation is similar in approach to the classification of risk categories related to safety and economic factors as described in BS5268: Part 5.

Two issues related to the way in which the standards will be used and which have increased in prominence of late are "Attestation of Conformity" and "Factory Production Control". These relate, essentially, to practical aspects of the application of the standard in an industrial context. Article 13 of the CPD requires that the manufacturer of a product be responsible for the attestation that the product is in conformity with the requirements of the relevant technical specification. Further, the attestation of conformity is dependent upon the manufacturer having in place a factory production control system which ensures that production conforms to the technical specification.

The CPD defines four attestation procedures from which to select the one most appropriate to the production of any particular construction product, depending on the importance it has to the essential requirements (eg mechanical resistance and stability) of the CPD. The systems for selecting the appropriate procedure has been developed into a decision tree (figure 7). The system numbers refer to:

1. Certification by an approved independent body;
2. Manufacturer's declaration of conformity with certification of factory production control by an approved body;
3. Manufacturer's declaration with initial type testing by an approved body and then manufacturer's factory production control;
4. Manufacturer's declaration, initial type testing and factory production control, all independent of outside control.

In initial discussions on this subject CEN/TC38 Working Group 3 suggested that those preservative-treated timbers that had structural significance for the construction (eg were load-bearing) would require system 2, while those which do not have this significance would require system 4. However, this may be modified after further representations.

Factory production control is the subject of a guidance paper issued by the EEC Standing Committee for Construction (Guidance Paper No. 7). In effect, this suggests that the control system largely follows the existing European Standard EN29000 (syn BS5750). The inspection and testing clauses are still causing concern to the UK members since the guidance paper states that product testing is to be carried out according to the methods given in the technical specification and there are no such methods at present in the draft specification prepared by Working Group 3. However, it does offer a solution to one of the major problems indentified by the UK in the early stages of the draft's development. Relying on results as the means of conforming to a specification means that treated products have to be checked to ensure that the required penetration and loading of preservtive has been achieved. For preservatives based on some active ingredients this would be extremely difficult and for all would be time-consuming and expensive for the manufacturer. As an alternative the guidance paper offers the possibility of indirect testing.

Indirect testing is a practical alternative where a safe relationship can be established between the technical requirements of the specification and the parameters measured in the manufacture of the product. For wood preservation in the UK the obvious approach to indirect testing is to use the control of the treatment schedule as a means of ensuring appropriate penetration and loading in the treated timber. Should this be accepted, the manufacturer will have to demonstrate that the treatment method used on the timber component will result in the required level of treatment; depending on the component an independent approved body would be involved in this exercise to a greater or lesser extent. Clearly this has great relevance to the earlier part of the paper. When the European Standards are in place, greater flexibility in treatment processes will be the norm as manufacturers use customized schedules to meet penetration and loading levels for specific components made from specific timbers. Since the result is paramount and there are no restriction on how it is achieved, there should be a resurgence of interest in developing methods of treatment in a more competitive, but much larger market.

6. Concluding Observation

The current UK systems of specifying preservative treatment for timber is based upon the selection of a treatment process according to the treatability of the timber concerned. This has led to difficulties in achieving the successful preservation of certain commercial timbers. Problems have been identified by both the producer and the user, and subsequently demonstrated by experiment at BRE. Using the specification currently recommended in codes of practice (eg BS5589) it has been found that

i) treatment of Douglas fir used for motorway fencing posts does not achieve full sapwood penetrating in all cases;
ii) commercial hem-fir timber absorbs too much preservative fluid with the more severe schedule but is not penetrated sufficiently when using the less severe schedule;
iii) only a proportion of joinery-grade *Shorea* is adequately treated.

In all cases, it can be claimed that the problem arises from the inherent variation in response to treatment of certain timber species and to the practice of marketing mixed species in commercial consignments. The extent of this variability has been quantified in the work described in this paper by examining the level of treatment achieved within individual members of a charge after processing with a specified treatment schedule. In effect, the failure to achieve adequate treatment was identified by applying a results-type examination of the processes employed.

The standards covering the preservative treatment of timber currently being produced in Europe are based upon a results-type specification where requirements are defined in terms of penetration and loading values that must be achieved in the treated timber. Little attention has been paid, to date, to the problem of variability, such as that identified in the treatability experiments described in this paper. It is essential that further negotiations in the development of the European Standard take full cognizance of the difficulties inherent in defining penetration expectations for some timber species commonly treated in the UK.

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TABLE 1

Kilning schedule to give 16±2% moisture content in Douglas fir posts

Moisture content of timber, %	*Dry bulb °C*	*Wet bulb °C*
Green	60	56.5
50	65	58.5
30	70	60.5
20	80	61.5

Then conditioned at 60°C with 4° wet/dry gap to give final moisture content.

TABLE 2

Uptake of preservative and penetration of sapwood in Douglas fir posts kiln-dried to moisture content of 16% (batch A)

Source	*Uptake of preservative kg/m³*	*Percentage of sapwood*	*Percentage of sapwood treated*
Supplier 1	295.5	28	97
	371.1	15	100
	305.2	23	75
	354.5	27	89
	388.5	37	67
	451.4	31	92
	451.2	25	100
	283.1	25	100
	272.1	29	98
	351.2	16	82
Mean	352.4	26	90.0
SD	64.94		

TABLE 2 (contd.)

Uptake of preservative and penetration of sapwood in Douglas fir posts kiln-dried to moisture content of 16% (batch A)

Source	*Uptake of preservative kg/m³*	*Percentage of sapwood*	*Percentage of sapwood treated*
Supplier 2	510.6	57	97
	425.5	12	96
	406.5	26	55
	395.8	12	95
	349.6	39	87
	258.6	27	100
	350.0	30	86
	271.0	19	100
	310.0	16	73
	408.1	31	64
Mean	368.6	26	85.3
SD	76.7		

TABLE 3

Uptake of preservative and penetration of sapwood in Douglas fir posts air-dried to moisture content < 40% (batch B)

	Uptake of preservative kg/m³	*Percentage of sapwood*	*Percentage of sapwood treated*	*Moisture content %*
Supplier 2	265.6	17	82	25
	156.3	14	100	26
	204.4	10	100	27
	231.3	19	100	28
	149.8	19	100	28
	333.8	14	100	28
	350.2	35	100	30
	188.9	35	81	30
	178.1	32	100	35
	211.6	32	100	35
Mean	277	23	96	29
SD	69.6			
Supplier 1	176.9	18	86	23
	277.0	17	100	25
	139.3	25	100	25
	211.4	37	81	26
	257.0	14	100	28
	276.8	60	100	28
	301.4	44	99	28
	345.3	27	100	29
	359.3	23	100	29
	212.9	18	90	40
Mean	250.7	28	96	28
SD	71.0			

TABLE 4

Uptake of preservative and penetration of sapwood in Douglas fir posts kiln-dried to moisture content stated (batch C).

Source	*Uptake of preservative kg/m³*	*Percentage of sapwood*	*Percentage of sapwood treated*	*Moisture content %*
Supplier 2	268.1	55	80	40
		47	78	40
		42	77	40
	320.3	9	100	25
		20	100	24
		37	100	25
	175.3	5	100	26
		5	100	26
		5	100	26
	168.9	15	79	30
		14	77	30
		25	57	32
	176.6	17	80	24
		10	100	24
		13	90	24
	280.4	24	100	27
		40	100	28
		49	100	26
	284.9	4	90	23
		18	88	23
		8	92	22
	209.8	17	95	24
		17	94	24
		17	100	24
	145.3	5	100	25
		4	100	28
		19	97	23
	220.3	14	70	24
		11	80	25
		17	90	24
Mean	225	20	90	27
SD	59.8			
Supplier 1	254.8	47	81	25
		48	90	40
		38	74	40
	263.6	53	56	50
		50	54	50
		62	76	50
	303.9	60	48	45
		59	68	60
		58	92	40
	203.4	34	71	45
		33	67	OS
		33	65	OS
		32	82	50
	191.2	25	80	50
		33	68	OS
		39	72	OS
	286.1	22	100	24
		17	100	45
		16	100	28
	214.2	27	85	40
		31	91	40
		34	85	45
	262.8	16	100	26
		27	96	26
		24	100	26
	221.7	40	67	40
		33	74	50
		46	73	60
	261.9	25	85	26
		25	96	26
		22	92	26
Mean	246.4	36	80	47
SD	36.9			

Note - OS = off-scale, over 60% moisture content

TABLE 5
Penetration before and after re-treatment of posts from BRE stock (batch D)

Source	*Sample number*	*Timber*	*Percent sapwood*	*Percent sapwood treated*		*Increase*
				initially	*after re-treatment*	
BRE stock 1	6S	D fir	10	50	66	16
	8S	D fir	35	5	100	95
	13S	D fir	20	60	90	30
	17S	D fir	40	30	100	70
	26S	D fir	45	5	73	68
	21S	pine	70	40	100% *	60
	22S	pine	90	40	100% *	60
	23S	pine	90	30	100% *	70
	25S	pine	95	25	100% *	75
	27S	pine	10	30	90% *	60
BRE stock 2	10R	D fir	35	70	89	19
	19R	D fir	25	50	95	45
	37R	D fir	30	65	81	16
	41R	D fir	15	35	39	4
	58R	D fir	20	35	48	13
	61D	D fir	50	55	100	45
	72D	D fir	63	42	46	4
	79D	D fir	20	20	44	24
	83D	D fir	15	40	87	47
	95D	D fir	40	40	94	54
		mean	31	45	72	27

* = of whole cross-section

TABLE 6
Summary of preservative rention and penetration of Douglas fir sapwood for batches A, B, C

Moisture content %		*Retention kg/m³*	*Percentage of sapwood treated*
16	– batch A	360	88
25-30	– batch B	239	96
22-28	– batch C	NA	94
30-60+	– batch C	NA	74

TABLE 7
Schedules used to treat *Shorea* samples

Schedule	*V1*	*V4*
initial vacuum	- 0.33 bar, 3 min	- 0.83 bar, 10 min
impregnation stage	0 bar, 3 min	1 bar, 1 hour
final vacuum	- 0.67 bar, 20 min	- 0.83 bar, 20 min

TABLE 8
Comparison of properties of *Shorea* from the two suppliers

		Supplier A				*Supplier B*		
Property	*Mean*	*SD*	*Range*	*Median*	*Mean*	*SD*	*Range*	*Median*
Density, Kg/m³	466	60.6	358-721	459	473	76.1	325-709	457
Hardness value	2501	682.8	1370-5810	2300	2505	823.1	1170-6180	2190
Reflectance value	90.0	15.7	57-124	89.5	81.9	14.5	49-124	83.4
Uptake V1	19.6	18.3	1.4-111	14.0	9.8	5.8	4.4-40	8.4
Uptake V4	74.1	89.1	6.4-458	46.3	51.7	36.3	14-230	37.4
Lateral penetration V1	1.81	2.54	0-11.2	0.8	0.4	0.7	0-4.1	0.1
V4	5.47	6.31	0-20	2.8	3.8	5.4	0-20	1.3
Longitudinal penetration V1	12.0	28.3	0-162	3.0	4.5	12.5	0-93	1.0
V4	93.4	84.3	1-240	69.0	23.1	49.9	1-240	5.0
Mass loss % basidiomycete attack	8.26	4.98	0.6-25.1	7.7	6.52	4.27	0.1-16.4	6.7

Uptake = uptake of preservative in Kg/m³. Penetration in mm.

TABLE 9

Natural durability classifiction from basidiomycete testing

Mass loss	*Natural durability rating*
< or = 1%	very durable
> 1% and < or = 5%	durable
> 5% and < or = 10%	moderately durable
> 10% and < or = 30%	non-durable
> 30%	perishable

TABLE 10

Proportion of *Shorea* samples suffering the indicated percentage mass loss

Percent mass loss	*Proportion (%) with mass loss caused by basdidiomycete attack*
< 1	6.7
> 1 and < 5	28.2
> 5 and < 10	40.5
> 10 and < 30	24.6
> 30	0
< 10	75.4
> 10	24.6

TABLE 11

Cumulative frequency table of percentage of *Shorea* samples achieving the stated penetration using schedules V1 and V4

Penetration Depth, mm	*Lateral Schedule V1*	*Lateral Schedule V4*	*Longitudinal Schedule V1*	*Longitudinal Schedule V4*
< 1	67.2	32.8	33.3	1
< 3	88.2	61.0	65.1	24.6
< 5	92.8	71.8	73.8	31.8
< 10	98.5	81.5	83.6	41.5
< 20	100	93.3	90.8	56.9
< 30		100	92.3	60.5
< 40			94.4	63.1
< 100			98.5	72.8
< 200			100	89.2
< 300				100

TABLE 12

Median and range of propertiess for samples of *Shorea* in the various mass loss classifications

	Mass loss caused by basidiomycete in lab test			
Property	*< =1%*	*>1% and < 5%*	*> 5% and < =10%*	*> 10%*
Density, Kg/m³	539 382-690	487 390-721	456 342-577	434 325-576
Reflectance	70.8 50-110	83.4 52-104	87.0 63-124	96.5 64-124
Uptake, Kg/m³ schedule V1	7.0 1-20	9.1 4-60	10.3 4-79	12.7 5-111
Lateral penetration, mm schedule V1	0 0-7	0.2 0-6	0.3 0-11	0.4 0-11
Longitudinal penetration, mm schedule V1	0.4 0-26	1.0 0-93	1.8 0-162	2.0 0-148

TABLE 13

Percentage of *Shorea* samples classified as 'non-durable' after elimination of certain density and reflectance values

	Percentage of samples	*Percentage of samples R < 100*	*Untreated (U) or treated (T)*	*Percentage of selected samples exceeding 10% mass loss by basidiomycete attack*	
Oven-dry density				*No limit on R*	*R > 100*
> 325	100	8.10	U	24.6	20.2
			T	18.5	13.3
> 400	87.2	73.3	U	21.2	18.2
			T	14.7	11.2
> 420	77.4	68.7	U	17.9	16.4
			T	12.6	10.5
> 430	71.8	63.6	U	16.4	13.6
			T	11.4	9.7
> 440	67.2	59.5	U	14.5	13.8
			T	9.2	7.8

> 450	57.9	52.3	U	13.3	12.7
			T	8.0	6.9
> 460	46.7	42.1	U	9.9	8.5
			T	6.6	4.9
> 470	39.5	34.9	U	9.1	7.4
			T	7.8	5.9
> 480	36.9	32.3	U	8.3	6.3
			T	6.9	4.8
> 500	25.6	20.5	U	10.0	10.0
			T	8.0	7.5

Note – only the untreated (U) samples were tested for decay. The number of treated samples exceeding 10% weight loss was calculated by assuming that a preservative penetration of at least 3mm renders the timber "moderatley durable or better".

TABLE 14
Schedules used for treatment of hem-fir

Schedule	*Initial vacuum*	*Pressure*	*Final vacuum*
A	-0.33 bar for 3 m	0 bar for 3 m	-0.66 bar for 20 m
B	-0.,33 bar for 5 m	+1 bar for 5 m	-0.66 bar for 20 m
C	-0.83 bar for 10 m	+1 bar for 60 m	-0.66 bar for 20 m
D	-0.66 bar for 10 m	+1 bar for 10 m	-0.83 bar for 20 m
E	-0.66 bar for 10 m	+1 bar for 15 m	-0.83 bar for 20 m
X	-0.33 bar for 5 m	+1 bar for 5 m	-0.83 bar for 15 m
Y	0.33 bar for 5m	+2 bar for 5 m	-0.83 bar for 15 m

TABLE 15
Comparison of retention and penetration of preservative using five schedules on one batch of hem-fir

Timber	*Schedule*	*Retention kg/m³*	*Penetration Lateral*	*Penetration Longitudinal*
Hemlock	A	21 (7.9)	1.8 (0.7)	66 (43)
	B	50 (25)	4.1 (2.1)	175 (87)
	C	243 (78)	6.7 (4.8)	430 (95)
	D	108 (60)	6.6 (4.8)	328 (93)
	E	97 (57)	8.5 (5.7)	285 (83)
Fir	A	22 (6.8)	3.5 (2.7)	103 (77)
	B	50 (15)	6.7 (4.8)	216 (114)
	C	267 (75)	–	479 (32)
	D	91 (26)	12.5 (4.2)	408 (106)
	E	90 (25)	12.3 (4.1)	306 (80)

TABLE 16
Comparison of retention and penetration of preservative using three schedules on two batches of hem-fir

Timber	*Schedule*	*Retention kg/m³*	*Penetration Lateral*	*Penetration Longitudinal*
Hemlock batch 1	B	45.8 (10.8)	6.3 (2.7)	158 (48)
	X	63.3 (17.1)	9.4 (4.1)	246 (117)
	Y	75.9 (19.3)	10.6 (2.6)	241 (88)
Hemlock batch 2	B	46.4 (18.6)	14.2 (5.2)	180 (116)
	X	59.6 (24.8)	17.6 (4.0)	264 (119)
	Y	56.4 (21.4)	16.3 (4.5)	233 (120)
Fir batch 1	B	42.2 (19.1)	10.9 (6.4)	208 (168)
	X	53.1 (26.0)	13.4 (7.8)	213 (174)
	Y	60.6 (26.8)	14.8 (6.2)	252 (166)
Fir batch 2	B	68.5 (29.8)	18.4 (5.2)	328 (173)
	X	85.1 (32.2)	21.0 (0)	388 (90)
	Y	78.8 (26.1)	21.0 (0)	424 (33)

TABLE 17
Penetration classes as defined in prEN351

Penetration class	*Penetration requirement*	*Analytical zone*
P1	None	2mm from lateral faces
P2	None	3mm from laterial faces
P3	Min 3mm lateral and 40mm axial of sapwood	3mm lateral of sapwood
P4	Min 6mm lateral of sapwood	6mm lateral of sapwood
P5	Min 6mm lateral and 50mm axial of sapwood	6mm lateral of sapwood
P6	Min 12mm lateral of sapwod	12mm lateral of sapwood
P7	Full sapwood	Sapwood
P8	Full sapwood and min 6mm lateral of exposed heartwood	Sapwood and 6mm lateral of heartwood
P9	Min 20mm of sapwood, or, if sapwood thickness is > 20mm, full sapwood	Sapwood or 20mm of sapwood
P10	Full sapwood or minimum 20mm whichever is the greater	Sapwood or 20mm of sapwood

Fig. 1.
Percentage of Douglas Fir sapwood penetrated when moisture content is below and above 30%

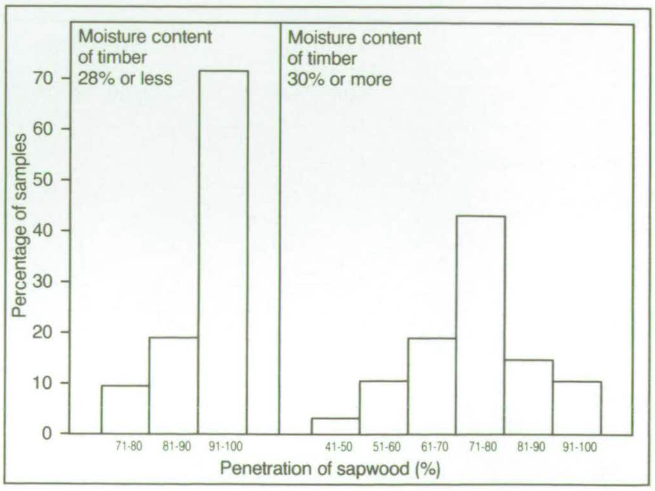


Fig. 2
Comparison of density and hardness value

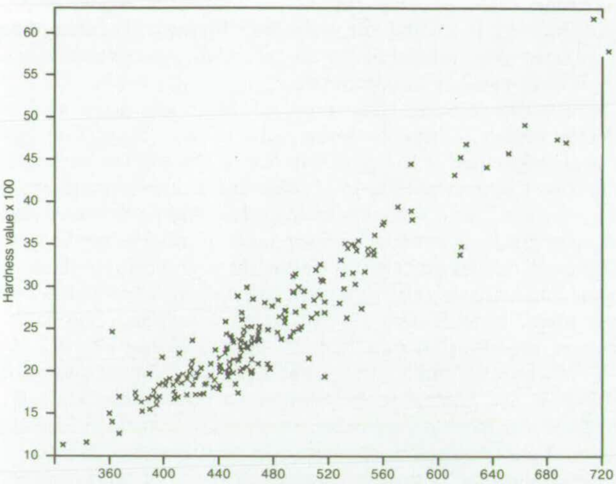


Fig. 3
Reflectance value of timber compared with oven-dry density

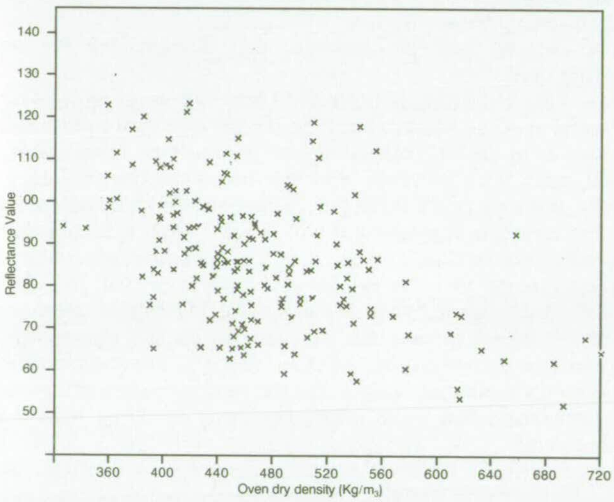


Fig. 4
Uptake of preservative using schedule V1 compared with reflectance

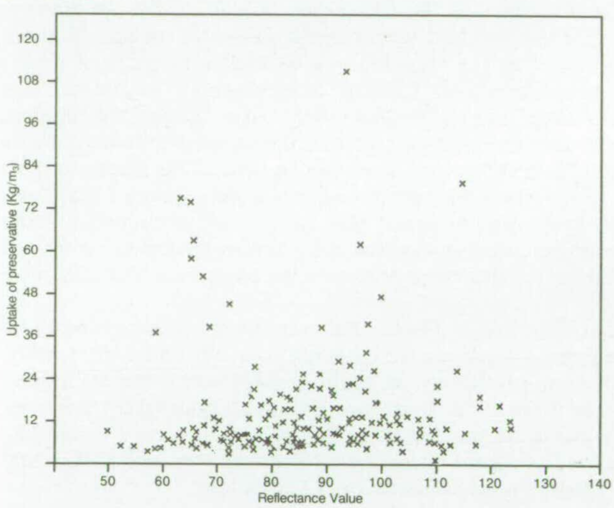


Fig. 5
Weight loss caused by fungal attack in the laboratory compared with oven-dry density

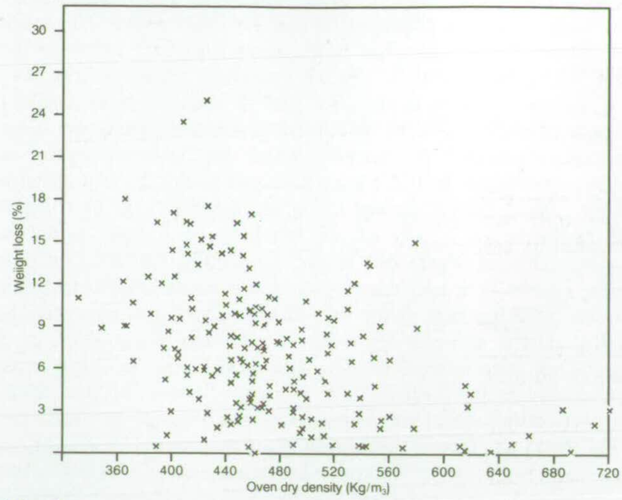


Fig. 6
Weight loss caused by fungal attack in the laboratory compared with reflectance value

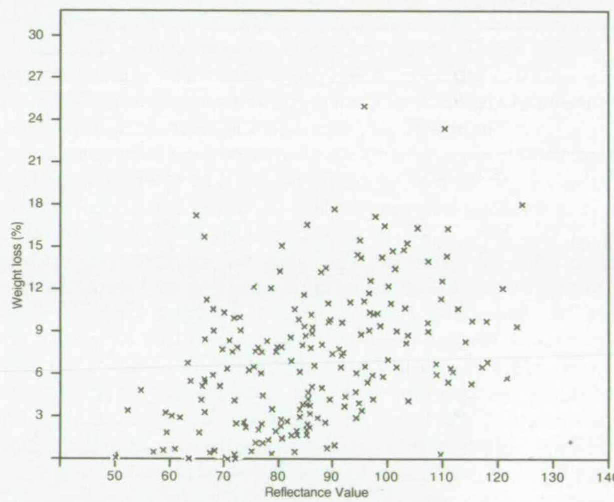
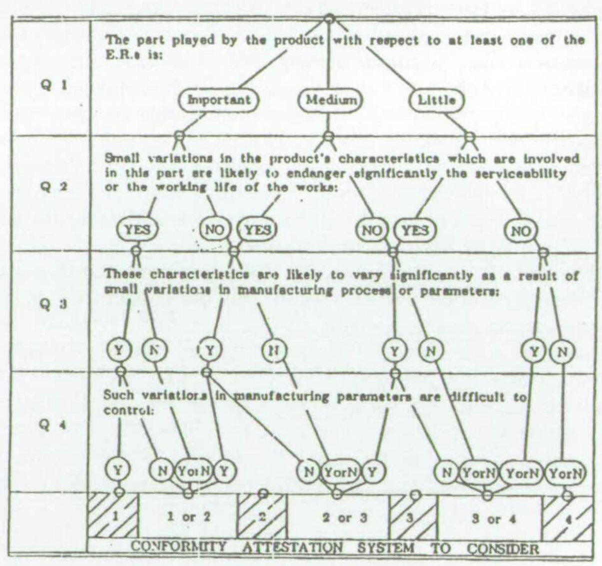


Fig. 7.
Decision tree for the selection of attestation of conformity system.



DISCUSSION ON PAPER 4

Chairman: Mr. L. B. Woodhouse

THE CHAIRMAN: We are a little late, but the President has allowed five minutes for questions, so can we please have questions from the floor?

DR. L.D.A. SAUNDERS (Fosroc): Chairman, I have a comment and a question. My comment is that I do not necessarily agree with Dr. Orsler's view that there is no similarity between the First World War and TC38. My question relates to the way in which penetration is specified and defined. In your analysis of penetration of Shorea you have given a distressingly clear demonstration that the way in which we have attempted to define penetration in these standards just is not in contact with reality. When timber shows an erratic penetration, to try and talk in terms of a continuous envelope of 3 mm might be intellectually satisfying but is not practically realistic. As you know, I have long had the view that it is more helpful to think instead of 75 per cent in the sample showing 3 mm penetration, having all the samples showing 75 per cent penetration at 3 mm. That view, incidentally, was developed working with Spruce, but in the light of your work on Shorea, do you think that would be helpful way forward in this instance as well?

DR. ORSLER: Thank you Andy, I am not sure. As you know there are several ways of expressing penetration. In effect, what you are really saying, I think, is that it is an extremely difficult area to debate. CEN/TC38 Working Group 3, who are working in this area, have decided that penetration and loading requirements is the way forward, but they have made that decision on limited knowledge. Non-UK member countries tend to operate with timbers that are easy to treat and that allows a nice uniform advance of the preservative into their structure. Unfortunately, those that treat a relatively large range of timber species, such as the UK, are in a minority. Penetration patterns such as those I have shown today have not been fully appreciated by some of our European partners and that is why I hope that I have convinced delegates at this convention that we have to look at this area much more critically in the coming months, particularly in terms of the way we express penetration requirements and tolerance levels in the proposed standard.

MR. B. MOLDRUP (Danish Wood Treating Co): A slight correction: at the last meeting it was decided that the minimum penetration for resistant timber should not be 3 mm but 6 mm, and I think you are quite correct in assessing that the penetration requirements come from parts of the industry that are used to timbers which have a uniform penetration, and the actual studies in Working Group 3 is that in future for wood in ground contact or joinery you can only use Larch and Scots Pine. For all other species you will have to use incising. That is a view supported by a majority of countries.

DR. ORSLER: Thank you Bror. I do not want to get into an argument with you, but the 6 mm you refer to, quite correctly, is the minimum requirement agreed by Working Group 3 when associated with a clause stating that it is not the absolute minimum, for you can require lower penetrations for some cases. It is one of those somewhat nonsensical things we have to live with in order to produce a generally acceptable draft. The second point that you make concerning incising has been quoted in CEN/TC38 Working Group 3 meetings more than once, as you well know. I do not think that anyone would accept incising for high quality *Shorea* exterior joinery.

DR. C.R. COGGINS (Rentokil): Your comment about incising of Shorea of course is very valid, but the concept of incising of motorway fencing is rather more attractive, I think. Your percentage penetration of sapwood figures related, I think, to area of sapwood penetration, whereas strictly speaking one is looking for full sapwood penetration in the Department of Transport specification, so it is either full sapwood or not. In a number of the batches only 30 per cent of thereabouts of the pieces achieved full sapwood penetration, so wildly outside the sort of tolerances that prEN351 anticipates, and it seems to me that, given the sort of guarantees or performance expectation that the Department of Transport would want, maybe incising is almost the only way forward, because that will at least give predictability in terms of penetration every time. Would you like to comment?

DR. ORSLER: I think that much of what you have said is perfectly correct, Chris. However, one of the things that has not been addressed is the performance of the treated material. Everybody seems to be talking of achieving a certain penetration and loading, without actually stating what that penetration and loading might do in terms of performance. In considering *Shorea*, it might well be that putting this timber through a double vacuum process and achieving the minimal penetrations recorded in our paper might be sufficient to protect it in service. This is an aspect of preservation that has not been addressed by CEN/TC38 Working Group 3. One possible solution to this awkward problem is for *Shorea* to be treated to penetration class P1 (the draft standard requirement where only a surface loading is defined and there is no penetration requirement). However, this would not be completely satisfactory for it would imply that much of our timber treated by double vacuum could not be differentiated from other timber treated by less severe means to a P1 classification.

DR. COGGINS: It is a gap in the knowledge; we do not know in relationship to penetration.

DR. ORSLER: And performance, that is right, but we are working on it.

MR. E.A. HILDITCH (Cuprinol): There is a great temptation to waffle at some length about the discussion twenty years ago that led up to the UK compromise on process type specification. I will resist that, however, and ask two questions, if I may. Firstly, you indicated a belief that Europe will finish up accepting process type specifications but will require better evidence that a specific process does result in a certain minimum penetration. It seems to me that the results you have presented go a fair way towards showing that that is not so. My second question: Shorea is mixed species. Are you able to do any microscopic examination to determine whether there is any relationship between the individual species and the results you are reporting, even accepting that is an impractical way of doing it in the timber yard?

MR. SMITH: To answer the second part of your question, we did not identify the individual timber species within our sample. It is impossible to differentiate the various *Shorea* species microscopically. Herbarium material is required to achieve this, sometimes obtained by shooting leaves from the canopy of the forest with a gun.

DR. ORSLER: On the first point, Austin, I did not actually say that the standard would use processes as the specification. It is clear that the standard will be written in terms of results (ie penetration and loading requirements), but if a "safe relationship" can be demonstrated to exist between the required results and the treatment process being used to achieve those results, then the process itself can be used as the means to meet the specification through the indirect testing system I described. This does mean, however, that such a safe relationship would have to be demonstrated for every timber species being treated and for every treatment process being used, a not inconsiderable task.

THE CHAIRMAN: Thank you very much for answering those questions. I am afraid we have run over our time considerably. Ladies and gentleman, yet again we have been fortunate to have a paper from BRE. I am sure we are all grateful for the work they put in on our behalf in this particular area. I would like to ask you to thank the authors for their paper, and particularly Dr. Orsler for his presentation. *(Applause).*

THE CAUSE AND CONTROL OF PRE-TREATMENT DECAY IN HOME GROWN POLES

by D. J. Dickinson and R. J. Murphy
Timber Technology Research Group, Department of Biology, Imperial College of Science, Technology & Medicine, Prince Consort Road, London SW7 2BB

1. Background

The use of creosoted poles for telecommunication and for electricity transmission probably represents one of the foremost success stories of wood preservation over the last century. Numerous examples of poles in service for many decades exist and details of the chemical analysis of a pole removed from service after a century of use has been reported to this convention, (Betts, 1982). This impressive track record has been achieved by careful specification and quality control. Attention to the important factors of preservative quality, retention, moisture content of the wood and penetration of preservative serves as a fine example to preservation practice. Whilst other preservatives can claim a similar performance and advantages, it is understandable that many specifiers are reluctant to move away from a product and specifications that have proved so effective over the passage of time.

In recent years, however, the attraction to use home grown poles has been strong. The Forestry Commission are able to supply a substantial proportion of medium and light poles at present and this supply is likely to increase in the future. Much research has been carried out to overcome some of the treatment problems with home grown Spruce poles and high pressure sap-displacement with CCA preservatives now offers considerable attractions for the treatment of home grown pine for poles, (Fowlie, 1983). Many specifiers are understandably reluctant to move away from existing preservative systems even though they are prepared to accept home grown poles. A choice of preservative as well as pole supply is also very desirable, and it sems likely that the demand for creosoted home grown poles will remain significant. The Forestry Commission and treaters foresaw no real problem in supplying such poles and were prepared to adopt existing drying and treatment procedures to process these poles.

In the mid-1980's concern was expressed about the risks associated with attempting to conventionally air-dry home grown poles in the cool, wet climate prevailing in the U.K. Such conditions were considered to be highly conducive to the development of decay fungi, a situation likely to be exacerbated by the wide sapwood bands found in many of the home grown pine poles. Infection of this type is not only likely to weaken the poles but also act as infection which is carried over into service, possibly leading to early failure of the poles.

The occurrence of decay during air-seasoning has been recognized as a severe problem in warm, moist climates such as the Southern United States for many years. The potential significance of this problem for air-seasoning in any climate was highlighted by J.A. Taylor (1980). Since Taylor's article, additional information has become available on the frequency of pre-treatment decay and its importance in Douglas-fir *(Pseudotsuga menziesii)* in the Pacific Northwest (Morrell et al., 1987), and in Scots pine (Pinus sylvestris) in Sweden (Wikander, 1982, Lundstrom and Edlund, 1987).

In the late 1980's Morris, who was working at Imperial College on decay in poles in service, became convinced that many of the early failures of poles in-service were due to pre-infections caused during seasoning. In a limited survey of imported poles after treatment, he found that 30% of the "stout pole" samples had infections of *Lentinus lepideus* in the heartwood. As a result of this finding and the experience in other countries, a research proposal was put to the Electricity Council to study this problem, with particular regard to the seasoning of home grown poles. At about the same time, the Forestry Commission and treatment industry were experiencing decay problems in poles which were being air-dried at Thetford Chase. Hurried surveys showed that a considerable decay problem existed and that the predicted problem was rapidly becoming a reality.

As a result of all these factors it was decided that a major study of the problem of pre-treatment decay in seasoning home grown pines used for poles should be undertaken. The object of the study was to identify the risks associated with the accepted practice of air-drying poles prior to creosoting and to devise and investigate procedures capable of overcoming the problem. The project was jointly funded by the Electricity Council, the Forestry Commission and the pole treaters (Calders & Grandidge).

2. Introduction

The situation at the start of the project was that there was a commercial desire to supply conventionally air-dried, creosoted home grown poles to the distribution industry, and it was rapidly becoming recognized that such material was likely to suffer from pre-treatment decay and to be unacceptable to the industry. A full understanding of the problem and answers were urgently needed. Several options were considered which could avoid the problem. The first was complete adoption of high pressure sap-displacement with CCA's. This option had attractions in that it avoided drying, thus totally elminating pre-treatment decay. As discussed earlier, it was considered essential to be able to supply conventionally creosoted home grown poles. Sap-displacement with creosote remains a possibility, but the problem of very high retentions, due to the full cell treatment achieved, still requires major research input.

Kilning and pre-steaming techniques are options still under consideration. The experience of the treatment industry with kilning alone is that the treated poles, tend to bleed after treatment. The colonisation of the poles during seasoning by micro-fungi is an essential part of the procedure, resulting in a very permeable pole which gives good "kick-back" of the preservative and consequently does not bleed after treatment.

The third and chosen option was to study the ecology of fungal decay during conventional air-drying and to devise procedures and treatments which would allow only the early colonizing mould and stain fungi to grow. This would result in the desired permeability increases, but prevent the establishment of decay fungi. Such an approach would deviate only slightly from current practice, give a problem free pole wiht respect to bleeding and pre-treatment decay, and probably be the most economical and convenient procedure.

The investigation consisted of two distinct phases:-

(a) A field survey of the colonisation by decay fungi of home grown poles during air-drying and of imported poles.

(b) A series of field trials to study the effectiveness of selected pre-treatments designed to control or eliminate infection by basidiomycete decay fungi.

3. Field Survey

Three separate sets of poles were examined in the survey. Due to the extensive nature of such a survey this study was restricted to British grown poles seasoning near Thetford Norfolk, and imported poles stored at Boston Lincolnshire. The poles consisted of:

(a) material stored for 6-9 months at Thetford.

(b) material stored for 16-20 months at Thetford.

(c) 2 sets of imported poles, imported both recently and one year previously stored at Boston.

3.1 Materials and Methods

3.1.1. *British Grown Poles:*

3.1.1.1. *6 to 9 Months Seasoning, 1988 Sampling*

These poles were felled in Sept. and Oct., 1987 from the Thetford Forest, debarked between Nov. 1987, and mid Jan, 1988, and then stacked for seasoning at the forest pole yard at High Ash, Thetford, Norfolk. eight Scots and 8 Corsican poles (9 meter long, mediums) were sampled for incidence of decay fungi in mid June to early July, 1988. Selection of poles as either Scots or Corsican could only be made based on the relative amount of heartwood present in the pole cross-sections. Poles containing no visible heartwood were considered to be Corsican pine, while those containing a heartwood core at least 6 cm in diameter were considered to be Scots pine.

One each of the Scots and Corsican poles were sampled on the 16th of June, with the remaining poles sampled on the 5th and 6th of July. Four poles in each group were sampled using a "full-sampling design", with the other 4 poles sampled using a "half-sampling design". The "full-sampling design" involved removing an increment core from each quadrant of the pole (spaced at 90^0 around the pole circumference) at 0.05, 0.25 meter, and then every 0.25 meter to 3.00 meter down the length of the pole from the butt end. This provided a total of fifty-two increment cores removed per pole. In the half-sampling design, only twenty-six increment cores were removed from each pole. Cores were removed at 0.05, 0.5 and then every 0.50 meter to 3.00 meter from the butt end from opposing quadrants 'A' and 'C', and at 0.25 and every 0.5 meter to 2.75 meter from the butt end from quadrants 'B' and 'D'.

3.1.1.2 *16 to 20 Month Seasoning, 1988 Sampling*

These poles were felled, debarked, and brought to the High Ash pole store, Thetford, during the spring of 1987. On 18 Oct. 1988, 4 Scots and 4 Corsican poles were sampled using the "half-sampling design" for increment core removal. This sampling was much less intense than for poles seasoned for 6 to 9 months, and was mainly designed to determine if longer seasoning would dramatically influence the extent, distribution, and species of decay fungi colonizing the poles.

3.1.2 *Imported Scots Poles:*

1988 Sampling, Recent & 1 Year After Import

Eight newly imported poles (received at Calders & Grandidge pole yard at Boston, Lincolnshire in July or August, 1988) and eight imported poles seasoned for 1 year at Boston (received in July or August, 1987) were sampled for decay fungi. These 9 meter medium poles were imported from Finland and were felled during the winter prior to importation. These poles were all sampled on the 23rd of August, 1988 using the same sampling design as for the British grown poles above. The recently imported poles have been peeled only to the inner bark, while the previous years poles were dressed prior to sampling.

3.1.3 *All Poles:*

All increment cores were stored at 4^0C until they could be cultured. Cores were cut into 1 cm long sections for the first 4 cm from the outside of the pole, and then 2 cm sections for the remainder of the core. The individual sections were lightly flamed and then partially submerged into 2% malt, 1.2% agar media supplemented with 200 ppm streptomycin sulphate and 8 ppm benomyl. All sections from each increment core were placed on a single media plate and observed for fungal growth for at least 1 month. Fungi growing from the cores were identified using Stalpers keys (1978).

After increment cores were removed from each pole, the poles were sampled for internal moisture content at 0.50 and 2.00 meter from the butt end. Poles were cross-cut through the increment core holes at these distances, and then 1 1.3 cm diameter plug-cutter was hammered 2.0 cm deep along the wood grain at three equidistant replicate sites around the cross-section at 2, 4, and 8 cm in from the pole surface. A 2 cm wide disc was then cut from these pole ends and the plugs of wood removed and individually sealed in polyethylene bags for transport to the laboratory for moisture content determinations.

3.2 Results and Discussion of Field Survey

3.2.1 *Pole Moisture Content:*

The average moisture content of poles did not differ substantially when measured at either 0.5m or 2.0m from the butt end of the poles (Table 1), suggesting a minimal influence of pole ends on pole drying beyond the 0.5m distance. However, wood moisture content often varied greatly between replicate measurements at each depth within the same poles. This probably reflects the presence of pockets of fungal invasion causing localized differences in wood permeability, and therefore drying and re-wetting characteristics of the wood.

After 6-9 month air-seasoning (winter '87-'88 to July '88) at Thetford, the moisture content of British grown Scots and Corsican pine poles were still well above the maximum of 28% MC desired for creosote treatment. Pole moisture content was especially high in the Corsican pine poles, which often oozed water as plugs were cut for sampling. As would be expected, the poles which had air-seasoned for 16-20 months (winter-spring '87 to Oct. '88) were much drier, although they occasionally contained areas above 28%MC. Moisture content above 28% were only observed at the 2cm depth in the Scots pine poles, but were observed at all depths sampled in two of the Corsican pine poles. This suggests that any decay fungi present in these poles could still be actively decaying localized areas of some poles.

Scots pine poles which were recently imported from Finland contained wet pockets suitable for decay development (Table 1). Poles which had been imported the previous year and seasoned for 1 year in Great Britain were generally well below the 28%MC considered necessary for active decay, suggesting that damage should no longer be occurring.

TABLE 1
Average moisture content of pine poles sampled after air-seasoning in Great Britain.[a]

Depth from Surface	% MC 0.5m from butt Range	Average	% MC 2.0m from butt Range	Average
BRITISH GROWN CORSICAN PINE POLES:				
6-9 MONTH AIR-SEASONING:				
2 cm	37 - 120	62	38 - 119	61
4 cm	43 - 176	115	45 - 164	102
8 cm	45 - 211	132	48 - 204	110
16-20 MONTH AIR-SEASONING:				
2 cm	23 - 36	28	23 - 33	27
4 cm	23 - 34	26	23 - 36	27
8 cm	22 - 38	25	23 - 48	29
BRITISH GROWN SCOTS PINE POLES:				
6-9 MONTH AIR-SEASONING:				
2 cm	29 - 81	42	25 - 64	41
4 cm	27 - 135	51	29 - 118	50
8 cm	21 - 35	30	29 - 41	33
6-20 MONTH AIR-SEASONING:				
2 cm	22 - 40	26	22 - 31	25
4 cm	22 - 27	24	24 - 25	25
8 cm	21 - 25	23	23 - 25	24
IMPORTED SCOTS PINE POLES:				
IMPORTED JULY-AUG. 1988:				
2 cm	21 - 73	33	22 - 103	31
4 cm	24 - 75	35	25 - 73	33
8 cm	26 - 55	32	25 - 34	29
IMPORTED JULY-AUG. 1987:				
2 cm	18 - 27	21	19 - 24	21
4 cm	20 - 26	23	19 - 25	23
8 cm	18 - 26	23	22 - 29	24

a All averages and ranges were based on 3 replicate moisture content samplings at each site for each pole.

3.2.2 *Basidiomycete Infection:*

The frequency of basidiomycete isolation from poles is reported based on both the total incidence of cores infected within individual poles (Tables 2-4). The relative sensitivity of the "full-sampling" (52 cores/pole) and "half-sampling" (26 cores/pole) schemes in estimating fungal colonization in poles was analyzed by splitting data from each "full-sampling" into 2 separate "half-sampling" schemes. results using the "half-sampling" scheme generally were very similar to those using the "full-sampling" scheme, except as one might expect, for fungi isolated at low frequencies from the poles. Fungal colonization data were therefore not weighted when averaging results from both schemes. The frequency of basidiomycete isolation from poles is reported based on both the total incidence of cores infected within individual poles (Tables 2-4).

In British grown poles seasoned for 6-9 months, *Peniophora gigantea* was the most frequently isolated basidiomycete, followed by *Cylindrobasidium evolvens (Corticium laeve), Sistotrema brinkmannii, Stereum sanguinolentum,* and *Heterobasidion annosum,* respectively. Whereas *P. gigantea* was consistently found in all poles, and usually at high frequencies (Table 2). The frequency of isolation of other fungi often varied from undetected by the sampling scheme to being present in over 50% of the cores removed. In general, *C. evolvens, S. sanguinolentum,* and Type 3-3A were more prevalent in Scots pine poles, with only *P. gigantea* being isolated slightly more frequently from Corsican pine poles.

Although British grown poles that were seasoned for 16-20 months were sampled much less intensely than poles seasoned for ony 6 to 9 months, the data suggests some potential changes in basidiomycete colonization with time (Table 3). In these older poles, the frequency of isolation of *S. sanguinolentum* is much higher and was the most prevalent basidiomycete detected, while *C. evolvens* appeared to be relatively less common. Pole number 41 was extensively (almost exclusively) colonized by *P. gigantea.* The wood in this pole was distinctly soft, strongly suggesting that *P. gigantea* can cause extensive structural damage to Corsican pine after 16 to 20 months air-seasoning.

The composition of basidiomycetes isolated from Scots pine poles imported from Finland (Table 4) differed in several ways from that observed in the British grown poles (Tables 2 and 3). *Peniophora gigantea* was isolated at much lower frequencies, and *H. annosum* was not isolated at all from the imported poles. Instead, *S. sanguinolentum, C. evolvens,* and Type 3-3A were more frequently isolated from the imported poles. Except for *C. evolvens,* the frequency of basidiomycete isolation from recently imported and poles imported the previous summer did not appear to differ substantially.

TABLE 2

Incidence of basidiomycete fungi isolated from British grown Corsican and Scots pine poles air-seasonsed for 6 to 9 months at the High Ash pole yard, Thetford, Norfolk.[a]

Percentage Cores Infected in Individual Poles

Corsican Pine	*1*	*3*	*5*	*6*	*9*	*13*	*14*	*15*	*Avg*
P. gigantea	21	15	15	46	38	42	65	58	38
C. evolvens	0	13	0	2	42	23	8	8	12
S. brinkmannii	6	35	40	15	4	0	8	8	15
S. sanguinolentum	12	0	0	0	4	0	0	8	3
H. annosum	0	15	6	4	4	0	4	0	4
Unidentified	6	2	0	4	0	0	8	4	3
Type 3-3A	2	13	0	0	0	4	0	0	2

Scots Pine	*2*	*4*	*7*	*8*	*10*	*11*	*12*	*16*	*Av*
P. gigantea	12	38	37	31	65	27	15	42	33
C. evolvens	0	52	25	60	0	15	12	8	22
S. brinkmannii	25	2	12	4	35	12	42	19	19
S. sanguinolentum	8	33	15	12	38	31	4	15	19
H. annosum	0	0	14	0	0	4	35	12	8
Unidentified	4	4	0	0	12	15	8	12	7
Type 3-3A	0	10	4	0	12	8	12	12	7

a Poles sampled with 52 (poles 1-8) or 26 (poles 9-16) cores per pole over the first 3 meter from the butt end in late June to early July, 1988.

TABLE 3

Incidence of basidiomycete fungi isolated from British grown Corsican and Scots pine poles air-seasoned for 16 to 20 months at the High Ash pole yard, Thetford, Norfolk.[a]

Percentage Cores Infected in Individual Poles

	CORSICAN PINE					***SCOTS PINE***				
Fungus	41	44	46	47	(Avg)	40	42	43	45	(Avg)
S. sanguinolentum	8	46	77	15	(37)	35	38	19	65	(39)
P. gigantea	92	4	19	0	(29)	12	23	8	50	(23)
S. brinkmannii	0	15	0	12	(7)	54	12	19	15	(25)
C. evolvens	0	12	4	0	(4)	23	19	12	0	(13)
H. annosum	0	8	0	31	(10)	0	0	19	0	(5)
Unidentified	8	35	4	4	(13)	4	0	0	4	(2)
Type 3-3A	0	0	12	0	(3)	0	0	0	0	(0)

a Poles sampled with 26 cores per pole over the first 3 meter from the butt end in mid October, 1988.

TABLE 4

Incidence of basidiomycete fungi isolated from Scots pine poles imported from Finland in July to August of 1987 or 1988, and sampled in late August, 1988.[a]

Percentage Cores Infected in Individual Poles

Imported 1988	*20*	*21*	*22*	*23*	*28*	*29*	*30*	*31*	*Avg*
S. Sanguinolentum	48	6	77	21	23	23	35	73	38
C. evolvens	83	35	40	87	46	81	0	27	50
Type 3-3A	0	67	21	15	4	23	19	15	21
Unidentified	2	10	2	4	0	15	27	0	8
P. gigantea	2	0	2	0	0	8	35	0	6
S. brinkmannii	2	2	2	2	4	0	23	0	4

Imported 1987	*24*	*25*	*26*	*27*	*32*	*33*	*34*	*35*	*Avg*
S. sanguinolentum	46	27	15	19	65	54	38	62	41
C. evolvens	10	35	0	19	12	31	35	27	21
Type 3-3A	4	19	0	12	12	19	15	35	15
Unidentified	10	10	6	2	4	4	23	19	10
P. gigantia	0	0	0	10	4	4	4	4	3
S. brinkmannii	2	0	0	0	4	4	0	0	1

a Poles were sampled with 52 (poles 20-27) or 26 (poles 28-35) cores per pole over the first 3 meter from the butt end at the Calders & Grandidge pole yard, Bostol, Lincolnshire.

The hazard that these fungi represent to the poles' strength will depend on how much structural damage they cause during air-seasoning and their potential to survive creosote treatment and cause further decay in service. Reports in the literature suggest that *C. evolvens,* H. annosum, and *S. sanguinlentum* are all capable of causing at least moderate decay in laboratory decay tests (Henningsson, 1967; Morrell et al., 1987; Perrin and Sylvestre, 1975; von Aufsess, 1965). Chernykh (1981) also reports that *P. gigantea* is capable of breaking down Scots pine wood 4 times faster than *H. annosum* in laboratory tests. The potential for these fungi to cause structural damage to poles is well established, but whether substantial damage is occurring using current air-seasoning practices is unknown. The major brown rot decayers which can cause rapid structural damage were not identified in these poles. It is significant to note that *P. gigantea* has been effectively used by the Forestry Commission in Great Britain to control infection of stumps by the root-rot *H. annosum* in the areas where these poles were felled (Greig, 1984). The isolation of *H. annosum* from air-seasoning British grown poles highlights the need for some form of control for this root-rot fungus. The high incidence of *P. gigantea* in these poles may result from infection during stump treatment with this fungus, or natural infection by a common forest fungus. If *P. gigantea* infection is occurring as a result of stump treatments, an alternate method of root-rot control may be desirable. The high incidence of this and other basidiomycetes in air-seasoning British poles suggests that alternative seasoning methods may be desirable. The extensive colonization of these poles by basidiomycetes during air-seasoning in Great Britain justifies the investigation into alternative seasoning methods, as described below.

4. Field Ttreatments

4.1 Introduction

The objective of the field treatment study was to investigate the effectiveness of selected pre-seasoning treatments to reduce, or eliminate basidiomycete colonization of British grown poles during air-seasoning. The selection of treatments was based on their environment and handing safety, low cost, and ease of use. The treatments were boron (Timbor) spray, boron spray combined with a *Trichoderma* sp. spore incoculation, and the covering of pole stacks during storage for both Scots and Corsican pine poles. The effect of these treatments on isolation of decay fungi, permeability and subsequent creosote treatement was studied.

The effectiveness of any field treatment will depend on its ability to reduce decay damage during air-seasoning, while still allowing sufficient colonization by non-decay organisms to improve pole permeability and prevent creosote bleeding after treatment. It is important that pre-seasoning treatments are applied early to poles, before any decay fungi become established, otherwise treatments which may effectively prevent colonization may appear ineffective due to an inability to sterilize a previously infected pole.

Attempts to control colonization by decay fungi during air-seasoning can typically involve the use of chemical, biological or storage methods. Where feasible, a combination of techniques would be expected to provide the best control.

4.2 Materials and Methods

4.2.1 *Chemical Treatments*

Several chemical treatments have been investigated in the past for control of decay in seasoning poles. These include fumigants, fluorides, boron compounds, and chlorinated organic compounds. After discussion with members of the project working group as to which chemicals would be acceptable for use under mill conditions, the boron compounds appeared to be the only viable chemical option. Boron is toxic to decay fungi, comparatively non-toxic to non-decay fungi, and relatively safe in use. It may be applied externally, as a dip or spray treatment. Boron diffusion from surface treatment into wood is dependent on high moisture content, which is not a problem in freshly felled trees. The potential disadvantage of boron is its leachability.

4.2.2 *Biological Treatments*

Currently the most promising biological tretament involves the use of a *Trichoderma* spp. which acts in antagonistic competition with decay fungi in poles. This fungus is an efficient and rapid colonizer of freshly felled wood. It is also known to increase wood permeability by penetrating pit membranes, leading to good treatment quality in the poles. Chemical treatment with Boron may also enhance biological methods. The ability of a chemical to stimulate the natural colonization and growth of non-decay fungi, which are often antagonistic to decay fungi, may be as important as the toxicity of the chemical itself. A supplementary application of an antagonistic fungus, which is resistant to any chemicals used, would ensure a more rapid infection. The high surface sugar content of freshly peeled poles is also conducive to rapid fungal growth.

4.2.3 *Storage Methods*

Storage methods indirectly control decay organisms by manipulating the local environment. This includes proper pole stacking for good air flow (rapid drying), sanitation to minimize the fungal spore infection in the vicinity of the pole stacks, and selection of poles which are free of any infection by decay fungi. It is assumed that these measures will be undertaken as a matter of course under normal circumstances. The only storage method investigated was the use of coverings over the air-seasoning stacks to minimize leaching of chemical treatments and to speed drying by preventing re-wetting of poles.

4.2.4 *Initial Experimental Set-Up*

This experiment was designed to investigate the effectiveness of 5 treatments over 3 seasoning periods using both British grown Scots pine and Corsican pine poles. The 5 treatments selected were:

1. Controls poles, Uncovered: no chemical or biological treatments, and pole stacks not seasoned under cover.
2. Control poles, Covered: no chemical or biological treatments, but pole stacks seasoned under cover.
3. Boron sprayed poles, Uncovered: poles sprayed with a 30% solution (w/v) of 'Timbor' with pole stacks not seasoned under cover.
4. Boron sprayed poles, Covered: poles sprayed with a 30% solution of 'Timbor' with pole stacks seasoned under cover.
5. Boron sprayed poles, *Trichoderma* sp. inoculated, Uncovered: poles sprayed with a 30% solution of 'Timbor', allowed to dry a few days, re-sprayed with a spore suspension of an isolate of a *Trichoderma* sp., and pole stacks not seasoned under cover.

The three air-seasoning periods were selected as 6, 12, and 18 months after the start of air-seasoning. Eight replicate pole sections (3 metre) of each species were made available for sampling after each period of air-seasoning. all eight sections in each treatment group were sampled for decay fungi, while 4 of the sections were used for creosote treatability (penetration and "bleeding") tests. Some pole sections used for creosote treatment tests required further drying by kilning prior to creosoting.

Seventy each of Scots and corsican logs (6.2 metre long) were cut from the Rendlesham Forest (from compartments planted in 1948) with minimum top and maximum butt diameters of 18 and 26 cm, respectively. These logs were selected from trees of utility pole quality, with few large knots and reasonably straight. Trees were felled between the 5th and 13th of September, 1988, and transported to Nelson Potter's Saw mill on the 13th and 14th of September, 1988. The logs were then cut into 3 metre lengths, debarked, and prepared for the seasoning trials on the 13th through the 15th of September, 1988.

Each debarked pole section was numbered, and both pole sections from each log were kept together in individual treatment groups. Groups of 28 Scots and 28 Corsican pine pole sections were then laid out on bearers and prepared for each of the 5 treatment groups. Of these pole sections, 12 in each group were monitored exclusively for decay fungus colonization during seasoning (sampling up to 2 meter from butt), and 12 for colonization (sampling up to 1 meter from butt) as well as treatability with creosote. The remaining 4 sections were used as extras to help maintain pole stack size. All pole sections were sealed with Hevokote Heavy (Thomas Ness Ltd., Caerphilly, Mid-Glamorgan) on their small ends so that these 3 meter pole sections would mimic full length poles during air-seasoning.

Pole sections designated for boron treatment were then sprayed with a 30% solution of 'Timbor'. This solution was made by dissolving 3.6 kg of 'Timbor' (supplied by Rentokil) in hot water to make 14.6 litre. The 'Timbor' solution was sprayed onto pole sections using a backpack sprayer with a coarse nozzle. Approximately 32 kilos of 'Timbor' were used to treat the 168 pole sections, although a large portion of this did not stay on the pole sectins due to wind dispersal and drainage from the pole sections. The water temperature needed to be well above 50°C to prevent clogging of the sprayer during use.

The pole sections were transported to the pole store at High Ash, Thetford, on the 14th and 15th, and stacked on the 16th and 20th September, 1988. Pole sections were stacked 4 rows high with coverings then placed over stacks 2 and 4. During the delay between the initial boron spraying of pole sections and the completion of the covered pole stacks, rain storms wetted the pole sections. To compensate for any loss of boron due to leaching during these storms, and to ensure a high quality initial boron spray treatment, pole sections in the covered and uncovered boron treated stacks were lightly re-sprayed with a hot 30% boron solution (3.6 kilogram 'Timbor' per stack).

Pole sections in stack number 5 were then sprayed with a spore suspension of *Trichoderma* sp. This fungus was previously isolated from cores removed from the 6 to 9 month old Thetford High Ash poles sampled in the Field Survey above. The spore suspension was produced by growing this fungus on both 2% malt agar plates and sterile vermiculite supplemented with a 2% malt solution. Spores were washed from the vermiculite (0.5% gelatin/water used as a surfactant) and agar plates, and then sprayed onto the poles with a backpack sprayer using a coarse nozzle. The spore suspension was estimated to contain about 1 X 10^6 spores/ml based on a spore count.

The initial coverings for stacks 2 and 4 were destroyed during a storm after the stacks were completed. These were recovered about a week later with stronger tarpaulins. Undoubtedly, these stacks were rained on during this time and some of the 'Timbor' may have leached out. Further wind damage took place and the effectiveness of the sheeting must remain in question in this trial.

4.2.5 *Sampling of Pole Sections*

After 6 months air-seasoning, 8 Scots and 8 Corsican pole sections were randomly selected from each stack. These pole sections were pulled from the stacks (10 March, 1989) and transported to the Calders & Grandidge (Boston) pole yard on 13 March, 1989. One-half (4) of the pole sections in each group were sampled by removing opposite pairs of increment cores from alternating quadrants at 0.05m and 0.25m, then every 0.25m out to 2.0 meter from the butt end (18 cores), while the other 4 pole sections were sampled out to 0.75m from the butt end (8 cores). The second sampling regime (out ot 0.75m) was designed to increase the pole sampling replication, but leave sufficient undamaged pole length for creosote treatment.

Increment cores were removed in March 1989 for the 6 month assessment, November 1989 for the 12 month assessment and April 1990 for the 18 month assessment and were then cultured as in the field survey described earlier, except for the 18 month assessment where the sampling regime was reduced by 50%.

The 4 pole sections that were sampled to 2.0m were also sampled for moisture content at 0.5m. Cross-sections of boron treated poles (0.5 meter from butt end) were sprayed with curcumin reagent. This is sensitive to concetrations above 0.3% w/w boric acid equivalent which is an effective concentration for control of decay fungi.

4.3 **Results**

4.3.1 *Month assessment*

The pole sections sprayed with 'Timbor' still contained detachable concentrations of boron after the 6 months air-seasoning. In many of the poles, the boron had migrated 2 to 4 cm into the pole, providing a fairly wide shell of protection. This was generally most distinct in the covered poles, although several of the uncovered poles also showed good distribution of boron. The pole sections were still very wet after six months and were far from dry enough to limit decay activity or be suitable for creosote treatment, (Table 5). Pole sections in covered stacks were slightly drier on average than poles in uncovered stacks although this difference was probably not significant as this was probably due to the inefficiency of the temporary covers used.

The efficacy of the boron treatment in reducing overall basidiomycete colonization can clearly been seen in Table 5. Basidiomycete infection of the poles was higher in Scots than in Corsican pine poles. This higher infection rate was almost exclusively the result of colonization of the Scots pine poles by *C. evolvens,* which was not observed in any of the Corsican pine poles. Studies have shown that this fungus does not cause rapid structural damage to wood, although its presence indicates the susceptibility of the poles to colonization by basidiomycetes. More important is the absence of more damaging white-rot fungi *S. sanguinolentum, P. gigantea* and *H. annosum* in the boron treated poles. The coverings placed over some the stacks to prevent re-wetting and chemical leaching did not noticeably influence colonization by basidiomycetes over this period. Although the poles were sparsely colonized by basidiomycetes after this initial 6 month air-seasoning, they were heavily infected by non-decay fungi.

TABLE 5

Colonization of pole sections in the field treatment study after 6 months air-seasoning at Thetford, Norfolk

Sampled ID Fungus	*Scots Pine Poles (n/8)*	*Scots Pine Cores (% of 104)*	*Corsican Pine Poles (n/8)*	*Corsican Pine Cores (% of 104)*
Control poles:Uncovered				
C evolvens	4	18	0	0
Peniophora sp	2	2	1	1
S brinkmannii	2	2	2	3
S sanguinolentum	2	2	1	1
Basidiomycete	0	0	1	1
Control poles: Covered				
C evolvens	5	20	0	0
H annosum	1	5	0	0
Peniophora sp	1	1	1	1
S brinkmannii	1	1	1	1
S sanguinolentum	1	2	2	2
Basidiomycete	1	1	0	0
Boron poles: Uncovered				
Basidiomycete	1	1	0	0
Boron poles: Covered				
Basidiomycete	0	0	1	1
Boron/*Trichoderma* poles				
S brinkmannii	0	0	1	1
Basidiomycete	1	1	0	0

4.3.2 *Month Assessment*

Boron was still very evident in cross sections of the treated poles when sprayed with curcumin reagent. The results for the basidiomycete infection are shown in Table 6. The basidiomycete infection in the control poles was greater than that at 6 months with approximately 30% of cores yeilding basidiomycete infection. The Corsican pine poles were now similarly infected to the Scots pine poles although the isolation of *C. evolvens* was very low in contrast to the more destructive white-rots which now predominated. In contrast to the controls all the experimental treatments performed very well, with low isolations of basidiomycetes recorded. The results being virtually the same as the 6 month samples for the treated poles.

Despite the selective medium, moulds and stainers were prevalent. In fact one particular organism was prevalent in many poles, especially those that had been boron treated. Exhaustive testing revealed that it was not a basidiomycete. However, because of its prevalence, it was decided that a complete identification was important. Eventually, with the aid of the International Mycological Institute at Kew, Surrey, it was identified as *Fusarium avenaceum* a leaf litter mould which would seem to be boron resistant but which is in no way detrimental to the soundness of the poles.

The *Trichoderma* treated poles yielded isolations of this fungus from 95% of the cores which would indicate that the fungus has succeeded in establishing itself well and perhaps aided in the prevention of basidiomycete infection.

The moisture contents were lower than at 6 months, but were still high enough to support decay and too wet for creosoting.

4.3.3 *18 Month Assessment*

The results for the fungal isolations can be found in Table 7. At this time it can be seen that the experimental treatments, although still performing well, are showing low signs of basidiomycete infection, when compared to that present at 12 months. Especially important is the isolation of *Peniophora* sp., one of the more damaging white-rots in both the covered boron poles and the boron/*Trichoderma* poles. Although isolation of mould and stainers remained high the incidence of *F. avenaceum* is slightly lower than at 12 months which is probably due to seasonal variation.

In the control poles it is interesting to note the increase in the levels of *Peniophora* sp., indicating a continuing accretion of problem fungi. Even more important is the isolation from these poles of suspected brown rot fungi, which are still absent from any of the treated poles, indicating that the treatments remain effective, despite the low level of white rots present. Brown rot infection, especially in the heartwood is of particular danger as it can be carried over into service causing early failure of poles.

The moisture content data for all samples are shown in Table 8. It can be seen from this data that the moisture contents for all the poles throughout the treatments have reached a satisfactory level for creosote treatment. It is also interesting to note that variation between the poles is much less than that seen at 12 months.

4.3.4. *Creosoting Trials*

Twelve samples from each treatment at each time period were only sparsely sampled for decay fungi in order to give material suitable for creosoting trials. Many of the samples were too wet for creosote treatment and were, therefore, kiln dried to 28% moisture content. No treatment problems were experienced with any of the samples, indicating that even a 6 month storage results in poles suitable for good treatment with no subsequent bleeding. None of the poles in any of the treatments gave any problem of bleeding after storage.

TABLE 6

Colonization of pole sections in the Field Treatment study after 12 months air-seasoning at Thetford, Norfolk

Sampled ID	*Scots Pine*		*Corsican Pine*	
Fungus	*Poles (n/8)*	*Cores (% of 104)*	*Poles (n/8)*	*Cores (% of 104)*
Control poles:Uncovered				
H annosum	0	0	1	1
H punctulatum	1	1	2	3
Peniophora sp	4	5	5	19
S brinkmannii	2	8	1	1
S sanguinolentum	2	2	0	0
Basidiomycete	4	13	3	5
Sus. Basidiomycete	2	4	1	2
F avenaceum	8	64	8	48
Moulds	5	12	7	12
Control poles: Covered				
C evolvens	1	1	3	4
H annosum	1	1	1	1
H punctulatum	1	2	1	1
Peniophora sp	7	13	7	14
S brinkmannii	1	11	1	1
S sanguinolentum	2	2	2	2
Basidiomycete	5	9	3	5
Sus. Basidiomycete	3	4	0	0
F avenaceum	8	62	8	53
Moulds	7	16	7	20
Boron poles: Uncovered				
Basidiomycete	1	1	0	0
F avenaceum	8	68	7	67
Moulds	7	45	8	70
Boron poles: Covered				
Basidiomycete	2	2	1	1
F avenaceum	8	75	8	68
Moulds	8	62	8	75
Boron/*Trichoderma* poles				
Basidiomycete	0	0	1	1
Favenaceum	2	5	3	5
Trichoderma	8	95	8	85

Note: Although figures are given four mould and Trichoderma isolation, it should be borne in mind that a selective medium, not conducive to mould growth, was used. The true figures are almost certainly higher.

TABLE 7

Colonization of pole sections in the Field Treatment study after 18 months air-seasoning at Thetford, Norfolk

Sampled ID	*Scots Pine*		*Corsican Pine*	
Fungus	*Poles (n/8)*	*Cores (% of 64)*	*Poles (n/8)*	*Cores (% of 64)*
Control poles: Uncovered				
Sus. borwn rot	1	1	1	1
H punctualtum	1	1	0	0
Peniophora sp	6	23	7	37
S brinkmannii	2	8	2	6
S sanguinolentum	3	5	2	3
Basidiomycete	4	9	4	12
F avenaceum	6	12	7	22
Moulds	7	42	7	37

Control poles: Covered				
Sus. brown rot	1	1	1	1
H punctualtum	1	1	0	0
Peniophora sp	3	9	7	37
S brinkmannii	3	10	2	4
S sanguinolentum	3	5	1	1
Basidiomycete	3	17	3	10
F avenaceum	3	34	3	20
Moulds	8	50	8	43
Boron poles: Uncovered				
Basidiomycete	2	3	4	9
F avenaceum	6	30	5	50
Moulds	8	87	8	81
Boron poles: Covered				
Peniophora sp	0	0	1	1
Basidiomycete	4	7	4	7
F avenaceum	6	39	6	46
Moulds	8	56	8	65
Boron/*Trichoderma* poles				
Peniophora sp	2	6	1	3
Basidiomycete	0	0	0	0
F avenaceum	7	50	5	46
Trichoderma	8	75	8	71

TABLE 8
Summary of Moisture Contents at 6, 12 & 18 months

SAMPLE ID	*Moisture content (%)*		
	6 mths	*12 mths*	*18 mths*
CONTROLS			
SCOTS PINE			
Uncovered	59	43	25
Covered	57	40	21
CORSICAN PINE			
Uncovered	112	54	44
Covered	94	58	38
BORON			
SCOTS PINE			
Uncovered	73	36	34
Covered	68	34	20
CORSICAN PINE			
Uncovered	97	60	25
Covered	81	38	28
BORON & *Trichoderma*			
SCOTS PINE			
Uncovered	99	84	19
CORSICAN PINE			
Uncovered	97	61	29

Results based on 3 replicates taken at 3 depths, (2, 4 & 8cm), for each of 4 poles in each group.

5. Second Field Trial

5.1 Introduction, Methods and Materials

In view of the successful results from the first trial a second was set up to determine the minimum levels of Boron needed per treatment and to study the effect of *Trichoderma* sp. treatment alone. In this trial all the Boron treatments were initially sheeted for 2 weeks after treatment to allow initial diffusion to occur, prior to drying or exposure to rain. The Boron treatments were applied by brush rather than spraying which had proved problematical in the first trial.

There were eight replicate pole sections of each species of Pine per treatment. Four full pole sections were also treated in each treatment group to allow further work on full sized poles after the trial. The treatments consisted of:

1. Control Poles – Uncovered: no chemical or biological treatments, and pole stacks not seasoned under cover.
2. Control Poles – Covered: no chemical or biological treatments, and poles seasoned under cover.
3. Boron treated (30%) Poles – Uncovered: poles treated with a 30% solution of 'Timbor' with pole stacks not seasoned under cover.
4. Boron treated (30%) Poles – Covered: poles treated with 30.0% solution of 'Timbor' with pole stacks seasoned under cover.
5. Boron treated (15%) Poles – Uncovered: poles treated with a 15% solution of 'Timbor' with pole stacks not seasoned under cover.
6. Boron treated (15%) Poles – Covered: poles treated with a 15% solution of 'Timbor' with pole stacks seasoned under cover.
7. Boron treated (10%) Poles – Uncovered: poles treated with a 10% solution of 'Timbor' with pole stacks not seasoned under cover.
8. Boron treated (10%) Poles – Covered: poles treated with a 10% solution of 'Timbor' with pole stacks seasoned under cover.
9. *Trichoderma* treated poles – Uncovered: poles treated with a spore suspension of a spore suspension of *Trichoderma* sp., and pole stacks not seasoned under cover.
10. *Tirchoderma* treated poles – Covered: poles treated with a spore suspension of *Trichoderma* sp., and pole stacks seasoned under cover.

Both the chemical and biological treatments were assessed after 6 months (August 1990).

5.2 Results

As can be seen from Table 9 the level of infection in the control poles in higher than that present in the first trial after a similar period of time. However, there seems to be little difference between the Corsican pine poles and the Scots pine poles in contrast to the 6 month results in the first trial. The efficacy of the boron treatments can clearly be seen. In the 10 & 15% treatments a low level basidiomycete infection was found, especially from the white-rots, *S. sanguinolentum, Peniophora.* sp and *H. punctulatum.* The incidence of desirable mould fungi in the treated poles was much higher than in the controls. Isolations from poles treated with 30% boron, as in the first trial, indicated an extremely low percentage of infection for basidiomycetes whilst sustaining a high incidence of mould infection. The poles treated with all three levels still showed detectable concentrations of boron when sprayed with curcumin regent. Penetration of the boron varied between 2 and 4 cm into the poles and a shell of boron could clearly be seen around the outside of the poles forming a protective barrier against basidiomycete infection. there seems to be little variation between the covered and uncovered poles in the levels of detectable boron, however, this is probably due to the fact that all the poles were close sheeted for 2 weeks prior to exposure. This allowed diffusion of the boron into the poles mnimizing losses due to leaching from rainfall.

The inoculation of poles with *Trichoderma* did not seem to be effective in limiting infection by basidiomycetes. As can be seen from the table the extent of colonization by basidiomycetes is very similar to that of the control poles. It appears that failure to control basidiomycetes is not related to any loss in viability of the initial inoculum since high levels of *Trichoderma* were detected in these poles. It is possible that the use of more virulent strains of *Trichoderma* will produce a more efficient method of treating poles biolgically. further work is recommended in this area.

Moisture content analysis of the poles can be seen in Table 10. The data shows that after six months the poles were very dry compared to the moisture contents determined at a similar period in the first trial. This is probably due to a combination of the thinness of the poles and the hot, dry summer.

TABLE 9

Colonization of pole sections in the second Field Treatment study after 6 months air-seasoning at Calders and Grandidge, Boston Lincs.

Sampled ID	*Scots Pine*		*Corsican Pine*	
Fungus	*Poles (N/4)*	*Cores (% of 32)*	*Poles (N/4)*	*Cores (% of 32)*
Control poles: Uncovered				
C evolvens	2	6	2	9
H punctualatum	0	0	2	9
Peniophora sp	1	25	3	31
S sanguinolentum	2	12	3	9
F avenaceum	1	9	0	0
Moulds	2	6	2	9
Boron poles (10%): Uncovered				
H punctulatum	0	0	1	3
C evolvens	1	9	2	12
S sanguinolentum	1	3	0	0
Moulds	4	94	4	87
Boron poles (10%): Covered				
C evolvens	0	0	1	9
Peniophora sp	1	3	1	3
H punctualatum	1	3	0	0
F avenaceum	0	0	1	6
Moulds	4	96	4	90
Boron poles (15%): Uncovered				
Peniophora sp	1	3	1	3
S brinkmannii	1	3	0	0
Moulds	4	94	4	96
Boron poles (15%) Covered				
C evolvens	1	3	0	0
H punctulatum	1	3	0	0
S sanguinolentum	1	3	0	0
Moulds	4	90	4	100

TABLE 10

Summary of Moisture Contents 6 months into second trial

SAMPLE ID	*Moisture content (%)*
	CONTROLS
SCOTS PINE: Uncovered	21
CORSICAN PINE: Uncovered	19
	BORON (10%)
SCOTS PINE: Uncovered	24
SCOTS PINE: Covered	14
CORSICAN PINE: Uncovered	23
CORSICAN PINE: Covered	15
	BORON (15%)
SCOTS PINE: Uncovered	17
SCOTS PINE: Covered	22
CORSICAN PINE: Uncovered	18
CORSICAN PINE: Covered	14
	BORON (30%)
SCOTS PINE: Uncovered	17
SCOTS PINE: Covered	18
CORSICAN PINE: Uncovered	15
CORSICAN PINE: Covered	14
	Trichoderma
SCOTS PINE: Uncovered	20
SCOTS PINE: Covered	27
CORSICAN PINE: Uncovered	13
CORSICAN PINE: Covered	32

TABLE 9 (ctd.)

Colonization of pole sections in the second Field Treatment study after 6 months air-seasoning at Calders and Grandidge, Boston Lincs.

Sampled ID	*Scots Pine*		*Corsican Pine*	
Fungus	*Poles (N/4)*	*Cores (% of 32)*	*Poles (N/4)*	*Cores (% of 32)*
Boron poles (30%): Uncovered				
S sanguinolentum	1	3	0	0
Moulds	4	96	4	0
Boron poles (30%): Covered				
Moulds	4	96	4	100
Trichoderma poles: Uncovered				
C evolvens	4	25	1	3
H punctulatum	2	6	2	6
Peniophora sp	3	31	3	31
S brinkmannii	1	3	0	0
S sanguinolentum	4	22	3	12
Moulds	3	40	4	65
Trichoderma	4	50	4	37
Trichoderma poles: Covered				
C evolvens	2	15	2	12
H punctulatum	1	3	1	3
Peniophora sp	3	37	2	37
Basidiomycete	2	6	0	0
F avenaceum	0	0	1	3
Moulds	4	34	3	40
Trichoderma	4	72	4	68

6. Conclusions

1. Home grown Scots and Corsican Pine and imported Scots Pine poles are susceptible to basidiomycete infection during air-seasoning. The level of infection in home grown material is considered unacceptable.
2. Treatment with simple borate solutions appear to be effective at preventing this infection.
3. A 30% solution of 'Timbor' appears to give excellent protection for up to 18 months.
4. Inoculation with *Trichoderma* sp. and with borate appears promising but *Trichoderma* alone requires further investigation.
5. The development of moulds and staining fungi is uninhibited in the boron treated material giving rise to desirable increases in porosity and resulting in excellent creosoting properties.
6. Sheeting for 2 weeks after treatment with boron is recommended to achieve both better treatments and reduce susceptibility to leaching.
7. Further work using antagonistic primary mould fungi alone should be considered.
8. It should be ascertained how long the poles under bark can be kept prior to peeling and boron treatment.

9. It is also advisable to determine whether boron treatment will relieve infection incurred during initial storage and transport after felling.

In summary, it is recommended that home grown roundwood which is to be air-dried for use as poles should be dipped or sprayed with a 30% "Timbor" solution immediately after peeling and within 2 weeks of felling. Further work relating to points 7, 8 & 9 above is already planned with the Forestry Commission. Trials with imported timber and alternative treatments which avoid the need for air-drying are also envisaged.

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DISCUSSION ON PAPER 5

Chairman: G.O. Hutchison

THE CHAIRMAN: Thank you David. I was certainly fascinated by your presentation and I am sure there will be questions. We have not got very much time available, but can those wanting to ask a question give their name, their organisation, and they will be given a microphone.

DR. A. BRAVERY (BRE): Thank you very much for a very stimulating and interesting paper. I was tempted to draw parallels from across two pieces of the work that you described. In an earlier part of the talk you were discussing getting Boron into the centres of poles to give prolonged performance, prolonged protection to the otherwise vulnerable part, and I was struck by the distribution patterns that you were showing in your sprayed poles. If I remember the figures correctly, the curcumin spray reaction depends on there being something like 1 kg per m^3 retention, which is the level required for effectiveness, and you actually had that in pretty deeply after your spray application to the green poles. I just wonder whether there will be any residual effect there carried on through the life of the pole, and you have actually got part of the way towards achieving at the outset what at the moment you are having to put in retrospectively. can you comment on that?

DR. DICKINSON: Yes. The same had occurred to me, and obviously we were not going to over-state this and over-hype the situation. There is still a lot of Boron there, and if that Boron is then going to be sealed in with the creosote treatment, the potential for it remaining and giving protection to the heartwood is certainly very real, and we have spoken to treaters about this, i.e. looking at the possibility of being able to treat Spruce. If we got large amounts of Boron into the wood initially, possibly by sap displacement, and let that move into the heart, and then put an annulus of a very heavy creosoting around the narrow sapwood bound, we may end up with a product which could perform very well. The potential for Boron inside the annulus of creosote treatment is something which we need to further explore, but I would not claim at this stage that these initial treatments were going to carry over and give long-term service effects, but they may well.

MR. M. CONNELL (Hicksons): Thank you, David for a very interesting paper. In the current environmental debate which is going on in Sweden, there have been proposals put forward that only the butts are treated, usually with creosote, to reduce the use of preservatives. Following your comments on the mechanism of infection and also possible capillary action of moisture up the holes, what are your views regarding these particular proposals?

DR. DICKSON: I am very sympathetic towards it, providing one goes high enough up the pole, say the bottom ten feet and probably six feet above the ground, because these infections which get in the checks tend to start at that level. Obviously everybody knows poles which have decayed from top to bottom, but the general picture is that infection probably starts at about three or four feet and you get the column of decay descending to the heartwood. Full cell treatments at the butt end linked with shrink-wrapping of the butt end are distinct possibilities, and we need to look at these possibilities so that we can defend the position for materials like creosote, which have given such an excellent service life. If there are problems like bleeding, we eliminate it. If people want to reduce the retentions, these very high loadings at the butt end, possibly linked with some physical protection system are a possibility.

MR. A.G. PARKS (Burt Boulton & Haywood): Thank you very much for your paper, David. It was interesting. I wondered if when you were looking at the problem of rot or pretreatment decay in home grown poles you considered the seasoning regime to any extent. I was interested in the situation in which one sees these poles in Thetford Forest and contrasted that with other regimes, where a home grown pole can be felled, preferably in the winter months, and not only debarked but then dressed – that is, the inner bark is removed – and then put in very open stacks, often using creosoted poles as bearers, and allowing the poles to enjoy a more open aspect. We have found that you can get poles to a low moisture content without a high infection of these pretreatment decays, and during the period when the Inspectors were rejecting high quantities of these poles from the Forestry Commission, we found the poles sourced from private growers and subjected to that sort of seasoning regime were not being rejected, and I just wondered if consideration of the seasoning regime could be subjected to some scrutiny by you.

DR. DICKINSON: Yes. In fact, Alan, it was, but time did not permit me to explain this during the presentation. It was done at different times of year, and in fact the second trial was carried out not in Thetford Chase because of this very problem, but at Grange Court, and those poles were removed from the forest and the trial was done at Grange Court in the way in which you describe. You will have noticed – and I did allude to it briefly – that the levels of white rot infection in the second trials were something like 50 per cent less than in those first trials. So there is an effect. However an isolation decay is present but not so evident to the eye. This may be a worse situation because the inspectors would miss it.

MR. A.J. BUIJS (Flexichemie): It was a very interesting paper. Also blue staining fungi are not always accepted. I wonder whether it could be recommended to use a combination product or Boron compound and a compound against blue staining. What do you think about it?

DR. DICKINSON: It is a possibility, but I am convinced that what has been described as weathering is due to biological activity and this increase in porosity is due to micro-organisms. We can try this, obviously, but if we did try drying poles using additives to prevent blue staining mould, it may be as bad as material which is being kiln dried. I am convinced it would be nowhere near as acceptable from the treatment and bleeding point of view as poles in which the micro-organisms and moulds, stainers, bacteria, have been allowed to develop during the storage period, so I think it is very desirable that we do have stain and mould developing deep in the sapwood of these poles during the seasoning period.

THE PRESIDENT: Thank you very much for an excellent paper. My question indicates a vested interest in CCA. The question really revolves around two concerns about the system that you are proposing. One, we are looking at very high cost in inventory, holding stocks over what is a two-year period of air drying. The other is also a potential to ground contamination by Boron spraying. In view of that, you talked about CCA sap displacement. Why is CCA sap displacement not considered to be the preferred route?

DR. DICKINSON: I avoided that discussion. I think Mr. Hutchinson can confirm this. When we had the first tentative meetings early on I said, "Look, I believe there is a real problem but if you are prepared to accept sap displacement with CCAs we do not have a project," and I have a lot of sympathy with what you say, but there is a desire for creosoted poles. Perhaps I am not the person to answer the question; there are people here in the audience from the electricity supply industry who could probably tell you why they prefer a conventionally creosoted pole to a sap displaced CCA treated pole. Perhaps somebody else would like to comment. We were presented with a problem, i.e. "We want to creosote these poles and we do not want them to go rotten." As to why they do not want CCA sap displacement treated poles I cannot comment. I know there have been some problems with electricity conductivity and they are very heavy to handle. I think it is probably a healthy thing that there is a choice as well.

THE PRESIDENT: I am all for the choice being available!

THE CHAIRMAN: It looks like we have come to the end of the questions and the time. David, thank you very much again for an interesting paper and thank you to the audience for participating. *(Applause)*

FUNDAMENTAL STUDIES ON THE FUNGUS CELLAR/SOIL BED

by Kevin Archer
Laporte Timber Division, Harrisburg, NC, USA

Introduction

The process for approving new ground contact preservatives in Europe and other regions of the world differs in several respects. Historically, the European approach has emphasised laboratory testing. In other countries preservative performance in field tests has been the dominant criterion for approvals. The threat of environmental legislation against existing preservatives has led to a re-evaluation of preservative test protocols worldwide in anticipation of "environmentally friendly" chemistries being offered as alternatives to existing preservatives.

Laboratory tests have major advantages over field tests for a number of reasons. They are relatively short in duration and they can, in theory, be standardised among different laboratories. However, on the down side, depletion, detoxification, weathering and biological succession which contribute to preservative performance in the field, can only be simulated in a laboratory test. Furthermore, the standard decay fungi used in laboratory testing may be of little relevance to bioassays of more novel preservatives because the fungi currently in vogue were originally selected for their tolerance to conventional preservative systems such as copper chrome arsenate (CCA), pentachlorophenol (PCP) and creosote (Butcher, 1968).

Ground contact field tests address many of these problems. As a result the performance of a preservative in a field test is generally considered to be representative of its expected in-service performance. But, not in all circumstances. For example it is impractical to test all preservatives in every situation where they could expect to be used. Geographical differences in climate, soil type and soil fertility make it difficult to standardise field tests. This can lead to contradictory performance data. From a commercial standpoint the time required to generate meaningful data in a field test is also a draw back. Despite these apparent draw backs it is interesting to note that the value of the field testing approach as an adjunct to laboratory testing is being thoroughly explored in the lead up to European standards homologation in December 1992.

Gersonde and Becker (1958), Hansen (1973) and Hedley and Butcher (1985) suggested that fungal cellars or accelerated "field simulators" serve as a useful compromise between pure culture laboratory tests and field tests for the evaluation of new preservatives. There has been steady progress towards developing accelerated unsterile soil contact decay test procedures for several decades (Hedley, 1980; Johnson *et al.* 1988; McKaig, 1986; Merrill and French, 1963; Morris *et al.*, 1987; Murphy *et al.*, 1982; Polman *et al.*, 1991; Preston *et al.* 1983; Stockwell and Goodell, 1990; Vinden *et al.* 1982) Soil bed testing has been in use for many years but the technique has not been developed to the point where it can be regarded as a true accelerated ground contact field test encompassing the diversity of decay types found in nature. Soil bed research has culminated in the development of unsterile soil contact soft rot test protocols (Bravery, 1968b; Gray, 1986; McKaig, 1984) some of which are under evaluation by the European Standardisation committees. The polarisation towards soft-rot tests has probably resulted because of the incidence of soft rot type decay in natural soil contact situations with preservative treated timber and from the work of Clubbe (1980, 1982, 1983) who showed that soft rot fungi presented the climax organisms in the decay of CCA treated wood. The importance of soft rot in the eventual demise of CCA treated material in the field cannot be ignored but the question is, will soft rot be of equal importance to the next wave of wood preservatives?

Problems in using the fungal cellar to accurately predict field performance have been noted by several authors (Hedley, 1983; Morris *et al.* 1987). A key issue important to the eventual development of a soil bed accelerated field simulator is an understanding of the inter-relationships among temperature, soil moisture and its influence on wood moisture content, soil aeration, soil fauna, soil nutrients/fertility, soil pH, cation exchange capacity, stake size and preservative depletion. Each of these parameters has been studied extensively in isolation but the complexity of investigating these parameters as a whole has proved to be a daunting prospect. Nevertheless, soil is a living ecosystem and a preservative treated stake installed in a soil environment becomes a part of that ecosystem. To develop a soil bed test procedure we must first understand the ecosystem and then attempt to optimise conditions for wood decay. Johnson *et al.* (1988) took a bold step in this direction by including termites into a soil bed system and coining the term accelerated field simulator or AFS to describe the new system.

Preliminary data from our own soil bed system in Harrisburg, NC are used to show that it is possible to sustain a soil ecosystem and maintain both basidiomycete and soft rot development. The performance of a preservative in soil contact is a function of its influence on water uptake into the test material, the leachability of the preservative components into the soil system and on its toxic effects on soil microflora. Studies in our facility are examining the relative importance of these interactions and preliminary data are presented. Complementary field test studies are also underway with the same preservatives exposed outdoors. These field tests provide data with which the soil bed results are compared. The goal of our research efforts is to develop a better understanding of processes which take place when timber is placed in soil contact.

Materials And Methods

Soil beds

Soil beds were constructed from plastic lined concrete burial vaults (2 x 1 x 0.75 m). Holes were drilled in each corner of the base to facilitate free drainage. Each burial vault was filled to a depth of 200 mm with a layer of loose gravel. Fresh soil was obtained from a forested area (mixed hardwood and softwood) close to the laboratory facility.

The top layer of leaf litter in the forest was removed from the soil and stored. The next 150mm of top soil was taken for use in the burial vaults. Each burial vault was filled to within 10 mm of the top with soil. Finally a 50 mm layer of the leaf litter removed the forest was placed on top. Before use each bed was thoroughly watered with a garden hose until water ran freely out of the drain holes. At this point the soil was considered to be at its water holding capacity.

Soil bed facility

Individual burial vaults were maintained in a modified double skinned, plastic tunnel green house. Energy input to the facility in the form of heat and light was reduced using horticultural shade cloth. Only partial control of temperature and humidity was possible with this type of construction especially in the summer months. Winter temperatures inside the greenhouse were maintained between 23 and 25°C whereas in summer the temperature ranged from 30 to 35°C. Soil temperatures were generally 2-3°C lower than the air temperature in summer.

Humidity in the greenhouse was maintained between 40 and 70% RH. The fluctuation in humidity reflected diurnal changes in external air humidity. Humidity was kept below 70% RH to promote moisture movement from the soil through the stakes.

Soil moisture content in some beds was controlled automatically using soil vacuum measuring devices ("IRROMETER") attached to a solenoid controlling an overhead fine mist water spray. The "IRROMETER" attached to a solenoid controlling an overhead fine mist water spray. The "IRROMETER" relies on the principle that as the soil dries it sucks fluid out of the device creating a vacuum. When the vacuum reaches a set point it triggers a switch controlling the solenoid. As the water spray wets the soil, the soil vacuum drops and the water spray is switched off.

Other soil beds were watered by hand using a garden spray. Using either automatic or hand watering it was possible to produce different soil moisture regimes to examine the influence of soil moisture on decay type and preservative performance. A range of soil moisture contents from 35% to 100% of the soil water holding capacity were evaluated.

Plant growth from seeds present in the soil and leaf litter was not discouraged from growing in the soil beds.

Stake material and preservative treatments

Kiln dried southern yellow pine (*Pinus* spp.) sapwood was used in the preparation of all test material. Stakes (19 x 7.5 x 200 mm) were quarter-sawn from clear boards. The stakelets were conditioned to 12% equilibrium moisture content (e.m.c.) in preparation for preservative treatment. Forty replicate stakes were vacuum impregnated with several different concentrations of the following preservatives:

CCA – type C oxide formulation
ACZA – ammoniacal copper zinc arsenate
ACA – ammoniacal copper arsenate
ACQ – ammoniacal copper quat (2:1 CuO : quaternary ammonium compound ratio)
DDAC – didecyl dimethyl ammonium chloride

The retention of preservative was calculated by weight for each stake and confirmed later by chemical analysis. Immediately after treatment, stakes were sealed in plastic bags and stored for 14 days to allow fixation to take place. After the wet fixation period, stakes were air-dried in preparation for installation in the soil beds. No post-treatment leaching was carried out.

Preservative performance

Ten replicate stakes for each preservative/retention combination were allocated to the forest and soil beds to evaluate preservative performance. Stakes were installed randomly in a 50 mm spaced grid pattern within the soil bed or forest site. Each stake was pushed vertically into the soil to a depth of 140 mm. Visual evaluations were made at periodical intervals using a method adapted from the American Wood Preservers' Association M7-90 standard procedure. In addition to the standard 5 ordinal soundness ratings, 3 intermediate grades were used. This created an 8 level rating scheme (Archer *et al.* 1989).

Soil contact depletion

The remaining stakes for each group were assigned to a soil contact depletion experiment. In this experiment a 50 mm section was removed from the end of each stakelet and retained as an undepleted reference sample. Stakes were placed in the soil beds using the same spacing as before except that the stakes were pushed into the soil so that only the top 10 mm protruded above the soil surface. Soil moisture in the beds was kept at 100% of the water holding capacity by frequent manual watering from above using a garden hose. Five stakes for each preservative/retention group were removed from the beds at 3 month intervals. Each stakelet was cleaned of any adhering soil and then conditioned to constant weight in a climate controlled room. Chemical analysis was then carried out for all the end matched, depleted and undepleted stakes.

Stake moisture contents

Moisture contents of individual stakes at different times after installation in the soil were calculated from weight measurements before and after installation.

RESULTS AND DISCUSSION

The physical and chemical characteristics of the Harrisburg forest soil are provided in Tables 1 and 2. The soil texture characteristics (Table 1) of the forest soil used in the soil bed experiments conform to a sandy loam type soil (Glinski and Lipiec, 1990). The water holding capacity of the soil was calculated to be 31%. Butcher (1983) surveyed the manner in which soil beds or fungal cellars were operated in different institutions around the world. He reported that soil bed soils were most commonly maintained at between 120-130% of the soil water holding capacity. Some were kept at 80-100% of the soil WHC. Vinden *et al.* (1982) and McKaig *et al.* (1986) in fundamental studies on soil bed procedures identified soil moisture content as a key determining factor on the type of decay which occurred in a soil bed. Vinden *et al.*, (1982) found that soil at a moisture content of 80% of the WHC promoted basidiomycete type decay in Scots pine and birch stakes. At a moisture content of 100% or greater soft rot prevailed. Soft rot was the most common decay type reported in Butcher's 1983 survey. Carey and Grant (1975) examined the effect of soil water holding capacity on the moisture contents of sample stakes. They determined that above 100% WHC, when free water is available, stake moisture contents increased exponentially. Sommers *et al.* (1981) observed that a soil moisture content between 50-60% of the soil WHC was the optimum range for microbial growth and metabolism. In this study it was decided to maintain soil moisture contents at levels below 100% WHC to promote basidiomycete decay.

TABLE 1
Physical characteristics of the Harrisburg forest soil

Soil texture

Coarse fractions				
75-20mm	20-5mm	5-2mm	2mm	
%				
0	3	5	92	
Fine Fractions (2mm)				
Clay	Fine silt	Coarse silt	Sand	
%				
11	21	14	54	
Sand Fractions (mm)				
2-1	1-0.5	0.5-0.25	0.25-0.1	0.1-0.05
%				
8	9	10	15	12
Water retention (1/3 bar)				
31.2%				

TABLE 2
Chemical characteristics of the Harrisburg forest soil

pH (H_2O)	*Organic matter (LOI %)*	*Organic carbon (%)*
5.14	4.8	2.2
	Extractable bases	
Ca	Mg	K
	ppm	
1242	258	195
Total Nitrogen (%)		*Total Phosphorous (%)*
0.175		0.025
	Cation exchange capacity	
	11.82 meq / 100g	

In a preliminary experiment the moisture content of stakes treated with several preservatives at different retentions was determined in both field exposure and soil bed exposure. Moisture content data for the stakes 3 months after installation are provided in Tables 3 and 4. Data were not collected after this time because of the likelihood that fungal colonisation would change the moisture content and distribution in the stakes. The data show clearly that soil moisture contents below soil water holding capacity significantly influence stake moisture contents. Of greater interest, however, are the different moisture contents observed among stakes treated with different preservatives and between treated wood and untreated wood. In all soil moisture regimes untreated wood was wetter than treated wood. As preservative retention increases, stake moisture content appears to decrease. There are indications that addition of a water repellent to a preservative formulation had a slight beneficial effect by reducing stake moisture content.

TABLE 3
Stake moisture contents in soil bed exposure

SOIL MOISTURE CONTENT = 12.7% or 40% WHC

Preservative	*Retention (kgm^{-3})*					
	1	*2*	*4*	*6.4*	*6.4 + WR*	*9.6*
ACQ 5:1	35.78	38.63	35.74	28.17	37.39	32.82
ACQ 3:1	48.26	40.73	28.72	30.91	29.52	32.87
ACQ 2:1	36.13	49.75	32.87	32.60	32.64	38.07
ACQ 1:1	52.56	40.76	30.26	31.08	33.15	41.12
ACQ 1:3	46.14	42.52	38.29	39.43	34.51	40.31
ACZA	40.12	39.75	34.73	31.87		30.51
CCA	50.52	25.07	32.26	35.12		31.16
UNTREATED	75.99					

SOIL MOISTURE CONTENT = 30.1% or 98% WHC

Preservative	*Retention (kgm^{-3})*					
	1	*2*	*4*	*6.4*	*6.4 + WR*	*9.6*
ACQ 5:1	95.43	97.43	67.58	42.65	39.48	35.10
ACQ 3:1	95.92	94.95	61.40	40.49	48.76	40.83
ACQ 2:1	104.60	91.20	74.33	51.14	38.72	41.96
ACQ 1:1	106.64	99.43	82.31	67.66	55.02	48.56
ACQ 1:3	95.20	119.56	91.74	80.52	66.48	71.64
ACZA	104.65	90.62	80.51	52.79		34.33
CCA	104.65	90.62	80.51	52.79		34.33
UNTREATED	91.31					

TABLE 4
Stake moisture contents in the forest site

SOIL MOISTURE CONTENT = 22.9% or 72% WHC

Preservative	*Retention (kgm^{-3})*					
	1	*2*	*4*	*6.4*	*6.4 + WR*	*9.6*
ACQ 5:1	107.54	96.62	63.38	53.67	53.42	47.60
ACQ 3:1	106.81	96.70	59.23	52.15	59.54	48.33
ACQ 2:1	97.12	96.01	73.03	57.28	59.54	54.78
ACQ 1:1	97.94	94.21	69.44	58.25	52.83	56.77
ACQ 1:3	97.04	102.47	89.55	60.50	54.92	66.88
ACZA	99.71	99.51	82.39	66.37		51.50
CCA	91.64	93.46	77.70	71.56		58.91
UNTREATED	116.04					

Gray (1986), Green *et al.* (1989) and Vinden *et al.* (1982, 1983) noted differences in moisture content between CCA treated and untreated blocks buried in soil. Vinden *et al.* (1983) observed that the moisture content of CCA treated Scots pine stakes stabilised at 28-30% at all CCA loadings. They interpreted this to mean that there was very little movement in to the stakes by capillarity. The higher moisture contents observed for treated wood in this investigation can presumably be attributed to mass movement of water due to capillarity induced by the low relative humidity above the soil and the "wicking" effect (Baines and Levy, 1979).

An important point related to wood moisture content/decay fungus relationships is the fact that wood moisture content is in dynamic equilibrium with the environment. Baines and Levy (1979) and Baines (1981) showed that when stakes are placed in soil contact they absorb water until an equilibrium is reached between their internal water potential and that of the adjacent soil. Input of water into a soil stake system can be from four main routes, rainfall or overhead irrigation, direction absorption from air, absorption from the soil via capillarity or from translocation into the wood from biotic influences e.g. the decay fungi themselves. Since the soil bed stakes are maintained in a controlled environment, soil moisture and consequently stake moisture contents should not fluctuate widely. In contrast soil moisture in the field will vary with the amount of rainfall and the change of the seasons. This highlights a deficiency in the data presented in Tables 3 and 4 and, for the bulk of published data. The measurements represent moisture content values at one discrete point in time.

Soil moisture profiles, measurement and control of soil watering and the reality of trying to maintain soil at a moisture content at a predetermined percentage of the water holding capacity are other important issues. In a free drainage soil system the maximum moisture content that can be achieved and maintained with any degree of reliability is 100% soil WHC. Any water in excess of 100% WHC will drain away. Attempts to produce a moisture content below 100% WHC will at best produce a moisture gradient. Vinden *et al.* (1982, 1983) examined soil moisture profiles in detail. They suggested that by maintaining a high humidity above the soil the rate of drying would be minimised and the soil moisture profile would become unfiorm at different depths. At the same time they advocated watering the soil beds from below. This approach creates a number of problems. To begin with these procedures bear little resemblance to reality. Most water in a free draining situation enters soil from above via rainfall. Moisture normally evaporates freely from the soil surface and via plant transpiration and in so doing nutrients and dissolved gases are transported to the surface. Retarding this process is likely to produce unnatural soil moisture profiles which may not be conducive to decay and, at the same time, migration of nutrients into stakes via "wicking" will be reduced.

To minimise loss of moisture from the soil in these studies a natural leaf litter layer was used. This litter layer served several ancillary purposes. Destruction of the soil surface structure through repetitive watering was prevented and it provided a slow release nutrient supply to the soil. It was envisaged that solubilised components from the leaf litter liberated by the activities of the soil fauna and flora would be washed into the soil during overhead watering.

Measurement of soil moisture at different depths is a slow and tedious process. The most accurate way is to remove soil samples and determine moisture content by oven drying. Vinden *et al.* (1982) investigated several alternatives with limited success. The oven drying technique has limited application if you are trying to calculate how much water to add to dry soil. A more promising, automated approach to soil watering was suggested by Stockwell and Goodell (1990). This method employed soil tensiometers (IRROMETER) controlling a solenoid which turned the flow of water to an overhead water spray, on or off. Commercially these instruments are employed in horticulture and agriculture to control the irrigation of crops. After 12 months evaluation in our soil beds they show a great deal of promise. Unfortunately they do not measure soil moisture content directly but, rather they record soil vacuum. Efforts to date have been devoted to calibrating soil vacuum to a desired soil moisture content.

The influence of soil-water relationships on decay has been studied by several investigators (Baines, 1983; Body, 1986; Carey and Grant, 1975; Griffin, 1977; Somers *et al.,* 1981; Vinden *et al.,* 1982). Moisture in wood affects the growth of wood decaying fungi at both ends of the moisture spectrum. It is generally accepted that wood is not susceptible to decay by most fungi below its fibre saturation point which on average equates to about 30% m.c. (Baines, 1981). At low moisture contents limitations are placed on hyphal elongation and general cell metabolism. At high moisture contents a water filled void space may pose a physical barrier to fungi but more importantly it can influence the gaseous regime within the wood tissues.

Thus, it has become widely accepted that soil moisture content and in turn wood moisture content influences the type of fungi which attack wood. It was therefore, no surprise to observe that soil moisture content influenced decay of DDAC treated stakes in our soil bed facility. The data in Table 5 clearly show that while soft rot decay was fairly uniquitous at soil moisture contents from 35% WHC to 80% WHC, basidiomycete attack was favoured by the lower soil moisture content range. Of the basidiomycete rot types brown rot was by far the most dominant. The difficulties in interpreting data of this type have been realised for some time. Although brown rot or soft rot were identified on the samples at the time of failure the possibility that other organisms were involved in the demise of the sample cannot be ignored (Butcher 1968). Successional changes in the microflora of wood in ground contact have been documented by a number of authors (Clubbe, 1980, 1982, 1983; Rayner and Boddy, 1988).

TABLE 5

Causes of failure in DDAC treated stakelets after 12 months soil bed exposure

Decay type causing failure (% occurrency)

	BR	*SR*	*WR*	*IN*
Tank 1 35% WHC	46	53	1	0
Tank 2 50% WHC	31	68	1	0
Tank 3 44% WHC	22	73	5	0
Tank 4 80% WHC	17	75	7	1

Soil WHC = 31%
BR = Brown rot
SR = soft rot
WR = white rot
IN = insect attack

All rot types assessed visually during inspection procedure

It has become common to compare decay rates in soil beds and field exposures to determine some form of decay acceleration factor in the soil bed. Various authors report acceleration factors as high as 12-15 times (Morris *et al.* 1987) and 5-10 (Hedley, 1983). Since these acceleration factors are dependent on the severity of the field site used for comparison, care should be taken in their interpretation. A comparison of the mean soundness of CCA, ACZA, ACA, ACQ and untreated stakes after 9 months exposure (Table 7) shows that the rate of decay is enhanced in the soil bed but it is of little value to calculate some form of acceleration factor at this stage. It is encouraging to observe the excellent performance of the ACQ formulation. At low retentions the mean soundness of ACQ is equivalent to that of CCA but slightly superior to ACZA.

It will be of interest to follow the performance of sub-toxic threshold levels of different preservatives in order to determine the relevance of these low treatment levels to the performance higher concentrations. Butcher (1983) found that low levels of CCA performed similar to untreated wood. In field exposure in Hawaii and North Carolina it is common to observe failure of sub-toxic levels of CCA before untreated material (Jin and Archer, 1991). King *et al.* (1989) observed that preservative losses from CCA treated blocks were maximal at low (sub-toxic) thresholds. Most losses occurred during the early stages of burial while further small losses occurred in decaying wood towards the end of the burial period. Schultz-Dewitz (1964) speculated that certain soil organisms were stimulated by low levels of certain preservatives. It appears that preservative performance at low preservative retentions is poorly understood but it seems likely that poor preservative distribution, poor fixation and rapid depletion are involved.

Hedley and Butcher (1985) considered that aqueous leaching of preservative treated material prior to use in a decay test, simulating in-service depletion, was an essential requirement. It was suggested that leaching overcame the "lag" phase in the colonistion of treated stakes by decay fungi. A variety of aqueous leaching regimes have evolved over the years (AWPA M11; Bravery, 1968b; BS5761, 1990; Lewis and Brooks, 1983). Recently in the United States there has been progress towards the development of a soil depletion procedure to determine how immobile a given wood preservative will be in treated timber (Nicholas, 1989 unpublished). The usefulness of this approach was evaluated in this study. In many respects it seems more appropriate to combine leaching/depletion with the decay test in one step. Table 6 illustrates depletion of copper from 4 different preservatives installed in the soil bed over a period of 6 months. The data show that the depletion of copper lost from ammoniacal copper quaternary ammonium treated stakes was similar to that of CCA. Loss of copper from ACZA treated material was approximately double that of CCA. These results have interesting implications for the performance of a preservative. Nicholas *et al.* (1991) observed that the leaching of DDAC in water was negligible whereas in soil contact it ranged from 30-35%. The importance of soil characteristics on preservative leaching have received little study. It seems reasonable to assume that soil pH, soil moisture content, soil microbial activity and cation exchange capacity all have the potential to influence preservative depletion.

Table 2 shows that the pH of the Harrisburg soil is acid (pH 5.12) with a cation exchange capacity (CEC) of 11.82 meg/ 100g soil. Soil pH will influence microbial growth but it may also affect solubility of preservative components in treated wood. CEC is a quantitative expression of the amount of negative charge per unit quantity of oven dry soil (Foth and Ellis, 1988). In other words it is a measure of the capacity of the soil to absorb cations from solution.

An attempt was made to determine whether the copper leached from the stakes remained in the soil or whether it was washed out from the soil system. Soil analyses for copper were made in the top 50 mm of soil adjacent to depleted stakes and also below the depleted stakes. Results are compared with background copper levels in Table 8. It is apparent soil adjacent to the stakes contains double the copper concentration found in a reference sample. Copper levels below the stakes were 50% higher than background levels. The results suggest that copper depleted from the treated stakes remains in the soil where it might be expected to influence soil microflora. The singificance of this observation needs to be evaluated by further experiment but it seems plausible that pH and CEC are involved in preservative depletion. In this context it is interesting to note that the CEC of vermiculite used in artificial soil decay test procedures ranges from 120-150 meg/100g, ten times higher than that of the natural forest soil. If a higher CEC is vermiculite increases the rate of depletion per unit time then perhaps the rate of decay in vermiculite amended soil systems will be greater than in unamended soil. This is in fact reported (McKaig, 1984; Gray, 1986) but other factors are almost certainly involved as well.

Other soil parameters that are under investigation include the influence of temperature and soil fauna on the decay process. Soil aeration, the "freshness" of soil and the function of sunlight and plants on decay processes. As far as temperature is concerned it has been established practice to optimise temperature for fungal growth and development. It is interesting to note growth optima for decay fungi have almost exclusively been determined on aritfical media (Duncan, 1960). Is a constant elevated temperature really the best approach? Hedley (1983 suggested that the temperatures maintained in fungal cellars would favour thermotolerant fungi at the exposure of more mesophilic organisms. If Hedley's supposition is correct do we wish to induce such changes in the soil microflora? In field applications it has been reported that diurnal changes in temperature and humidity influence the movement of gases into and out of soil through expansion and contraction. constant temperatures would interfere with this process.

TABLE 6

Depletion of copper from different preservatives installed in the soil bed

Preservative	*Retention (kg/m3 a.i.)*	*Percentage of total copper depleted*	
		3 months	*6 months*
ACQ 2:1	6.4	17.38	17.49
	9.6	15.50	17.91
CCA	9.6	12.53	17.64
ACZA	6.4	12.63	31.97
	9.6	16.94	32.49

ACQ 2:1 = ammoniacal copper quaternary ammonium in 2:1 CuO/Quat ratio
CCA = Type C oxide
ACZA = Ammoniacal copper zinc arsenate

All depletion values represent the mean of 5 samples
Soil moisture content = 30% or 100% of the WHC.

TABLE 7

Peformance of replicate stakes in soil bed and forest

Preservative	*Retention (kg/m^{-3})*	*Mean soundness* (9 months)*	
		Soil bed	*Forest*
CCA	1	99.3	99.8
	2	96.8	100.0
	4	99.8	100.0
	6.4	100.0	100.0
	9.6	100.0	100.0
ACZA	1	94.1	99.9
	2	94.1	99.9
	4	99.8	100.0
	6.4	100.0	100.0
	9.6	100.0	100.0
ACA	6.4	100.0	100.0
ACQ 2:1	1	92.0	100.0
	2	100.0	100.0
	4	100.0	100.0
	6.4	100.0	100.0
	9.6	100.0	100.0
Untreated	NA	68.0	82.4

* Mean of 10 samples

TABLE 8
Analysis of total soil copper by digestion

Sampling zone	*copper concentration ($mgkg^{-3}$ O.D. soil)*
Background	39
Leached bin top 50 mm	87
Leached bin 150 mm depth	64

The influence of soil fauna in the decay processes of preservation treated wood has received little attention even though the importance of soil animals in the breakdown of leaf litter and woody debris has long been recognised (Rayner and Boddy, 1988). Inclusion of termites in a soil bed system (Johnson *et al.*, 1988) is a step in the right direction but there is a need to advance further. Soil fauna were included in our soil and after 12 months a variety of worms and insects appear to be surviving. Unfortunately the population dynamics for the soil fauna have not been followed since installation of the soil beds and it is also not known whether their presence has affected decay rates. Preston (pers. comm.) has observed nematodes in close contact with decayed stakes in soil bed facilities maintained by other laboratories. It is too premature at this stage to comment on the implications of these observations.

Aeration is another area affecting soil micro-organisms that has been neglected in soil bed studies. As mentioned earlier soil aeration is closely linked to soil moisture levels. The gases of major concern in wood decay are CO_2 and O_2. Soil oxygen is primarily in the gaseous phase in soil and is contained only to a small extent in the soil water. Oxygen concentration usually decreases with increasing soil depth (Glinski and Lipiec 1990). It also changes with temperature and is usually lowest in summer. Carbon dioxide concentrations on the other hand vary dynamically in a manner opposite to oxygen. Maximum CO_2 concentrations occur in periods of increased moisture content and soil temperature. The ease with which gases from the atmosphere can exchange with those in the soil is influenced by the soil structure. Soils that are compacted or soils in which the surface has been repeatedly overwatered destroying the surface structure tend to be anaerobic.

Basidiomycete fungi are essentially aerobes but the tolerance of different fungi to low oxygen levels is variable. Soft rot fungi are much more tolerant of low oxygen levels which in part explains why soft rot decay predominates in waterlogged soils. Vinden *et al.* (1982) made provision for aeration by providing holes at the bottom of their soil beds. It was not reported how effective this provision was. It would be interesting to investigate the effect of introducing oxygen or air into the soil and allowing it to diffuse. Possibly this could stimulate fungal activity.

There is considerable dispute as to the value of using "fresh" soil when setting up a soil bed study. Bravery (1968, unpublished) suggested that air drying soil for 8 weeks did not cause a reduction in the decay potential of the natural soil microflora. This may be true for soft rot fungi but results from this investigation showed that soils subjected to severe leaching and then allowed to dry out did not show the same degree or type of fungal attack as fresh soil.

Summary And Conclusions

The preliminary data generated in this study show that it is possible to maintain a soil ecosystem in an artifical environment. Whether the "ecosystem" approach will provide more accelerated and reproducible decay rates than conventional soil bed systems is unknown at this point.

Through control of the soil moisture content it is possible to select the predominant decay fungi attacking preservative treated material. Soil tensiometers appear to offer an effective means of controlling soil moisture contents in soil bed facilities but further work is needed to establish their limitations and advantages over conventional techniques.

Preservative type and preservative retention influence wood moisture content in soil contact. Inclusion of water repellent emulsions in waterborne preservative formulations appears to be lower the equilibrium moisture contents of stakes in soil contact. This could have important implications on the performance of waterborne preservatives.

The soil bed technique offers a viable and perhaps more realistic alternative to leaching treated wood samples than water leaching prior to decay testing. Depletion of preservative components into the surrounding soil may influence the soil microflora and in so doing affect decay rates. It seems likely that cation exchange capacity and soil pH are important in soil contact depletion. The exact influence of these parameters needs to be determined by experiment.

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DISCUSSION ON PAPER 6

Chairman: E.A. Hilditch

THE CHAIRMAN: Thank you. Now questions.

DR. D. D. A. SAUNDERS (Fosroc): Thank you for a very interesting paper. I was interested at the beginning, as you sketched in the types of test, starting with monocultures and going through fungus cellars and accelerated field simulators and so on, and as you came to concrete burial vaults, which I assume is a concrete coffin, my mind was taken to the long-established graveyard test, for more than one reason. It seems that what you are doing in your concrete burial vaults is recreating what goes on in a graveyard test; you are seeking to recreate the soil. If we separate the fundamental studies, which clearly you do need to be able to control, for the purpose of assessment of workaday preservatives, I wonder if one of the conclusions from your work is that the acceleration is merely being achieved by using smaller stakes, and for workday assessment of alternative preservative formulations there is a lot to be said for simply burying smaller stakes than have conventionally been used for a graveyard test but burying them in real soil, in real conditions, in assessing their performance rather than wanting to take the test into the laboratory.

DR. ARCHER: What I am doing is essentially replicating everything that goes on in the soil bed system in the field. I am using identical sized stakes, identical soil, and I am looking for some form of acceleration factor. You have to be very careful with stake size. There have been a lot of attempts to correlate the performance of one size stake with that of another, and there is a big argument going on in the US about whether people should use 4 x 2 stakes and little tongue depresser type stakes and so on. I am trying to remove those issues by working with the same size stake in the field and in the soil bed system.

I am actually looking for an acceleration. At this point I do not know how much acceleration I am getting, but I am trying to generate an accelerated system at the same time as understanding the fundamentals of what is going on in the field. My soil bed system may not accelerate decay at all. It could be that essentially, as you have said, I have duplicated the field in the laboratory. I hope not.

MR. D.P. BLOW (Fosroc): I am afraid my question really follows on and ties in with Andy's. I tended to see your work looking very much at the fundamentals of what caused decay in ground burial situations, and I was wondering how much your future work was going to try and tie down the performance under the various conditions that you are looking at in the laboratory with what was found in the field. I wondered whether you would eventually end up with four or five completely different type of ground burial lab tests that mirrored very different conditions out in different field test sites. Is that your ultimate aim?

DR. ARCHER: I would not say that it was our ultimate aim, but it certainly is a possibility. Quite clearly, by manipulation of the parameters in the soil bed you can create an environment conducive for soft rot, a mixture of the two, or exclusively basidiomycete. We are basically, within the AWPA, trying to develop a standard protocol for a soil bed test, and a lot of the things we are building into this is towards that end, of understanding the parameters which affect preservative performance in soil contact. The ultimate goal is to have a standard soil bed test as an adjunct to field testing.

The philosophy is simply that by providing enough control reference material such as CCA ACZA, which are used currently in the US, by comparing the performance of new preservatives with those existing preservatives in these types of situations we will develop an idea of how well they may perform in the real world.

MR. BLOW: Can I just pick up on one thing you said? You said that the idea was eventually to end up with a laboratory test. Tying that in with your opening remarks that with a field test you had different soils and different climates, do you think it is likely that you are going to end up with one test? Is it not more likely that you would end up with a number of tests which mirrored different conditions in the field?

DR. ARCHER: I suppose, yes, you could argue that. I am using the word "test" in a broad sense. They are all soil bed tests, but by altering the conditions you are in effect creating another test regime. I would imagine that you could specify three different moisture regimes to simulate different types of decay and perhaps that would be the test. You would have three beds at different moisture contents. I do not know.

DR. D. J. DICKINSON (Imperial College): I would like to take up Andy's point. Are you really trying to produce the field in the laboratory and would it not be just as good to do it in the field? I can perhaps come to your rescue on this, because I believe that this type of work is the way forward, because what you are doing, what you have clearly shown is that you are trying to maintain the optimum conditions for decay. The problem with field tests of course is that you get such fluctuating conditions, drought and dry periods, and when you look at comparative decay rate across sites, it is the fairly fertile clay soils, which always have a good moisture content and never dry out, which give you the fast results, and you can, as you have clearly shown with your very careful work on moisture monitoring, by maintaining these critical levels of optimum conditions, get these good, reliable, fast decay rates.

If I can turn it now into a question, probably the most interesting point you made was the physical interreltionship of depletion with the soil. As you know, in our work we have been more interested, probably incorrectly, in the interaction of non-decay organisms in detoxification, but certainly it made me think very deeply that perhaps we would need to look much more closely at the relationships in depletion, your work in depletion, your work in depletion studies and your so-called leach pins, or whatever you call them. That is an excellent way forward. The scope here is really good, but have you also considered the interrelationship with the non-decay organisms, preconditioning stakes to accelerate depletion or accelerate detoxification?

DR. ARCHER: Certainly I was intrigued by Gray's paper and others along those lines. At this point we have not got very far at looking at the colonisation of the material. Conceptually the idea of a pre-treatment was something that I was trying to avoid, because you could argue – and it has been done – that where people use a pre-leaching for soil contact studies ... I am trying to avoid that by looking at leaching in situ – it is something that could be built into it, but essentially I am doing a lot of things, trying to squeeze a lot of information out of one system. At the moment the goal is to try and accelerate what does go on in the field by replicating events which take place in the field rather than superimposing external influences on the system.

DR. DICKINSON: Do you feel confident that you are going to get the full range of basidiomycetes though in this type of test situation? The thing that worries me about relying on natural inoculations of basidiomycetes is that you may not be picking up the critical preservative-tolerant organisms, which may take time even to arrive in the situations. In natural situations people know you put artificial preservatives into the natural environment and it might be ten or fifteen years before they fail to copper-tolerant basidiomycetes.

DR. ARCHER: It is difficult to answer, again, until we get some more results, but basically we are doing isolations on the replicate stakes, which are installed in the same soil, essentially a few hundred yards from where we have the soil bed facility. We have actually isolated basidiomycetes from some treated stakes after a matter of months. I do not know at this point whether they are going to be there at the end of the day or whether or not they are just temporary residents or what, but that will be interesting to have a look at, it is a lot of work. We are still at the very early stages of looking at it, but what we have isolated appear to be copper-tolerant fungi.

DR. A. BRAVERY (BRE): Kevin, I very much enjoyed your paper. Can I suggest though that somewhere in what you have been describing and the comments made from the floor there is a concept of renewable soil beds, which is distinct from sustainable soil beds. As I read it, you are addressing what I would call sustainable soil beds, where you try to create a field situation, with an element of control. You try to introduce some of the reality parameters of soil litter and plants and so on. The alternative approach is the renewable soil bed, where one just uses it for a short period of time and then rejects it and starts with a new bed. I have always been a little bit wary of a sustainable system because of the sorts of problems that you illustrated: accumulation of leached materials from your test samples, and the problem of distinguishing the dynamics of the natural situation from the more constant controlled conditions. You also have the problem that David referred to of the more complex micro-flora when you have the sustainable field test system. Would you care to comment on whether you are going in one of those directions or the other, and more specifically, could you comment on whether you see any variability in the behaviour of samples in your sustainable system, where you have plant matter in one part of the tank and not in another?

DR. ARCHER: I suppose the concept between the renewable and the sustainable is a good point, and at this point we are heading in the direction of a sustainable system. It could be that it is going to be too difficult to maintain and hold for a long period of time. As regards the plant matter and so on, generally the plants are pretty much widespread evenly among the bins. One thing that I have considered trying was to ask whether it is important to have plant life in there at all. What influence does it have? A lot of the work on rhizosphere organisms and so on suggests that root systems do influence plant micro-flora and fauna, but they also create pathways in the soil for aeration and a lot of other things. I have not actually done any work looking at the influence on plants, but it would be an interesting thing to study. There was some talk in the US about planting grass. Schmidt at Minnesota, I think, suggested that at one particular meeting; he planted grass seed in his system and he suggested that the decay was different when he planted than without. It would be an interesting thing to look into.

MRS. J. CORNFIELD (Hickson). Like David, I was surprised in the acceleration of the field test no mention was made of non-decay organisms. I thought it was quite likely that bacteria could play a large part in determining the fate particularly of the organic biocide, the quat (?) in the ACQ preservative. That relies on the quat for protection from basidiomycete decay. I wondered if you could comment on how the quat depletion in these fungal cellar type studies compares with that which you get in long-term field tests.

DR. ARCHER: On the first set of stakes, which were DDAC-treated, we did not actually do any depletion work. I do know from other studies we have done that DDAC does either deplete or it is chemically modified by various micro-organisms along the lines of the work by John Ruddick. It is documented that stain organisms do detoxify and change the structure of quats. On these particular stakes no work was done, quite obviously, these pre-colonisers are going to have some influence on not only detoxification but also depletion, and it is something that should be studied. It is a good point. One of the things I should be looking at in the early stages of these installations are those types of organisms.

MRS. CORNFIELD: The other thing that you said was an interesting fact was that the moisture content was increased at the lower retention levels and increased with the ACQs over the CCA, and I think possibly one explanation for that could be the increase in microbial activity that you get at the lower retentions. Do you think that is likely?

DR. ARCHER: It is certainly possible. The fungi and bacteria are going to change the porosity of the wood, and I suppose also by their activities are going to bring moisture into the stake. This whole issue of the validity of testing performance of wood preservative at low toxic threshold levels is something I am still coming to grips with. I have not gelled my thoughts on it. The difficulty is to use 0.5 kg of CCA and try and predict the performance of 6.4 or 9.6 kg or whatever, and is it valid to do that. How do issues like this fit into the scheme? I do not know.

MRS. CORNFIELD: You noted in your paper that sub-toxic levels gave decay faster than untreateds. That could possibly be due to selection for copper tolerance, which can then decay without competition.

DR. ARCHER: Yes, that is true, and another issue is that the distribution and penetration of preservative components at low levels can be anything but uniform, and we found some quite interesting penetration patterns at very low levels of CCA and very low levels of ACZA.

DR. A. VALCKE (Janssen Pharmaceutica): Kevin, thank you for an interesting paper. As you are aware, in Europe we are working with two lab test methods for soft rot testing, one using vermiculite, the other using *(inaudible)* soil. You stressed in your paper the importance of the cation exchange capacity, which is high for vermiculite compared to soil. From work we carried out with these two media, using pre-leached EN84 (?) stakelets, we found that for several chemicals the depletion was markedly greater in soil compared to vermiculite, so this led us to believe that perhaps the CEC of the medium is less important than other factors. Could you comment on this?

DR. ARCHER: I suppose that was pure speculation in the paper. We have been working fairly closely with Darrel Nicholas at Mississippi, State University on the soil depletion issue. Darrel favours a vermiculite/soil sandwich layer type of system and we favour the soil only system, and we have found that we get considerably different results, and we are essentially looking for an explanation as to why that might happen. I threw the CEC issue out, because I think it is something that is very seldom considered in depletion studies. In fact, we do not really understand what goes on with depletion. If not affecting the amount of preservative that depletes out of the stake, it may determine where the chemical resides in the soil, whether it flows through the system and is lost to the ground water or whether it actually sticks close to the soil. It is a complicated issue. I would like to do further work on this question of the influence of vermiculite and cation exchange capacity on depletion. I think it is a fascinating area.

MR. D. CAHILL (Irish Science and Technology Agency): Dr. Archer, two brief questions. First of all, in your slide on the moisture uptake for the 98 per cent water hold capacity you only showed one loading for CCA, the 6.4. Why was that?

DR. ARCHER: An oversight. No other reason than simply that we had several hundred thousand stakes in this test, and just one thing slipped through the crack. We neglected to weight them, or something along those lines.

MR. CAHILL: The second point is this. You said at one stage that you had a certain doubt about somebody doing measurements other than 100 per cent, yet later on you went on to show results for 35, 50 and so on. How can you reconcile that?

DR. ARCHER: Shooting myself in the foot, I suppose. I rationalise that by saying the only thing you can guarantee is essentially bone dry soil and 100 per cent of the water holding capacity in a free draining situation. Like everybody else, you fall into the trap of essentially 40 per cent of the water holding capacity is a drier soil. What happens in practice is that it is an average moisture content rather than uniform over the entire soil. You cannot dial up 40 per cent water holding capacity and achieve it with any degree of accuracy, because basically if you are watering from above, below or otherwise, you spray water on top of the soil, the top of the soil becomes saturated, and the water flows down into the depths of the soil or alternatively if you are going from below it soaks up and you get an advancing moisture front. So it is a dynamic situation; at any given time the soil will have a moisture profile, and I simply use the terminology there to avoid confusion. It is certainly not a uniform 40 per cent at all times.

THE CHAIRMAN: Thank you. I have personally found this a most fascinating paper. Way, way back, in 1965 I think, I gave a paper which spent most of its time pointing out the shortcomings of monoculture and similar tests and pushing in the direction of greater use of soil. For all the effect that paper has so far as Europe has been concerned in the intervening years, you would think that there were nothing but monoculture tests and that what happened in the laboratory was not right. We really must never forget that it is what happens in the field that is real; that is real life. The very meaning of the modern word "environment" is to take everything into account that surrounds a piece of treated wood, and this work which is going in this direction needs a great deal more input. Dr. Archer and his colleagues need encouraging. The paper and the questions have emphasized the complications, but that should not daunt those who are about this form of development. I would ask you to join me in both applauding Dr. Archer in a good paper and in encouraging its further progression. *(Applause)*

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THE CONTROL OF DAMPNESS BELOW GROUND AS A RESULT OF THE RISING WATER TABLE IN THE LONDON BASIN

by Phillip Hewitt
Vandex (UK) Ltd., P.O. Box 100, Epsom, Surrey KT17 3HH

Introduction

Rising water tables in several British cities look set to cause major headaches for engineers involved in the foundation design of new and old structures, with London, Liverpool, Nottingham and Birmingham likely to be the worst affected.

The problem is that industry is no longer removing water from wells in anywhere near the quantities it has done in the past. This abstraction of water during the period from the end of the eighteenth century up until the mid 1960's, caused a lowering of water tables. Decreased industrial requirements and increased water licensing controls have meant that water abstraction is greatly reduced, so the water tables are starting to return to their previous levels.

The result of these rising water tables on basements and foundations are signifcant, with the obvious increase in hydrostatic pressure being only part of the problem. As soil becomes more saturated, it's ability to resist imposed loads decreases, so the possibility of settlement increases. Further, clay soils will expand causing heave and subsequent increased loads on underground structures.

The purpose of this publication is to look at the long term implications this will have on existing structures where structural waterproofing is being considered. Systems that are applied now and function satisfactorily could well fail at some time in the future, and yet an understanding of the factors involved could result in a system being designed with a considerably reduced likelihood of failure.

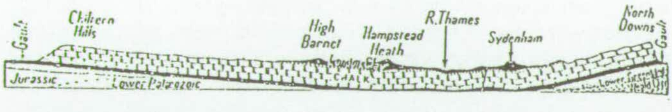
Because of the complexity of London's geology, this city alone will be investigated in this publication, as what is learnt from this can realistically be applied to other areas. It is also the area which is, potentially at least, at most financial risk because of the high building value and density over an extensive area.

1. Geology And Hydrogeology Of The London Basin

Geology

The London Basin may best be described as a layer of water bearing chalk (an aquifer) trapped between two layers of clay. (Gault Clay below, London Clay above). This chalk is exposed in the North at the Chiltern Hills, and in the South at the North Downs. (Figure 1). Where this chalk runs beneath London, it is known as the 'deep aquifer'.

Fig. 1



Most areas of the London Clay are overlaid by deposits of sand/silt/clay/gravel/made ground, which are of a variably permeable nature and vary in depth up to 12m, 1-4m being most common.

Hydrogeology

The effect of the geological situation in the London basin is to create two water tables – one trapped in the 'deep aquifer', and one 'perched' on top of the London Clay, within the overlying deposits.

The 'perched' water table is the one most frequently encountered by contractors working on relatively shallow foundations and basements. It's precise position and behaviour depends largely on where it is found, and the soil overlying the London clay which contains the water. It fluctuates with changing weather conditions, and in certain circumstances can result in very rapid raising or lowering with changing weather conditions. Broken drains and water mains can also have a large effect. There are underground streams in certain areas which can further complicate the situation. These streams can result in dramatic changes occurring underground within a few hours, or even minutes, of it raining.

In recent years, much publicity has been given to London's rising water table by various sections of the media. Whilst some specialist publications have reported accurately what is happening, others, such as television, radio and the popular press, have (inadvertently?) given the impression that it is the 'perched' water table that is rising. In fact, it is the water within the 'deep aquifer' that is rising, and this rise is between 0.8 and 1.5 metres per annum.

This is not to say that changes are not occurring within the perched table levels. In the short term, changing levels of the perched water table are likely to have much more significant implications than the 'deep aquifer'. CIRIA are currently investigating this aspect, and will be reporting their findings shortly.

To fully appreciate what has happened in the 'deep aquifer', we need to go back to the turn of the nineteenth century when the water table was at it's highest. (See Map 3, geological sections through the London Basin). This water was trapped in the aquifer between the layers of clay. The water level at each end of the aquifer was higher than the ground level at the centre, creating an 'artesian well' potential. When the fountains at Trafalgar Square were first constructed, the water gushed out well above the surface under it's own pressure.

During the 1820's, domestic and industrial abstraction of water increased to the point where the rate of abstraction exceeded the rate of inflow, and the water table started to fall. During the 1860's this abstraction increased dramatically, and stayed at this high level until the 1960's, when the demand dropped suddenly. Map 3 shows the water table in 1965, which was it's lowest level. In places, it is more than 200 feet below the original level. A decrease in abstraction since 1965 has meant that the water table is now rising, as can be seen from the water table level in 1985.

Whilst clay is a relatively impermeable material, certain of it's properties, such as volume, bearing capacity and sulphate contents can be significantly altered by changes in it's degree of saturation. While it is possible to protect a new structure against these changes by careful design, it must be remembered that properties designed and built after the water table was lowered, but before it was known that it was rising again, could be at risk of being damaged by settlement, heave, and sulphate attack.

Just how long it will be before buildings become affected by this rising water table is difficult to say, although it is not likely that any effect will be noticeable within the next ten to fifteen years. It is certainly likely to be at least 30 to 40 years before they reach their original levels, assuming abstraction ceases completely.

The Solution

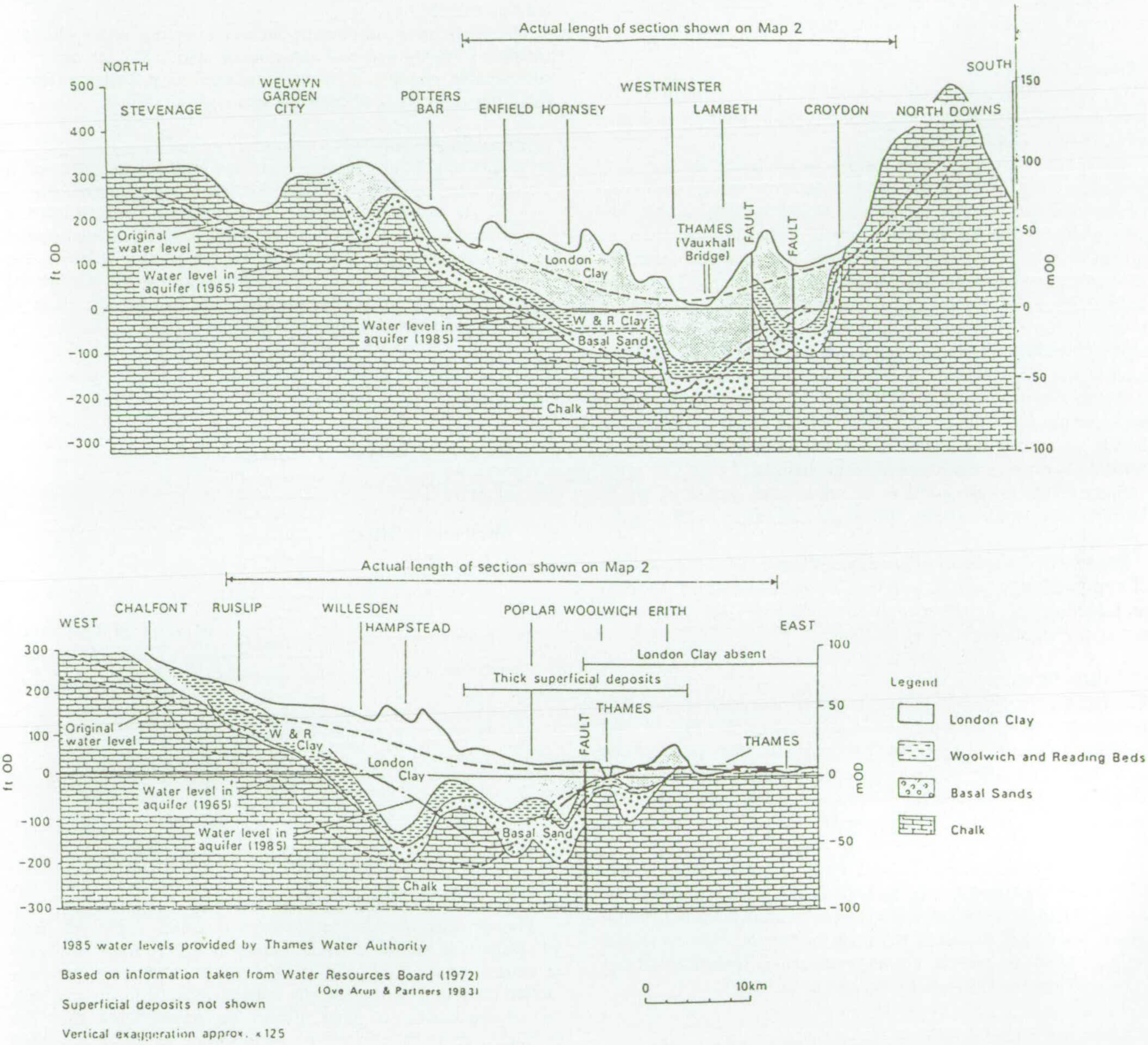
Several solutions to the problem are being considered, ranging from doing nothing and protecting individual buildings at risk, to pumping from deep wells. It seems that the most economic solution would be to pump from deep wells, and use some of this water, after suitable treatment, in the mains supply.

If this scheme is adopted, then the whole problem of London's rising water table becomes hypothetical, as the water table would rise no more. However, the lessons we can learn from investigating the problem can be very useful indeed when designing waterproofing systems for properties where a change in water table levels are likely.

The options at present are being investigated by Thames Water and the National Rivers Authority. It is likely to be some while before their results are finalised and a decision is made. The most obvious problem at present, as is always the case when there is no obvious 'blame' that can be attached to any one person or body, is 'who pays?'.

In the meantime, new buildings which could be affected are being designed to cope with the effects of a rising water table, assuming that nothing is done. The two most notable projects where there has been significant foundation design consideration are the new British Library, and the new office block opposite the Barbican in Aldersgate.

Map 3
Geological sections through the London Basin



Summary

1. London has two water tables – the 'deep aquifer', and the 'perched' water table.
2. The water table in the deep aquifer was artificially lowered by private and industrial abstraction.
3. In central London, this water table has been lowered by up to 200 feet.
4. Because much less water is being abstracted, the water table is now rising again.
5. If this rise is uninterrupted, in ten to fifteen years some buildings in London could be affected by it.
6. The water table can be kept down by planned abstraction.

2. Soil Response To Rising Water Tables

When the moisture content of a soil changes, then certain properties of the soil are likely to change as well. The most common changes are soil strength and volume, as well as from chemical changes.

Soil Strength

Soil strength is measured by it's 'bearing capacity', or ability to accept a load.

As a very general rule, the bearing capacity of a soil decreases with moisture content. If a soil has a high clay content, then this decrease in bearing capacity is gradual. However, if the soil is mainly sand, then this decrease is likely to be fairly sudden when it becomes saturated, or is approaching saturation.

It is very difficult to quantify just what this decrease will be, although tests have shown that for a change from dry to saturated, it is not likely to be more than 50%.

Volume Change

Soils containing significant amounts of clay (i.e. particle sizes less than 0.002mm in size) are liable to volume changes as degree of saturation changes.

As a soil absorbs water, there is a tendency for any clay particles in it to swell. If the clay is a relatively small proportion of the total soil volume, then much of this swelling is absorbed within the soil itself, provided there is sufficient void space to accept it. Obviously, as the degree of saturation increases, the void space decreases, and the overall volume change will increase. Soils that have a very high proportion of clay will suffer greater overall volume changes than soils with a low clay content.

This swelling of the soil is known as 'clay heave', and can have serious implications on foundation performance.

If the moisture content of a clay soil decreases, there will be a shrinkage of the clay. This shrinkage might or might not be the same amount as the clay heave, depending on loading conditions prior to the moisture level changes.

Since 1985, certain parts of London have settled by up to 200mm as a result of clay shrinkage, caused by falling water table levels.

Because of consolidation (gradual settlement of soils as a result of imposed loads, such as buildings or overburden) it is thought that a return of the water table to c1800 levels will only cause rising of ground levels by up to 100mm.

Chemical Effects

An increase in chloride levels has been observed in the deep aquifer groundwater, which has caused some damage to steel reinforced concrete structures. This chloride increase has been as a result of saline water intrusion from certain parts of the Thames, as the water table fell. As the water table rises, this intrusion will decrease, and eventually the chloride levels will fall.

Sulphates contained in the clay over the Basal Sands are likely to increase the overall sulphate level in the groundwater as the water table rises. Because of the low permeability of the London Clay, this is not expected to result in significantly increased sulphate levels in general, although structures with foundations at or near the Basal Sands level could be at risk.

Summary

A gradual increase in water table levels is likely to result in:

1. A decrease in soil bearing capacity.
2. An increase in ground pressure as a result of clay heave.
3. A rise in ground levels as a result of clay heave.
4. A gradual decrese of chloride levels.
5. A marginal increase in sulphate levels, but which could be significant in certain areas.

3. Building Response To Water Table Level And Soil Changes

Since the purpose of this publication is to investigate the likely problems that will occur to a waterproofing system as water table levels change, consideration will only be given to structures that have already been waterproofed at the time of this change.

Further, waterproofing within the preservation industry is usually done at a time when a building is refurbished, so only internally applied cementitious waterproofing systems will be considered.

The effectiveness of any internally applied system will be largely influenced by the soundness of the substrate to which it is applied. Any changes in stress types and levels in the substrate will be transferred to the waterproofing system. Before analysing the effect of these changes on the waterproofing, it is necessary to see how the stresses change within the substrate. (ie within the building fabric).

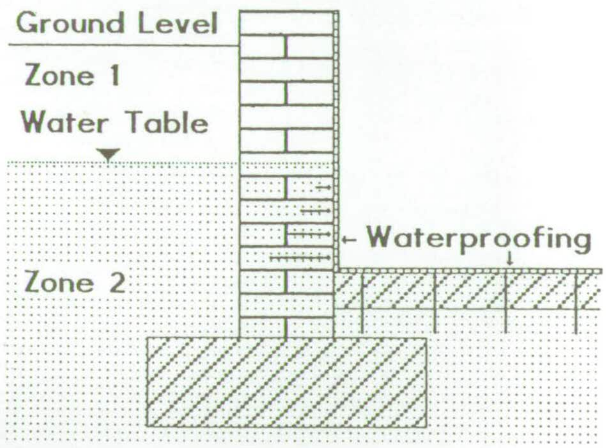
The three most important factors affecting stress changes within a building will be hydrostatic pressure, soil strength and soil volume changes. Chemical changes may further affect a buildings capacity to absorb changes without failure.

Hydrostatic Pressure

It is reasonable to assume that the walls and floor of a waterproofed structure are water permeable to a degree.

A rise in water table will, therefore, result in the substrate becoming saturated, and a hydrostatic pressure being applied to the waterproofing 'skin'. If the waterproofing is not going to fall into the building from this pressure, then it must be restrained by the substrate. This is going to have the effect of putting it into tension. (Figure 3.1).

Fig. 3.1



The amount of this tensile stress is small, (eg a 1m head of water will induce a tensile stress of 0.01N/mm^2) however it cannot be ignored. Although most new building materials would be able to withstand the tension induced in the majority of circumstances, it must always be remembered that the substrate could be affected by factors such as chemical attack (eg sulphates or nitrates) and freeze thaw action. This could result in failure of the substrate when the tensile stresses are induced.

In addition to the above, failure can occur because of debonding of the waterproofing system from the substrate, even if the substrate is sound. This would usually be from bad workmanship, since it should be possible to achieve an adequate bond if the correct preparation and rendering techniques are adopted

Soil Bearing Capacity

Although the bearing capacity of soils can be reduced by anything up to 50%, most foundations should have been designed to induce a bearing stress of only one third of the ultimate bearing capacity. As a result, failure of a building as a result of failed bearing will be rare.

The above notwithstanding, some settlement of foundations can occur. Provided this settlement is even throughout the structure, there should not be a problem. However, problems can occur where the subsoil varies, and differential settlement can occur.

Soil Volume

Rising ground levels as a result of clay heave should not present any problems, provided the rise is uniform over the entire building. However, when there is differential movement structural problems are likely to occur. When this happens, the structural defects are likely to fall beyond the scope of the waterproofing contractor.

Clay heave below ground level is likely to have far more wide reaching effects. The swelling ground has the effect of squeezing the building, causing lateral pressure on walls, and upthrust on floors. This can cause problems for cementitious tanking systems at stress concentration points, where construction joints open up and, in severe cases, where wall surfaces crack as a result of increased bending stress.

Dealing with differential settlement and movement falls beyond the scope of this publication, and should be referred to geotechnical and/or structural engineers.

It is becoming increasingly common for geotechnical surveys to be performed prior to a building being refurbished in order to establish the potential dangers, and to design accordingly.

Stress Concentrations

When a pressure is applied to a structure (eg from changing water levels or from clay heave) the structure will deflect very slightly in order to build up a counteracting stress within itself.

Whilst this deflection is not usually measurable, it is always present. Clearly, it will be greater in areas which are less restrained.

Where the structure is restrained, such as at wall/floor or retaining wall/partition wall junctions, there will be no movement, but there will be a very strong flexing tendency.

Fig 3.2

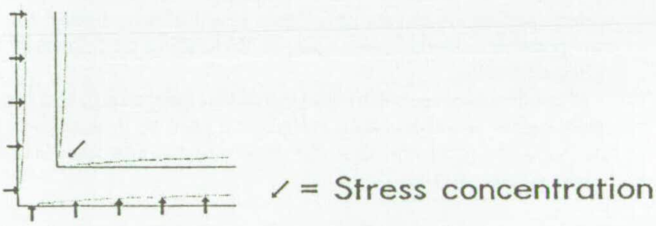
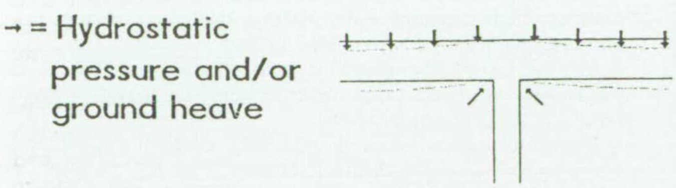


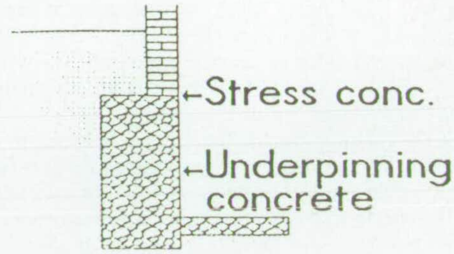
Fig 3.3



It can be clearly seen from Figures 3.2 and 3.3 that the stresses will come together at these points, creating very strong 'stress concentrations', that most cementitious waterproofing systems will not be able to resist without some help.

Another area where stress concentrations are likely to occur is where two differing materials abut in the same plane: eg a brick basement which has had the floor lowered will often have the foundations underpinned. (Figure 3.4). This results in a wall that is brick down to a certain point, and then concrete down to the floor. Because of the different properties of the two materials, changes in external forces will cause different stress reactions in the two materials. The point where they meet is where this stress change occurs. This results in a form of stress concentration at this point.

Fig. 3.4



Chemical Effects

Chlorides contained within the groundwater can contaminate reinforced concrete structures, and cause corrosion of the reinforcement. This problem is likely to decrease as the water table rises.

Sulphate contained in the groundwater will attack the cement paste in concrete, renders and mortars, causing a weakening of the material and subsequent blowing. This problem is not likely to get any worse than at present, with the exception of certain properties whose foundations and basements lie close to the Basal Sands under the London Clay.

Summary

1. Increased hydrostatic pressure will put the structure into direct tension, if waterproofed on the inside face.
2. Clay heave can cause properties to rise. Where the underlying soil is not uniform, differential movement, with consequential structural failure, can result.
3. Clay heave and increased hydrostatic pressure can cause 'stress concentrations' at rigid points. (Usually corners) and where different materials are adjacent to each other.
4. Clay heave and increased hydrostatic pressure can cause bending of the walls and floor, which could result in tension cracking at the surface, and opening up of construction joints, if any.
5. Chlorides can cause steel corrosion.
6. Sulphates will chemically attack cement, causing weakness and disruption.

4. Cementitious Waterproofing Response To Stress And Chemical Changes

In general, it is reasonable to say that a cementitious waterproofing system is only as good as the substrate to which it is applied. If that substrate cracks, shears, bends and breaks, or fails in any way, then the waterproofing system will most likely follow suit.

However, provided the substrate failure is not too severe, it is sometimes possible to reduce or even eliminate the results of certain types of failure, by introducing certain precautions at the time of application. In order to do this, it is necessary to anticipate the response of the waterproofing system to stress and chemical changes.

Substrate going into Direct Tension

Figure 3.1 showed how the substrate went into tension when the water table rose. Naturally, this would only happen if the waterproofing system is well bonded to the substrate. It is not uncommon for the system to fail because the waterproofing coating has pulled away (debonded) from the wall.

Sometimes the system will fail because the tensile stress induced (when the waterproofing bond to the substrate is sound) exceeds the tensile capacity of the substrate material. When this happens, the waterproofing system comes away, with part of the substrate adhering to the back of it.

Surface Cracking of the Substrate

Often the substrate will crack on the surface because of bending stress or simply shrinkage.

If this happens after application of the waterproofing system, then it will most likely crack as well, even if the system used is elastomeric. (Unless it is specifically designed to cope with such situations). This is because the strain is infinite, since the original length is nil. Hence there is an infinitely high stress induced, which must result in failure.

Once the coating cracks, the tension induced in it is released, thus increasing the shear at the coating/substrate interface. This can lead to debonding if the bond was not very sound initially, or the tension in the waterproofing system was particularly high.

Stress Concentrations

Failure of the waterproofing caused by the two above problems will only happen if the substrate fails.

However, the waterproofing system can fail at stress concentration points, even though the structure remains totally sound.

Failure of a cementitious waterproofing system at a stress concentration point is often very difficult to detect, because it is not normally associated with a differential movement of the structure. It usually results in just a very fine hairline crack, which is only visible on very close inspection or when water starts to penetrate.

Structures where different materials join at a stress concentration point are far more likely to be affected than one where the structure is monolithic. For example, a brick wall joining a concrete floor slab is far more likely to result in a crack in the waterproofing system at the wall/floor junction, than a structure of reinforced concrete which is continuous through the junction.

Cracking of a cementitious waterproofing system can cause problems in two ways:

1. By allowing water to be drawn through the crack by capillary action. This is particularly serious if the system is finished with a gypsum based finishing plaster, as this draws the moisture like a sponge, resulting in very ugly and badly salt affected damp areas.
2. If there is hydrostatic pressure at the level of the crack, free water can be forced in through the crack, resulting in free water on the surface and even, in severe cases, flooding of the area.

Chemical Contamination

Cementitious waterproofing systems are vapour permeable, so any water that is trapped behind the system will gradually evaporate, and then be replaced by more water.

If this water contains the normal mineral salts found in groundwater, (ie chlorides, nitrates and sulphates) then these salts will be deposited at the point of evaporation, and will build up in concentration.

Chloride contamination is likely to lessen as the water table rises, so no special consideration need be given to this problem. In any event, chlorides do not normally represent a major problem for waterproofing systems, other than the fact that they can accelerate corrosion of steel in reinforced concrete.

Nitrates can cause damage to the substrate by forming efflorescent salts which can cause physical disruption. However, nitrate concentrations are not likely to be affected by the rising water table.

Where sulphates are likely to be in increased concentrations (around the Basal Sands area) then there could be potential problems.

Sulphates will attack portland cement by chemically reacting with it, and forming a disruptive compound. This can result in the renders losing their strength and waterproofing properties, and even peeling off the walls in extreme cases.

Summary

1. Hydrostatic pressure, which results in the substrate going into tension, can result in debonding of the waterproofing system, or even failure of the substrate itself.
2. Bending stress or shrinkage of the substrate can result in cracking of the tension face. This cracking will go through the waterproofing system.
3. Stress concentrations can result in fine hairline cracking of the waterproofing system.
4. Stress concentration failure is most likely to occur where differing substrate materials join, or where the structure is not continuous through the stress concentration point.
5. Cracking can result in water penetration through the crack either by capillary action, or by flooding.
6. Increase in sulphate concentrations can result in attack of the cement in the waterproofing system, or in the substrate itself.

5. Designing A System To Cope With Stress And Chemical Changes

Having broadly established the type of stress changes which can result from a rising water table and looked at the response by an applied waterproofing system, it should now be possible to design a system which would be able, in most instances, to cope with these stress changes.

Note: When designing a waterproofing system, it is important to accentuate that although a change in structural stresses can be allowed for, it is not feasible to design a system if the structure is liable to serious failure. (eg cracks larger than 0.3mm, significant deflection of structural members, etc). If there is any doubt, a structural survey by a suitably qualified person should be implemented.

Designing for tension in Substrate

It is now understood that when direct pressure on the waterproofing system is applied as a result of raised water tables, two possible failures can result, ie debonding or failure of the substrate itself.

In order to reduce the likelihood of this happening, and before applying the waterproofing system, we need to be satisfied that the bond is sound and that the substrate material can take the tensile stresses induced.

Bonding

The principles involved in achieving a good bond are well known, although they are surprisingly often ignored. The most obvious aspects are:

1. The substrate must be clean and sound.
2. There must be a good mechanical key.
3. Excessive or insufficient suction needs to be controlled.

There are various ways of achieving the above, of which grit blasting, high pressure water jetting, bush hammering, needle gunning, scabbling, etc., are well known.

In addition to the above, it is always a good idea to rake out mortar joints on brick or stonework, to provide a positive bond for the first render coat.

If surface preparation is correctly carried out, it is not unreasonable to expect bond strengths of up to 2 N/mm^2. This is capable of holding back a head of nearly 200m of water, which is well in excess of normal expectations.

Substrate Tension
If the bond of the waterproofing system is sound, then water pressure will put the substrate into tension. If this tensile stress that is induced exceeds the tensile capacity of the substrate, then it will fail, allowing the waterproofing system to come away with some of the substrate bonded to it.

In order to design agains this factor, two items of information are necessary. First, it must be established what head of water is likely to occur. Secondly, the tensile capacity of the substrate should be assessed, to establish that it is capable of withstanding these stresses.

Because of the difficulty in establishing just how high the water table is likely to rise, it is reasonable to assume the worst possible scenario when calculating the water head. This would be if the water table reached ground level.

Assessing the tensile capacity of the substrate is not quite as simple. Most new or sound building materials will readily accept tension of 0.5 to 1 N/mm^2, which translates to a water head of 50 to 100m. However, in an old building, it is very likely that the building materials will be adversely affected in some areas by outside influences such as spalling, salt contamination, chemical attack, etc. This means that there are likely to be some areas of considerably reduced tensile capacity.

If these areas of reduced tensile capacity are very localised, correct use of agressive surface preparation techniques such as grit blasting or very high water pressure jetting will often remove the affected areas back to sound material.

If there is any doubt about the acceptability of a substrate, then the tensile capacity can be physically measured by means of pull-off tests. This involves gluing metal discs to the substrate, and then measuring the force required to pull them off. To establish the tensile stress is a simple calculation of dividing the force required to pull off by the area of the disc. The precise number and extent of the tests would need to be established during a site inspection.

If it is established that the substrate is not sound enough to take the increased water pressure, then consideration can be given to applying a structural lining by either building new walls internally, or by applying fibre reinforced coatings of gunite or shotcrete. This is a very specialised field, and can be very expensive although the results can be impressive.

It is important to understand that the ability to accurately assess a structure's ability to withstand increasing hydrostatic pressures after waterproofing is largely a matter of experience. A less experienced surveyor would be wise to call someone more experienced to assist in a difficult survey. The consequence of not doing so can be expensive.

Designing Against Surface Cracking
Because it is extremely difficult to anticipate exactly where surface cracking of the substrate is likely to occur, any specification written to protect against the cracking going through the waterproofing system would need to cover the whole area to be waterproofed.

Two systems which are effective against cracking from a sound substrate would be the in depth cementitious crystallisation system, or a flexible waterpoofing coating (there are several polymer modified cementitious systems) reinforced with a suitable stucco type matting.

The crystallisation system is a coating applied to the surface of the waterproofing, and also into the construction joints where applicable. When dampness appears through a crack, certain chemical are dissolved by the water, diffuse back into the render or concrete, and react with the free lime from the cement. This forms insoluble crystalline complexes which block the crack.

The reinforced flexible coating system is applied in two coats, with the reinforced matting sandwiched between them. When the substrate cracks, the first layer of the system would tear until it reaches the reinforcing, which then absorbs the stress. The top layer remains intact and waterproof.

It could be argued that the expense of doing this extra work is not justified, and that the cracks could be repaired as they occur. This might well be true if the waterproofing remains undecorated and exposed. However, if the system is lined or plastered, then the cost of remedial work could be extremely high. The relative merits and demerits of the extra work need to be assessed in each application.

Designing Against Chemical Attack
Chloride and nitrate levels should not be adversely affected by the rising water table, so no additional action is likely to be needed.

Because there will be some areas where sulphate concentrations are likely to increase significantly, consideration should be given to incorporating additional protection to guard against these.

It is possible to test the groundwater for sulphate concentrations, but it must be remembered that the groundwater levels could be misleading. Because a cementitious waterproofing system is vapour permeable, the concentration of sulphates is likely to increase with time at the point where evaporation is taking place. This may well cause the levels to increase beyond that which would be effectively guarded against by the use of Sulphate Resisting cement. It would be advisable to consider using an Anti-Sulphate additive, either applied to the wall beforehand, or added to the render coats. The precise positioning of the Anti-Sulphate would depend on the type of system used, which would determine where the evaporation will take place.

Summary
1. Bonding of the waterproofing system is very important to prevent it from being pushed off the substrate.
2. The substrate must be sound enough to take the tensile stresses induced by a hydrostatic pressure. If necessary, do pull-off testing.
3. The effects of surface cracking can be reduced by using flexible reinforced flexible coatings, or in-depth crystallisation systems.
4. Guarding against damage by increasing sulphate levels can be achieved by using a suitable Anti-Sulphate system.

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THE CHAIRMAN: Thank you, Phillip. I am certain now that we have quite some time for questions, so be prepared.

DR. P. FITZSIMMONS (Cementone-Beaver Ltd): Thank you very much, Phillip, for your talk. I am sure it is very thought-provoking for all of us. The question I would like to ask is that you are talking about the diffusion system and flexible coatings, which will accommodate slight changes in the structural background. These systems presumably will work very well if you get very small cracks appearing uniformly in a number of places, but if you get a weak point in the structure such that all the stresses result in one large crack appearing, how well do these systems work? In other words, what kind of size of crack forming in the substrate can be accommodated?

MR. HEWITT: That is a good question. Basically, what one has to assume is that the substrate itself is sound, and that any cracking that occurs will fall within the tolerances that are normally allowed within a structure. Codes of practice come and go and change, but generally speaking, if you look at the design codes CP100 and 110 and so on, they talk about limit state of design for cracking as being up to 0.3 mm. That is the definition of a hairline crack. Anything over 0.3 mm is considered to be probably structural. So most of the systems that I have discussed would easily deal with anything up to 0.3 mm, which does not sound like a lot, but that is actually quite a big crack. Anything where you are going to have structural failure of the substrate itself brings you into another area completely, and it then is beyond the realms of waterproofing, and one has to assume when designing a waterproofing system that the substrate is structurally sound. You find usually that that is included as a qualification in any quotation.

MR. C.J. JONES (BWPDA): I notice that in your illustrations you in effect talk about a structure being raised on a concrete raft. In many of the refurbishment areas you usually find that the previous ground floor timbers have been removed and you get an infill of brick rubbish and so on married up to an existing wall which is basically going down to the foundations. I did not see that illustrated there. When the problems arise with that, how do you cope?

MR. HEWITT: Very carefully! One needs, when approaching a structure like that, to be incredibly careful. You cannot just walk into a building like that, look at it, and say, "Okay, this is what we are going to do." It just does not work. What I would do in a situation like that is throw it back into the court of the client or the architect and say, "Really, what we need on this structure is an engineer's report, bearing in mind the fact that certain types of stresses are going to possibly be induced at a later stage." Very often you will find that the engineer will come back and say that it cannot be done or it can be done, but you can never be sure that it will not cause any problems. The type of structure that you describe is probably one of the worst that you can come across. So I repeat what I said at the beginning: I would deal with that very, very carefully, and I might even say, "I am sorry, it is not feasible, in fairness to you, to do something and guarantee it."

MR. B. QUIGLEY (P.J. Quigley Ltd): What amount of water pressure do you propose that these coatings might withstand?

MR. HEWITT: The various manufacturers of coatings all have their own figures. To a very large degree, the amount of water pressure that a cementitious coating or polymer modified cementitious coating can withstand would depend on the actual thickness to which you apply it, but certainly, to deal with heads of water in the region of 30 to 50 metres is neither here nor there, but types of heads that most of the coatings will withstand will be far, far greater than the actual structure would withstand, so the chances are that long before you get leaking through the system you would get a failure on the substrate. There are systems around that will deal quite happily with a 150 metre head of water.

DR. FITZSIMONS: You started off your talk saying that you felt that in all likelihood planned abstraction would result in the rising water table problems not occurring. Then you said several times later on that it is reasonable to suggest to potential clients in the central London area that they ought to be planning for this to occur. If somebody has a dry cellar, are you morally justified in telling them that they could have a problem in the future, when you believe that planned abstraction will result in that problem being solved?

MR. HEWITT: Certainly. The way I got into this research was because of the rising water table, so obviously I started investigating the deep aquifer, which was the one that they are referring to, and I discovered that that is in actual fact unlikely to be a problem. But it did lead me on to the situation where we then started looking at the perched water table, because that is the one that we understand, and the perched water table is on average increasing. CIRIA are currently doing some investigations into what is happening in the perched water table, but whilst it is not nearly as dramatic as the deep aquifer, the water tables generally are rising, and we have found in the past few years, with some fairly extreme climatic conditions that the fluctuations are going both ways. You are getting water tables both rising and dropping.

So what we are saying to a client is that just because their basement is relatively dry today does not mean to say that the day after tomorrow it will not be flooded, or if it is flooded at the time of inspection, it may be in a couple of days' time it will be dry. With these perched water tables in certain parts of London you get some incredible aanomalies, where you have heavy rain for maybe 20 minutes and anything from half an hour to two or three days later you suddenly get massive changes in water table levels, either from underground streams or from an overall situation. So, yes, I take your point, but definitely there are sufficient changes in water table levels to make the client beware. You obviously need to assess at any given time, whether the change is going to be big enough to justify the additional expense, because these systems – certainly the polymer modified reinforced system – are not cheap.

MR. G. JACKSON (Remtox): You mentioned the word "guarantee". What are your views on guarantee in the industry and the life of these protective coatings?

MR. HEWITT: The whole guarantee situation within the underground waterproofing industry is fraught with potential pitfalls, and it has to be approached with great caution. You often find applicators will issue guarantees, and they are accused that the guarantee is not worth the paper it is written on, or there are some companies that will underwrite guarantees or offer back-up guarantees and the same accusation is levelled at them. The main reason is that, as we have discussed, a waterproofing system is only as effective as the structure to which it is applied. If that structure is going to fail singificantly, the system will fail.

My attitude to guarantees is that if you can assure me that the structure will remain sound and unaffected by changing stress levels from outside, then I can guarantee that that tanking system will last as long as that structure will last, but it would be a very unwise man who would guarantee it carte blanche, because structures have a nasty habit of failing, and it is very often in the most unexpected of places as well.

MR. H.F. SALTER (Protim Services Ltd): One of the examples you showed us, Phillip, was the stainless steel expanded metal between the cementitious lining and the substrate. What systems of fixing the stainless steel do you normally advocate when it is into brickwork?

MR. HEWITT: I would not. There are a lot of fixings around, and various manufacturers of different types of fixing. There are fixings that you can literally just drill the structure and plug. There are chemical fixings you can use which are epoxy resins mixed up in glass phials which you can ram into the hole and it mixes itself. There are quite a few around. What one needs to do is to investigate the substrate itself and see how unsound it is before deciding on the actual type of fixing itself. The criteria are the depth to which it needs to be fixed and the spacings, but I would not like to go as far as to prescribe a specific type of fixing. Certainly chemical, resin anchors and plugs, correctly chosen, would be quite suitable, but plugs will obviously be a lot cheaper then resign anchors, which tend to be very expensive.

DR. C.R. COGGINS (Rentokil): Chairman, I am promoted to ask, following Phillip's several warnings about the difficulties in getting these systems right, what training provision there is, and indeed what level of training is needed to assure competency in specifying systems of this nature. Of course, I am very interested in this are. I am Chairman of the next paper, which is covering qualifications and training in our industry. What can you say about that?

MR. HEWITT: That is a very good question, Chris. The answer to that is none. At the moment there is no formalised training that anybody can get anywhere. There are a couple of textbooks that have been produced on the subject, but obviously that is not sufficient. That is just scratching the surface. I would be tempted to say put the ball in the BWPDA's court.

THE CHAIRMAN: Ladies and gentlemen, if everyone has finished, I am spellbound and find it hard to describe how interesting that talk was to me in particular, and I am sure you are all of the same opinion. Please, with me, thank Phillip for his very, very interesting paper. *(Applause)*

TRAINING AND VOCATIONAL QUALIFICATIONS IN WOOD PRESERVING AND DAMP PROOFING INDUSTRIES

by Tricia Wright

The Wright Approach, First Base, Beacontree Plaza, Gillette Way, Reading RG2 0BP

Introduction

The National Council for Vocational Qualifications (NCVQ) was set up by the Government in 1986, and was asked to "hallmark" qualifications which met the needs of employment – National Vocational Qualifictions (NVQs) – and to locate them within a new Framework.

In Scotland, the same remit has been given to the Scottish Vocational Education Council (SCOTVEC) and the equivalent to NVQs are Scottish Vocational Qualifications (SVQs).

In Northern Ireland, the Department of Education and the Department of Economic Development have jointly established a Vocational Qualifications Unit to liaise with NCVQ. This is based in the Training and Employment Agency, Belfast.

Fundamental Criteria

To be accredited as a National Vocational Qualification, a qualification must be:

* based on national standards required for performance in employment, and take proper account of future needs with regard to technology, markets and employment patterns;
* based on assessments of the outcomes of learning, arrived at independently of any particular mode, duration or location of learning;
* awarded on the basis of valid and reliable assessments made in such a way as to ensure that performance to the national standard can be achieved at work;
* free from barriers which restrict access and progression, and available to all those who are able to reach the required standard by whatever means;
* free from overt or covert discriminatory practices with regard to gender, age, race or creed and designed to pay due regard to the special needs of individuals.

NCVQ therefore aims to:

* improve the value of vocational qualifications to employers and individuals alike;
* encourage individuals to develop their vocational competence by improving access to vocational qualifications and by clearly defining progression routes;
* encourage the provision of more and better vocational education and training through NVQs which meet the real needs of employment and prepare individuals for changes in technology, markets and employment patterns, thus contributing towards improved national economic performance.

Lead Bodies

There are three main types of lead body:

The **industry specific** lead body is in most cases an existing industry training organisation which has wider remit than the development of standards eg Agriculture Training Board or the Meat Industry Training Organisation. In other cases a lead body has been established with the encouragement of the Employment Department specifically for the purpose (eg the Museums Training Institute).

The **consortium** brings together a number of lead bodies or other interested parties which are active in similar or overlapping areas to minimise duplication and identify common needs (eg Care Sector Consortium).

The **cross-sectoral** lead body has been established to develop standards in occupations or functions occurring across the full range of employment (eg Administrative Lead Body, Management Charter Initiative and Training and Development Lead Body).

In areas where lead bodies are concerned with the development of standards for higher level occupations or professions, the appropriate professional bodies will have an important role to play.

Activities

Lead bodies are expected to undertake the development process leading to NVQs, which will include the following stages:

1. Mapping of the occupational areas within the coverage or scope of the lead body. Occupations should be identified where possible using the Standard Occupational Classification (SOC) and coverage must include Scotland.
2. Reviewing any existing work on occupational standards and existing qualifications relevant to the sector. This identifies awarding bodies already involved in the sector and likely to want to remain involved in the arrangements for assessment and certification. It also identifies current qualifications and the way in which they are being delivered. This could have considerable bearing on their replacement, modification or continuance. Considerations must include SCOTVEC's provision.
3. Producing and implementing an Action Plan to ensure delivery of the widespread use of the agreed standards and qualifications.
4. Conducting an analysis by functions of the whole sector in order to identify standards required in employment at various levels extending from the lowest to the most senior professional and managerial levels.
5. On the basis of the analysis, agreeing with NCVQ and SCOTVEC a framework for vocational qualifications in this sector, statements of competence and the associated performance criteria and assessment guidance.
6. Ensuring that suitable arrangements are devised for assessment of the defined competences. This should involve the awarding bodies (examining and validating bodies) relevant to the sector.
7. Ensuring that the relevant lead bodies have the appropriate certification arrangements with the chosen awarding bodies.
8. Ensuring that the awarding bodies, with support from the lead body, present the qualifications and gain accreditation for them from NCVQ and SCOTVEC.
9. Devising and implementing arrangements for the continuing revisions and updating of both standards and NVQs.

   In Northern Ireland, the Vocational Qualifications Unit secures awareness of, and where appropriate, involvement in the formulation of national standards of competence which will form the basis of NVQs. The unit consults on an ongoing basis with sectors of industry and commerce, and identifies those bodies in Northern Ireland which it is agreed can represent the views of their sector in the national context.

Breadth

Breadth is implicit in the concept of "national" standards. A national standard for an employment function implies that it is generally applicable to all organisations and contexts in which that function is performed. The specification of statements of competence will thus normally be more general and broader than if they were to apply only to a particular organisation or job.

Training for occupations or professions has tended to concentrate upon the technical requirements of jobs, the skills and tasks that need to be performed, while often neglecting the wider aspects of performance required to fulfil a work role. Thus engineers may be competent at solving engineering problems but poor at communicating their solutions. The aspects of competence which go beyond the technical are classified under the headings "task management", "contingency management" and "role/environment skills". The emphasis placed on them should encourage the development of those core skills which are likely to endure and remain relevant despite changing technology and work practices.

An essential part of the methodology of stating competence is the range statement which indicates to assessors the range of application to which the element of competence is expected to apply, and provides the basis to judge what demonstrations of competence, knowledge and understanding are required to attest to competence.

The "breadth" of competence is intimately tied up with the question of knowledge and understanding. The statement of competence unreservedly concentrates on the ability to perform effectively but effective performance also depends on an individual having a body of knowledge, theory, principles and cognitive skills on which to draw. So, in order to feel sure that an individual can perform effectively over an extended period of time and in difference contexts, knowledge must be assessed. Evidence derived from knowledge assessments must always be combined with some evidence arising from performance.

Assessment in NVQs involves the collection and evaluation of evidence against performance criteria. However, it is not practicable to assess performance over the range to which an element of competence applies as defined by the range statement. The issue which is raised is whether the evidence gathered from observable demonstrations is sufficient to attest to competence over the required range. In some cases, variation in practice may be small between different contexts, when demonstration in one context may be sufficient. If on the other hand variations between contexts resulted in significant variation in performance requirements then transfer would not be a straightforward matter. Thus knowledge must be assessed to cope with variation in practice which cannot be assessed through performance demonstrations and therefore the assessment decision should be made on the sum of performance plus supplementary evidence.

Analysis Of Functions

The starting point for the definition of standards is the analysis of occupational area and asking "what needs to happen for this to be achieved?" The answer will identify the functions. The process is repeated until the necessary level of detail is achieved. This systematic approach ensures that the objectives of the activity are never lost sight of.

To avoid specifying standards narrowly in terms of jobs, tasks, activities, processes or skills the work role should also be considered in terms of the wider functions that it encompasses.

If the analysis of functions is done properly, four coponents of competence will emerge:

* task performance;
* task management;
* contingency management;
* job/role environment.

At each level of the analysis these aspects of competence must be identified to make the full nature of the competence explicit.

Generic Units

NCVQ uses the term "generic units" to refer to units which express functions or work activities which are common to almost all occupational areas. Such units should reflect the generic nature of the competence concerned. Generic units produced by lead bodies such as the Administrative Lead Body, the Information Technology Lead Body, the National Retail Training Council, the Languages Lead Body, the Management Charter Initiative, the Training and Development Lead Body, or relating to health and safety will often be incorporated into statements of competence developed by other lead bodies. This will add breadth to their standing and provide a basis for transfer.

Where generic units are used, lead bodies should not amend or in any way change the statements of competence on which the units are based. If there are significant changes, for example by altering range statements – the units may no longer be generic, although they may still be used in specific NVQs.

In cases where activities are common to a more limited range of occupational areas, for example, within the land-based sector, NCVQ will still expect the standards to be expressed in a way that provides maximum opportunity for transfer across the areas concerned.

Core Skills

Problem solving, communication and personal skills are the most fundamental core skills, underpinning almost all employment functions. A second group of core skills, which are not necessarily inherent in all subjects and occupational areas are numeracy, use of information technology and modern language competence. NCVQ aims to identify and enhance core skills in NVQs in order to:

* enhance the transferability of competent performance between different contexts and occupations;
* help employees to respond flexibility to changing skill requirements;
* provide a basis for progression with the NVQ Framework.

The three fundamental core skills will normally be developed as an integral part of occupational competence leading to an NVQ. This already occurs but trainees will probably be unaware of the fact. The performance demonstrations which are part of the assessment required for units of competence will also provide evidence of the possession of core skills.

When the core skills currently identified in an NVQ are at a level below that required for transferable core skill credits, attempts can be made to enhance their development. In most cases it is assumed this would usefully broaden the NVQ statement of competence. This could be achieved by addition of related employment functions to expand what is currently covered by the NVQ. It is vital that any such additional steps to develop core skills are perceived as relevant to the needs of employers and the employment opportunities of trainees.

It must however be emphasised that such enhancement or extension does not mean that core skills will be "taught" or acquired separately from occupational units. Evidence of the achievement of core skills would be derived from occupational performance, and credit for core skills would be awarded as a by-product of the performance required for an NVQ.

The conscious acquisition of core skills by individuals will enhance their occupational competence and normally have immediate benefits to performance in employment. Moreover, it will provide a stronger foundation for transfer and progression and the potential to cope with future changes in technology and work practices.

Health And Safety

Health and Safety are essential parts of an NVQ. Lead bodies must always consider them when developing statements of competence, and consult experts in their sector of employment if they do not have the knowledge themselves. Additionally, the Health and Safety Executive (HSE) publishes a range of guidance material.

Merely incorporating the words "health and safety" into statements of competence will be insufficient. In development work, lead bodies should consider and ensure competences reflect:

* the need to identify hazards associated with the occupation concerned (i.e. situations with a potential to cause harm), and the risk of harm from the hazards identified (i.e. the chance and severity of harm posed by the hazard);
* the ability to recognise and understand the risks present in their own workplace. They should be aware of relevant legal requirements and appropriate guidance in, for example, codes of practice issued by HSE, other guidance issued by HSE, and by the sector of employment concerned. Other sources of information available may include materials supplied by designers and manufacturers of articles and substances for use at work;
* the need to identify measures to remove the hazard or minimise the risk of harm posed by it. This includes the adoption of working methods which eliminate the hazard

altogether, and the introduction of engineering controls, physical safeguards, safer systems of work and where necessary personal protective equipment which individually or collectively minimise the risk of harm. Persons at work should be able to monitor their work, recognise when hazards and risks change and when control measures remain adequate or require amendment.

Lead bodies will also need to ensure that competences for supervisory and managerial occupations reflect job-holders' responsibility for the health and safety of those who work for them. Depending on their seniority, job-holders will need to be able to apply the above process in respect to the jobs of those for whom they are responsible.

THE NVQ FRAMEWORK

Framework

The NVQ Framework provides the NCVQ with a means to:

* rationalise and simplify the provision of vocational qualifications, in order to facilitate progression by clarifying the career routes which are open to individuals by making the relationships between work and NVQs clear;
* make explicit the relationship between qualifications, and to aid comprehension by presenting and classifying them in a systematic and logical way;
* make the provision comprehensive in order to cover all significant occupations and work activities.

Levels of qualifications

The NVQ Framework presently incorporates five levels to cover the provisions of NVQs from the most basic to those representing the professions.

The levels of award indicate progressive increments in achieved competence. These increments can take different forms in different occupational areas. For example, an individual can increase his or her competence by increasing the range of work-related activities he or she is able to perform, by mastering more complex tasks, or by specialising. The Framework is designed to order qualifications in such a way that all forms of progression which develop an individual's competence in employment are encouraged.

The higher the level of qualification the more of the following characteristics it is likely to have:

* breadth and range of competence;
* complexity and difficulty of competence;
* requirement for special skills;
* ability to undertake specialised activities;
* ability to transfer competences from one context or work environment to another;
* ability to innovate and cope with non-routine activities;
* ability to organise and plan work;
* ability to supervise others.

The particular combination of these factors will vary from award to award according to the nature of the competence and the level of the award. The variation will depend on the nature of occupations and the organisational context in which the competence is commonly practised.

The increment of competence between levels may affect the case of progression. If it is too large, the opportunity and motivation to acquire an award at a higher level may be reduced. NCVQ does not, however, permit awards to be offered at intermediate levels of competence because this would negate its objective for the classification of awards to be easily understood.

Design of qualifications

Another aspect of breath, apart from the form of specification of the elements and units, is how units are combined to make up any NVQ or a group of NVQs. An NVQ may be defined as a group of units which have relevance to employment and likely to make the holder of an NVQ employable. It is equivalent to the concept of an occupation, although in many areas and levels, NVQs are being created where occupations have not previously existed.

An NVQ must cover a range of functions, represented by a range of units. This will frequently be broader than an employee's current job which might in some instances be limited to the equivalent of one or two units.

As the NVQ Framework is developing, it is becoming clear that NVQs will play a key role in setting the targets for training and providing a framework for the delivery of the national training system. Programmes targeted on NVQs at level 2 or 3 are already required for YT funding, in areas where the NVQs are in place. The training credits, to be piloted in 1991, will also be based upon NVQ outcomes where they exist. The expectation from these programmes is clearly that NVQs cover an appropriate range of functions to provide suitable targets for a specified amount of financial investment.

An NVQ must cover a range of functions appropriate to its level.

A further design principle is that NVQs are based upon a statement of competence which should become widely recognised and understood in industry and outside. To say that "I have an NVQ in, say, Retail Distribution - Level 1" should convey that the holder has achieved a standard of competence in a generally recognised range of basic competences in retail distribution. If there is considerable choice and variation in what one can obtain within such an NVQ, the meaning of the qualification wil not be understood. If optional units were to make up a substantial part of the NVQ, two holders of the NVQ in retail distribution may have covered different units and have little in common. If there is significant variation within what can be obtained within an NVQ then the two offerings should have different titles, and thus be two different NVQs.

Put another way, the title should accurately reflect the content of an NVQ. If through options, one can specialise in the coverage of competence with an NVQ, then the specialisation should be reflected in the title. One cannot claim competence in "retail distribution" if what one has actually covered is a specialised area of distribution.

The NVQ Framework

The NVQ Framework is the national system for ordering NVQs according to progressive levels of achievement and areas of competence. It provides a structure for accredited qualifications which indicates the relationship between them and helps identify progression routes.

The NVQ Framework currently has five levels - the following definitions are intended to be indicative rather than prescriptive and should be seen as clarifying rather than changing the definitions in previous NCVQ publications:

Level 1 competence in the performance of a range of varied work activities, most of which may be routine and predictable;

Level 2 competence in a significant range of varied work activities, performed in a variety of contexts. Some of the activities are complex or non routine, and there is some individual responsibility of autonomy. Collaboration with others, perhaps through membership of a work group or team, may often be a requirement;

Level 3 competence in a broad range of varied work activities performed in a wide variety of contexts and non-routine. There is considerable responsibility and autonomy, and control or guidance of others is often required;

Level 4 competence in a broad range of complex, technical or professional work activities performed in a wide variety of contexts and with a substantial degree of personal responsibility and autonomy. Responsibility for the work of others and the allocation of resources is often present;

Level 5 competence which involves the application of a significant range of fundamental principles and complex techniques across a wide and often unpredictable variety of contexts. Very substantial personal autonomy and often significant responsibility for the work of others and for the allocation of substantial resources feature strongly, as do personal accountabilities for analysis and diagnosis, design, planning, execution and evaluation.

DRAFT INTERIM REPORT

OCCUPATIONAL & FUNCTIONAL MAPPING FOR THE WOOD PRESERVING AND DAMP PROOFING INDUSTRY

INTRODUCTION

Following an initial meeting in Autumn 1990 between the British Wood Preserving and Damp Proofing Association (BWPDA), the National Council of Vocational Qualifications (NCVQ) and the Training Enterprise and Education Directorate (TEED), the Association invited The Wright Approach to undertake the preparation of an occupational map for the Wood Preserving and Damp Proofing Industry (WPDI).

The aim of the mapping project was to determine the parameters of the Industry by its occupations and functions.

The objectives of the project were to:

* develop an occupational map illustrating the industry sub-sectors and the occupational roles
* identify, as accurately as possible, the numbers employed in the occupations and the Standard Occupational Classifications into which they fall
* establish the rate and extent of turnover within the Industry
* identify areas of commonality with other, particularly adjacent, industries
* identify the professional bodies relevant to the Industry
* identify the Trade Unions with which the members of the Industry are affiliated
* identify training currently available and any gaps that exist
* establish the range and usage of current vocational qualifications
* establish the breadth of other qualifications followed/used including in-house/in-company ones
* identify gaps in current qualifications
* identify current assessment and verification systems
* identify existing quality control systems

To carry out the Occupational Mapping Project, a Project Steering Committee was established to direct and monitor the outputs of the development work undertaken by the consultants.

The Wright Approach, the consultants, in cooperation with the Industry representatives, used a combination of research methods include:

* questionnaire
* direct interview
* telephone enquiry
* workshop and seminar
* written enquiry

The Occupational Mapping project culminated in a written report of the findings and statistical detail in the form of annexes.

The Wood Preserving and Damp Proofing Industry (WPDI) have a significant role to play within the Construction Industry. Although standards development work is proceeding within the construction Industry through the Construction Industry Standing Conference (CISC) and, on the Timber side through the Timber Trade Training Association (TTTA), neither of these bodies is proceeding with standards development relevant to the WPDI. The WPDI has an urgent need for standards for a National Vocational Qualification (NVQ) framework.

SECTION 1 – AN OVERVIEW OF THE INDUSTRY

1.1 **Industrial Sectors and Sub-Sectors**

Employment within the WPDI is split into three categories:

* Formulators and Distributors of Preservatives, Remedial Treatment Fluids and Damp Proof Course Chemicals
* Industrial Pre-Treatment Firms who carry pre-treatment including flame retardant treatment at Timber Treatment Plants prior to use and/or manufacture
* Remedial Wood Treatment and Damp Proofing Firms who carry out remedial, preservation and damp proofing treatment in buildings already constructed.

STANDARD OCCUPATIONAL CLASSIFICATIONS (SOCs)

These Sub Sectors have been matched with the relevant Standard Occupational Classification Code for ease of reference, statistical analysis and for the purpose of an overall occupational mapping for the UK.

1.2 **Numbers in the Industry**

The Industry is characterised by:

* the variety of processes and techniques used
* the wide dispersal of individual firms/works
* the physically demanding and type of work environment
* the ease at which certain sectors of the industry set up and start operating
* approximately 25% of companies change hands in one year

Ten per cent of the labour force is employed in family type businesses with a relatively static supply of labour.

The larger companies within the industry recruit graduates for management positions and have structures and provision for continuous personal development. A high percentage of large companies, however, recruit their operators, supervisors and surveyors from the local supply of labour and they progress at their own pace and fill positions as they become available.

The smaller companies tend to recruit operators from the Construction companies, and in times of recession from job centres and redundant employees in other industries. With no requirement for formal qualifications, there is a large floating labour market with a fair proportion of casual labour which does not reflect well on the Industry.

Supervisors are recruited from trained Operative level. Surveyors are recruited from supervisory and operative level. Sales skills, essential surveyor knowledge and skills are bolted on to this. Many company owners, managers and surveyors are recruited from all walks of life as the business is relatively easy to establish and become operational.

As a result of the above factors and particularly due to the large number of individual firms nationwide, it has proved difficult to calculate the numbers of personnel involved in the Industry as a whole or even within the different sectors.

We are presenty applying to the accrediting bodies and chemical suppliers for numbers of firms/workers accredited by them. The BWPDA estimates the numbers employed throughout the Industry to be between 15 and 20,000. We would wish to be a little more specific than this.

1.4 **Commonality with other related industries**

The three distinct sectors of the Industry have been identified and clearly defined with no development projects being undertaken for these sectors by neighbouring industries or Industry Lead Bodies.

There is a clear overlap with the Non Agricultural Industry. There is considerable interchange between the WPDI and this industry because WPDI are users of non-agricultural pesticides.

There are close links with the Timber Trade because of both the end product and the tests for pretreatment in which both Industries are involved and WPDI also includes an element of Building Services within its boundaries.

The areas of overlap are as follows:

* Timber	Timber Trade Association
* Construction	Construction Industry Training Board
	Construction Industry Standing Conference
* Chemical Industry	Chemical Industry Association
* Non-Agriculture Pesticides	Non-Agricultural Pesticides Industry
* Urban Environment Conservation	Council for Occupational Standards in Urban Environment Conservation
* Health & Safety	Health and Safety Executive

1.6 **Professional Bodies**

There are a number of professional bodies relevant to the Industry offering professional membership. They are listed as follows:

* The Institute of Wood Science (IWSc)
* The Royal Entomological Society (RES)
* The Institute of Biology
* The British Wood Preserving and Damp Proofing Association (BWPDA)
* The Royal Society of Chemistry (RSChem)
* The Institute of Remedial Treatment Surveyors

1.7 **Trade Unions**

There is very little Trade Union involvement within the Industry.

Pre-Treatment employees may belong to the Union of construction, Allied Trades and Technicians (UCATT). As a result of current reorganisation taking place in this union at the time of writing this report, it is not possible to say, how this will affect union membership and alignment in the future.

Both Pre-Treatment and Remedial Treatment employees may be members of the Transport and General Workers Union (TGWU).

1.8 **Current Training Provision**

There are four main classification of training provision in the Wood Preservation and Damp Proofing Industry:

* Colleges of Further Education
* Chemical Manufacturers, Formulators and Suppliers
* In-House Training
* Training Agencies

Training within the Industry needs an input from all the above sections if it is going to be progressive and relevant.

1.8.1 **Colleges of Further Education**

There are three centres actively providing long term courses and short term courses for operatives, surveyors, supervisors and managers.

They publish syllabii and other course details including charges. Course vary in duration. Because the Colleges have moved out of Local Education Authority control, they have developed a tendency to offer external services. This has benefitted both other Colleges and enabled larger companies to organise in-house training. The Colleges also offer short refresher courses which prepare candidates for examinations. On occasion, these have been adapted to suite specifiers who require intensive background information of Industry activities.

The lecture content of all the college courses is largely unknown as there is no input or participation by Industry staff.

The College courses do use some on-site skills however, a number of Industry representatives interviewed felt that there is a need for more practical elements to be included in the college syllabi and for candidates to have more opportunity to practice practical skills. A direct link with the practical side of the Industry needs to be maintained and steps must be taken to keep the College lecturers up to date on the practical skills required by the Industry.

The College courses are geared to the requirement of the Certificate of Timber Infestation Surveyor (CTIS) and the Certificate of Remedial and Damp Proofing Surveyor (CRDS). In-house end of college examinations are held and candidates are assessed to a standard but the award of the certificates is made by the Institute of Wood Science for the CTIS and the BWPDA for the CRDS.

The College courses have no link with nationally recognised awarding bodies. However, they do meet the statutory requirements of the control of Pesticides Regulations.

1.8.2 **Chemical Manufacturers, Formulators and Suppliers**

There are two categories in this section, namely

* Wood Preservation and
* Remedial Treatment

The Wood Preservation (Pre-Treatment) sector relies on the chemical manufacturers, mainly

* Hicksons
* Cuprinol
* Fosroc
* Rentokil

to provide training. The Supervisors' and Operators' courses are of short duration, a maximum of three days, and include both theory and practical study.

The Remedial Surveyor's and Operators' courses are of similar duration.

All courses concentrate on product application and the relevant regulations to be observed and the Codes governing controls, as well as giving a general appraisal of timber and decay agents.

In most cases, the formal courses are followed by a test or examination and usually award a certificate of proficiency and attendance. These have no general validity.

The informal instruction delivered through the formulating companies usually is accompanied by the award of a certificate of approval for the contracting company but not for the individual employees in the company.

1.8.3 **In-House Training**

This training is done mainly by companies employing in excess of 100 surveyors and operators in the Remedial Treatment sector of the Industry. The companies organise their own training syllabus and use their own personnel to carry out the training.

Large firms may also enlist outside agencies to instruct employees in the technical and practical aspects of the work.

Very small firms, however, tend to train new, unskilled labour using a more experienced employee who may or may not be qualified to train.

Organised training will only result when a system of recognised certification is required.

1.8.4 **Training Agencies**

Another source of training is the use of consultants who offer, in particular, general survey and advisory services.

Generally they offer 1 or 2 day courses of instruction dealing with theoretical knowledge contained in literature supplied within the Industry, the research establishments and BWPDA. They are flexible enough to be able to offer in house instruction to any organisation with the proper training equipment and facilities and provided that candidates receive adequate reading material prior to the course of instruction.

One of the most important functions performed by these agencies is that they prepare for examination candidates who may be of mature age or lacking in basic education standards.

1.8.5

An additional and important source of training is available a the Building Research Establishment. A three day course of instruction in timber technology, timber treatment and timber pests is available on regular basis.

1.9 **Vocational Qualifications**

Currently the vocational qualifications available to employees in the WPDI are the Certificate of Timber Infestation Services (CTIS) and the Certificate of Remedial and Damp Proofing Services (CRDS).

The CTIS is awarded by the Institute of Wood Science upon successful completion of a course of study at one of the three Colleges of Further Education. the CRDS is awarded by the BWPDA when the candidate has successfully completed the course of study, also at a College of Further Education.

Other certificates of competency are issued when employees have completed short training courses offered by Chemical Manufacturers and Suppliers. The certificates are usually issued to the company to which the employee belongs and not to the individual.

The Industry comes under the statutory requirements of the Control of Pesticides Regulations, Codes of Practice and Training Standards. Recommendations are published to assist all those involved in the sale, supply and application of such products in complying with the legal duties placed upon them. All employers and self-employed persons are required to provide adequate and regular instruction, information and supervision as is suitable and sufficient for the use of these products. Records are to be kept of the achievement of each employee or self-employed person who has successfully completed any stage of pesticide-user training.

1.11 **Current Quality Control**

There is ever increasing pressure on all parts of British Industry to improve quality control. The WPDI has been actively seeking, and achieving registration through the British Standards Institute Quality Assurance (BSIQA).

A number of other bodies accredit firms who provide wood preserving and damp proofing services to the required standard. These bodies include:

* British Wood Preserving and Damp Proofing Assoication
* Building Employers Confederation
* British Chemical Distributors and Traders Association
* Federation of Master Builders
* National House Building Council
* National Association of Preserving Specialists
* British Board of Agrément
* Guild of Master Craftsmen

Nominating Company Schemes have been developed with BSIQA by the major suppliers of wood preservatives and pre-treatment preservatives to try to ensure quality assurance of their products. These schemes allow companies to nominate their customers and share the auditing of operations through supply and pre-treatment operations.

A number of Chemical Formulators and Distributors of Remedial Treatment Fluids and Damp Proof Course Chemicals also approve some firms who use their products and some of whose employees have completed the short training course required. These bodies include:

* Hicksons Timber Products Ltd
* Sovereign Chemical Industries Ltd
* Palace Chemicals Ltd
* Safeguard Chemicals Ltd
* Remtox Chemicals Ltd

In 1990, the Health and Safety Executive published Recommendations for the users of non-agricultural pesticides which were issued for the purpose of giving practical advice on the training necessary for the safe use of non-agricultural pesticides including those used for wood preservation and remedial treatment. These recommendations are issued pending the development of NVQs applicable to this section of Industry. The recommendations were published to assist all those involved in the application of such products to comply with the legal duties imposed on them by:

* Health and Safety at Work Act 1974
* Control of Substances Hazardous to Health 1988 (COSHH)
* Control of Pesticides Regulations 1986 (COPR)

BWPDA is issuing a Code of Practice outlining the Standards of Training in Safe and Effective Wood Preservation and with effect from 1993, it will be a requirement of membership that firms should have 50% of their surveyors qualified to CTIS/CRDS standard.

However, at present there is no nationally recognised framework for qualifications of personnel in the Industry other than surveyors. The Training Committee of the Association has developed training standards for Operatives, both remedial and pre-treatment, in response to the requirements of the Control of Pesticides Regulations but there is, as yet, no nationally accredited system for assessing and confirming Operator competence in accordance with those standards.

QUESTIONNAIRES/CONFERENCE/WORKSHOPS

On 7 May 1991, a Conference was held to launch the development of standards and N/SVQs for the WPDI. The membership was composed of 21 members of BWPDA representing the south of England, the Midlands, Yorkshire and Wales. Five invited delegates were unfortunately unable to attend though they were subsequently contacted and invited to continue their involvement with the development process.

The aims of the Conference were to:

1. Introduce and describe NVQs
2. Explain and outline the benefits of NVQs to: Industry, Employers, Employees
3. Outline how NVQs are developed
4. Describe using examples how NVQs will be implemented
5. Outline how industry and training providers need to prepare themselves
6. Complete a questionnaire to enable us to start preparing an occupational and functional map for the WPDI
7. Facilitate a 'speakers corner' to enable delegates to express their views and opinions on the present state of play with regard to the Educating and training provision within the WPDI

Data collected from the questionnaire will be compiled together with information received from the research and development work presently being undertaken by the consultants to outline the parameters of the industry in order to produce an occupational and functional map.

The outcome from this project will be published in the September BWPDA Newsletter.

Finally your support is invaluable, the consultants will be consulting with you on a regular basis over the next six weeks, they would be grateful for your continued co-operation for the success of the project.

PRESIDENT'S CLOSING REMARKS

THE PRESIDENT: Ladies and gentlemen, in the immortal words, possibly of John McEnroe – but there would have been a few expletives there – all good things come to an end, and all that remains for me to do is to draw this 42nd Convention to a close. I think we would all agree that the papers have been of a very high quality, and it would be wrong of me to pick out any one particular author for special mention, although to have two out of the eight papers presented by women is welcome and I am sure must be a record for our Convention. The stimulating debate following each paper is testimony to the quality of the presentations, and I would ask you all, ladies and gentlemen, to join me in recognising the contributions, particularly of the authors but also of the chairmen who so efficiently controlled each session. *(Applause)*

A major feature of the number of papers was, in my mind, the opportunity of using them as a forum for debate. We started off with talking about the Control of Pollution Act and the role of HMIP, and clearly numerous anomalies, and if nothing else, the need for further meetings to resolve many of these issues. We talked about all the options for fixation, the problems and variability of results type specifications with a natural material like timber, the benefits – if indeed there are benefits – of Shorea treatment and the treatment of Douglas Fir. Again, I am sure on these issues there will be much more debate in the future, as there will also be on the subject of training.

The programme for this Conference was put together by Austin Hilditch and his Covention Committee, and I would like to thank them all for presenting us with both an interesting and a stimulating programme, and also for making life easier for the BWPDA staff by their organisational guidelines and advice. The staff, as always, through Mike Tuck, have done an excellent job, and through their quiet efficiency have made the whole thing look very easy indeed. I know that the Conference involves a tremendous amount of work for them, and I am also aware that the arrangements for next year are already well in hand.

As to next year, many of you know that the BWPDA will be deserting Cambridge, with the Conference being held in May in Stratford. That is Stratford Upon Avon, the home of Shakespeare, and not Stratford, East London, the home of BWPDA. There has to be a reason for this heresy, and there is, I think a genuine reason. We did discuss it long and hard, and that is because we are co-ordinating with IRG, who are holding their Annual Conference in the UK in Harrowgate, and as I live just down the road from Harrowgate, I can recommend that to you. Our Conference will be held in the week before theirs, and not surprisingly, St Catherine's is not available during early May. I therefore commend Stratford Upon Avon to you, and anticipate an even larger Conference next year, swollen by the influx of research experts from all over the globe.

Our Deputy President, Dr Coggins, we would all agree, is a man of many parts, and apart from being the prime question asker at this Conference, he is also one of the principal organisers of IRG. Chris has asked me to point out to you all, if you have not already got one, that outside the conference room you will find brochures on IRG. So for those who would like the details of both the Conferences for IRG and the BWPDA next year, it is available outside.

Before then, of course, we have our Conference Dinner, and I look forward to seeing you all later on this evening at St Catharine's College. Thank you all for coming. I look forward to seeing you all later. *(Applause)*

THE BRITISH WOOD PRESERVING AND DAMP-PROOFING ASSOCIATION 1991 ANNUAL CONVENTION – 2nd-5th JULY

LIST OF DELEGATES AND VISITORS

Name	*Company or Organisation*
	A
ARCHER, DR. K. J.	Laporte Timber Division
ARCHER, MRS. K.J.	
ARTHUR, L.T.	Borax Consolidated
ASTON, DR. D.	Hickson
	B
BAINES, DR. E.F.	Rentokil Ltd.
BAKER, J.M.	BRE
BARKER, K.J.	Anglia Property Pres.
BEADMAN, J.	Sovereign Chemical Ind.
BELFORD, DR. D.	Private Member
BELFORD, MRS. M.	
BELLINGHAM, DR. F.	Borax Consolidated
BERRY, R.W.	BRE
BIGG, DR. M.G.	HMIP
BLOW, D.P.	Fosroc
BOONSTRA, M.	Centre for Timber Research
BOS, MRS. J.	The Wright Approach
BRAVERY, DR. A.	BRE
BROMLEY, M.A.	BWPDA
BROOME, A.D.J.	Laporte Wood Preservation
BROWN, G.R.	Buckman Laboratories
BUCHAN, E.M.	Private Member
BUCHAN, MRS. E.M.	
BUIJS, A.J.	Flexichemie
BUNDY, C.	Rentokil Ltd.
	C
CAHILL, D.	EOLAS
CAREY, DR. J.K.	BRE
CARMO, J.	Anglo-Portuguesa
CARMO, MISS J	
CHALMERS, C.E.	Fosroc
CHALMERS, I.M.	Calders & Grandidge
CHAPMAN, R.G.	Schering
CHIDDLE, T.	Fosroc
CLARK, M.	Yorkshire Electricity Plc
CLAYDON, G.R.	NRA
COGGINS, DR. C.R.	Rentokil
COGGINS, MRS. A.	
COLE, M.	Wickes Europe Ltd.
CONNELL, M.	Hicksons
CORNFIELD, MRS. J.	Hicksons
COX-BROWN, J.	NCH Europe
COYLE, P.J.	Protim/Fosroc Ltd
CROCKER, N.E.	Buckman Laboratories
	D
DAVEY, R.N.	Cuprinol Ltd.
DAVEY, MRS. R.N.	
DAVID, J.	Honorary Treasurer
DAVID, MRS. J.	
DAVID, R.C.	Hicksons Timber Products
DAVIS, S.J.	Rentokil
DAWSON, B.	NCH Europe
DICKINSON, DR. D.J.	Imperial College
DIXON, MS. A.	TTJ
DUDLEY, MRS. N.	TRADA
DUVAL, A.J.	EIFORFA
	E
ELSEY, D.J.L.	Laporte Wood Preservation
ESSER, MRS. P.M.	TNO
EWBANK, G.A.	Fosroc
EYNDE, R. VANDEN	Buckman Laboratories Belgium
	F
FISHER, M.J.	Halifax Building Society
FITZSIMONS, DR. P.	Cementone-Beaver
FOWLIE, I.M.	Calders & Grandidge
FRANZEN, P.	Peter Cox President
FREEMAN, D.A.	GPT
FROST, R.A.	Cementone-Beaver Ltd
	G
GILL, DR. C.J.	TRADA
GILMOUR, DR. J.	Rohm & Haas
GODDARD, K.	South Eastern Electric
	H
HALL, DR. G.	TRADA
HARLING, D.J.	Mechema Chemicals Ltd.
HAYTON, J.P.	Rentokil Ltd.
HEWITT, P.N.	Vandex Ltd.
HILDITCH, E.A.	Cuprinol
HILDITCH, MRS. E.A.	
HILL, A.W.	Fosroc Ltd
HILL, L.	BWPDA
HISLOP, H.W.	Maljon Timber
HOLLAND, MRS. G.	BRE
HOLMES, M.	Rentokil Ltd.
HULL, MRS. A.V.	BRE
HUTCHISON, G.O.	Calders & Grandidge
	J
JACKSON, G.	Remtox
JEFFRIES, MISS J.C.	Bayer UK
JONES, C.J.	BWPDA
JONES, M.G.	Hickson
JONG, DE.D.	Bureau of Pesticides
	K
KACZMAR, P.M.	TRADA
KELLY, DR. A.W.	GORI
KENYON, A.	Fosroc Ltd.
KING, D.J.C.	Harcross Timber
	L
LAMB, K.M.	Cuprinol Ltd.
LAMBERT, D.J.C.	Safeguard Chemicals
LANDSIEDEL, H.	Schering
LEANEY, S.G.	Rentokil Ltd.
LEWIS, D.A.	Lambson Laminates
LOCKYER, A.A.	TTF
	M
MACGUINESS, DR. J.	HSE
MCCULLAGH, B.	Forsroc Ltd.
MALLINSON, T.S.	TTF
MARGOLIS, S.D.	BWF
MARSHALL, R.P.	GPT
MARTINEK, DR. P.	Solvay Osterreich Gmbh
MARTINEK, MRS. P.	
MILLER, D.	South Eastern Electric
MILLINGER, A.R.	Borax Consolidated
MOLDRUP, B.	Danish Wood Treating Co.
MORRISON, G.	Complete Preservation
	N
NORMAN, A.M.	St. Catharines College
NORTH, P.D.	Timberwise Consultants
NORTH, MRS. P.D.	

O

ORSLER, DR. R. .... BRE
OXLEY, J.E. .... Sovereign Chemicals

P.

PALMEIN, H. .... South Western Electricity
PARKER, J. .... Calders & Grandidge
PARKS, A.G. .... Burt Boulton & Haywood
PARSON, MISS. A. .... Fosroc Ltd
PAYNE, B.................... MacDonald Turner
PEARCE, E.M. .... GORI
PELTER, M.................. Hickson Timber Products
PERKIN, C. .... BWF
PERRITON, R.C. .... R.P. Associates
PINION, L.C. .... BWPDA
PLOWMAN, D. .... Troy Chemicals
PRINS, J.H. .... Stichting Keuringsbureau
PRIOR, MRS. M.C. .... Forests Forever Campaign

Q

QUIGLEY, B. .... P.J. Quigley Ltd.

R

ROBERTSON, C. .... Norweb
ROSS-JONES, DR. A. .... Rentokil Ltd.

S

SACHS, DR. H. .... Schering
SALTER, H.F. .... Protim Services Ltd
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SAYER, W. .... Southern Electric
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