Benchmarking solvent use in the UK furniture manufacturing sector

Supported by

Foreword

BFM Environment Ltd was established to build upon BFM's environmental expertise and conduct work of an innovative nature. As our organisation has been the voice of the sector with regard to wood coatings, it was only logical to start with solvent issues.

For those of you who are not already familiar with us, BFM Ltd is the sector's trade association. Around 350 member companies enjoy a wide variety of benefits – none of which have been more important than our environmental management services.

Over the past seven years BFM Ltd has been working with members on environmental issues - conducting site reviews, providing guidance notes, telephone support and training seminars. We have also been closely involved in representing the sector's interests during the formation of legislation – especially wood coatings.

This report shows that furniture manufacturers should be congratulated on the degree of solvent reduction progress that they have made. The 41 companies which participated in this project are saving over 605 tonnes of solvent every year compared to a 1998 baseline.

I hope that all manufacturers will read this report and make use of it. All coating operations should compare their performance to the benchmarks of solvent use and waste production. If your company falls short of the levels achieved by the best – then read the good practice suggestions and make appropriate changes. If you are already performing better than the best – congratulations!

Either way, please let us know about the progress you have made and any good suggestions that you would like to share with others.

I also hope that local regulators and the Department for Environment, Food and Rural Affairs take note of the sub-sectoral findings. Only 29% of large solvent users have been able to comply with requirements and no reproduction manufacturers are close to their targets despite a significant amount of expenditure. Consequently, it is surely time to revisit the policy that one target fits all sub-sectors.

Finally, my thanks go to the sponsors without whom this project could not have taken place: Biffaward, Granyte Woodcoatings Plc, Viatec, William Bartlett & Son Ltd, Bevan Funnell Ltd and Wood Bros Ltd.

Roger Mason

Photo from FFINTO

Executive summary

This report highlights a number of important issues with regard to UK wood coating operations. It estimates that the sector emitted 10,500 tonnes of solvent in the year 2000 – a lower figure than that suggested by some other sources. A further 983 tonnes of solvent were sent off-site for reuse and recovery.

The majority of the study concentrated upon 41 participating companies. These had achieved a significant amount of solvent reduction. Between 1998 and 2000, solvent consumption fell from 1,475 to 870 tonnes a saving of 41% or 605 tonnes p.a.

Significant expenditure was required to achieve this progress – totalling £7.63 million over five years. However, much of this sum was recouped by the £7.30 million of savings that accrued over the five year period.

There was a large variation in the degree of solvent reduction achieved by different wood coating users. For example, solvent to solids ratios ranged from 0.65:1 to 5:1.

Part of this variance can be explained by the nature of the relevant sub-sectors. The project concentrated upon three sub-sectors: reproduction, solid timber users and board material users.

Reproduction manufacturers made least progress at the highest cost. Between 1998 and 2000, the average solvent to solids ratio improved by 15% despite a solvent reduction spend of £231,000 per company from 1995 to 2000. None of the companies had been able to achieve compliance, having achieved a solvent to solids ratio of between two and five times the mass balance allowance.

By contrast, the board sub-sector had improved its ratio by 48% between 1998 and 2000, whilst making an average saving of £87,000 between 1995 and 2000. Consequently, 50% of large sites had achieved compliance.

Participating companies generated 173,000 litres of solvent waste p.a. 79% of this waste was sent off-site for recovery at a cost which varied from 10p to 67p per litre.

Some 36,600 litres were recycled on-site using solvent recovery machines. Savings of around £58,000 p.a. were generated by this means, due to the reduction in waste disposal costs and virgin thinner purchase.

Contents

1 Introduction

1.1 Background

Solvent reduction has been a major production issue for many furniture manufacturing companies since the introduction of process guidance note PG6/33 under Part I of the Environmental Protection Act 1990. This note regulates wood coating processes which use >5 tonnes of organic solvent in any 12 month period.

There has been a large variation in the success of wood coating operations in achieving compliance. The economics of the upgrade process have also varied significantly – some companies incurring significant cost whilst others have made sizeable savings.

Within the UK the majority of solvent reduction work has occurred on a company specific basis – i.e. in isolation. This report shows the degree of progress, associated costs and the impact in terms of solvent reduction. It also provides benchmarks with which companies can compare their own performance.

1.2 Aims and objectives

The main aims of this project were to:

- Generate information on the relative performance of different wood coating sub-sectors
- Quantify solvent emissions by coating type and sub-sector.
- Quantify levels of solvent waste generation by sub-sector and analyse the disposal and recovery routes.
- Develop solvent usage and solvent waste generation benchmarks.
- Produce guidance outlining the best operating practices and encourage the uptake of these practices.
- Contribute to the review of PG6/33(97) - the wood coating process guidance note.

1.3 Project structure

The project centred upon detailed solvent audits at 35 wood coating operations. Further information was generated through a postal questionnaire, discussions with wood coating manufacturers and coating equipment suppliers.

2 Controls on solvent use

2.1 Introduction

Organic solvents give rise to volatile organic compounds (VOCs) - organic compounds which evaporate easily at ambient temperatures.

When VOCs combine with nitrogen oxides (largely derived from combustion processes) in the presence of sunlight, a reaction occurs leading to the production of low level ozone. At ground level, such ozone is an undesirable substance which results in a brown atmospheric haze known as summer time or photochemical smog. This can lead to irritation of the eyes and nose - especially in those that are most sensitive, e.g. the elderly, young or those that are particularly active. High levels of ground level (tropospheric) ozone can also damage trees and crops.

In addition, some solvents are toxic and cancer causing, some contribute to high level (stratospheric) ozone depletion and global warming. Consequently, solvent use is controlled at a national and international level.

2.2 International agreements

A host of directives control air pollution at a European level. Of particular interest to the sector is the EU Solvent Emissions Directive which is intended to bring some degree of harmony to controls on a wide variety of solvent using sectors. Most of the wood coating requirements of this Directive are in line with the UK regime – albeit with a 2007 deadline rather than 1999. It is also notable that the Directive sets a 15 tonnes solvent use threshold for the control of wood coating operations compared to 5 tonnes in the UK. However, the latter looks set to be retained by the Department for Environment, Food and Rural Affairs.

2.3 UK legislation

Any wood coating operation likely to use more than 5 tonnes of organic solvent in any 12 month period must be authorised under PG6/33 – the wood coatings process guidance note. A summary of the requirements is provided in Appendix 1.

3 Characteristics of wood coating operations

3.1 Introduction

The wood coating industry is worth an estimated £50 mil p.a. There are generally recognised to be four major players in coating supply, the importance of which varies according to the source!

Table 1: UK wood coating supply	
Company	**Estimated % of wood coating market**
Becker Acroma Ltd / Granyte Woodfinishes Ltd	46%
Morrells Woodfinishes Ltd	18%
Sonneborne & Rieck	12%
Arch Coatings (formerly Hicksons)	12%

The earliest estimate of the amount of VOCs emitted by the sector was 14,000 tonnes in 1988 (DoE, 1993).

Work by the British Coatings Federation (BCF, 2000) suggests that VOC emissions were 18,200 tonnes in 1990 and 14,000 tonnes in 1998, with a predicted drop to 11,000 tonnes by 2010.

Table 2: British Coatings Federation estimate of furniture sector solvent usage			
	1990	**1998**	**2010**
Coating sales (tonnes)	24,200	25,300	22,000
Net VOC emissions (tonnes)	18,200	14,000	11,000

Between 1998 and 2010 the average solvent content of coatings is predicted to drop from 70% to 50%, reflecting the move to high solids, water borne and ultra-violet curable coatings. There is also likely to be an increase in the amount of powder coating used on timber. A significant proportion of the 1990 to 1998 progress is likely to have resulted from improvements in the management of thinners and general housekeeping.

3.2 Coating layers

There is significant variation in the number of layers / operations involved in finishing a piece of timber. The simplest of processes may just use a coat or two of lacquer. More usually, the process involves stain, sealer, de-nibbing and lacquer. However, at the top end of the reproduction market, all of the following stages may be required, though the sequence and degree of repetition will vary.

- **Bleaching** - undertaken, in certain circumstances, to lighten veneers and solid timbers.
- **Grain filler** - highly pigmented coatings with an oil base which are mainly used on open pore wood. Designed to set hard and reduce the degree of absorption of subsequent coating layers by the wood fibres.
- **Stain** - a pigmented coat which provides the desired colour, evens out natural colour variations and accentuates the wood grain.
- **Sealer** - designed to seal the wood, provide adhesion for subsequent layers and enable de-nibbing. Also known as base coat.
- **De-nibbing** - staining and sealing will frequently raise the wood grain, especially if water borne products are used. De-nibbing is the fine sanding stage which removes the raised grain.
- **Distressing** – a used appearance may be imparted through the use of lava rock, chains or other hand tools which lead to scratches and small indents.
- **Colour coat** - may be applied to accent areas and to correct patches of poor colouration. Only a very light dusting of colour coat is generally used. Also known as highlight.
- **Stipple** - comprising goldsize, turpentine and earth powders is applied by hand to further enhance an aged look.
- **Lacquer** - designed to protect the colour coats, enhance the final appearance and provide a durable surface. Also known as top coat.
- **Pullover –** thinners applied to a surface by hand to soften the top layer of lacquer and make it receptive to hand polishing.
- **Hand polishing –** various methods may be used to provide a hand polished appearance, e.g. pullover with the application of burnishing cream, fine grade sand paper with a white spirit lubricant or bees wax applied using fine grade steel wool.

3.3 Sub-sectors

The furniture industry is diverse in nature. Any analysis of solvent use based on sector-wide averages will be largely meaningless. For example, there is little similarity between the coating requirements of a foil covered office desk and a high quality reproduction desk. The former might require two passes through an ultra-violet cured coating line, whilst the reproduction desk may require 17 coating stages, all performed by hand.

Traditional sub-sectoral divisions centre upon the customer type, i.e. domestic, kitchen, office and contract etc. This classification is problematic from a wood coating perspective due to the range that exists in each category. For example, office desking may be based upon melamine faced chipboard which requires no coating, or it may be based on hand finished solid timber.

Therefore, this project has centred upon three specific areas of wood coating – referred to hereafter as the three sub-sectors:

- **Reproduction manufacturers:** typically companies producing high quality furniture, with labour intensive coating involving many stages and ending with hand finishing.
- **Solid timber manufacturers:** typically middle to top end manufacturers with fewer coating layers / operations and no hand finishing. This sub-sector includes companies that use real wood veneer on board material.
- **Board material manufacturers:** typically lower to middle end manufacturers, often with 3 or fewer stages in their coating processes, no hand finishing and a greater degree of automation. Board may be coated directly, but is more usually faced with plastic or paper foil.

It is recognised that there are failings in such a classification. Some manufacturers were involved in solid timber and board material manufacturing. Such operations were classed according to the major coating use.

Ideally, many more sub-divisions might be incorporated. However, further divisions would have prevented the accumulation of a suitable body of statistically significant information on each category.

4 Solvent use in the furniture sector

4.1 Introduction

The following section provides a breakdown of the results of the on-site audits, with additional information included from the postal questionnaires where relevant.

4.2 Characteristics of audited companies

35 wood coating operations were audited and a further 6 provided valid responses to the postal questionnaire. Of these 41 participants, 35 were authorised, 3 were in the process of applying for authorisation and 3 were just below the 5 tonnes threshold.

The companies holding authorisations represented 19% of the 183 registered wood coating operations (DETR, 2000).

4.2.1 Sub-sectors

The breakdown of responding companies by sub-sector was:

- Reproduction: 10
- Solid timber: 16
- Board material: 15

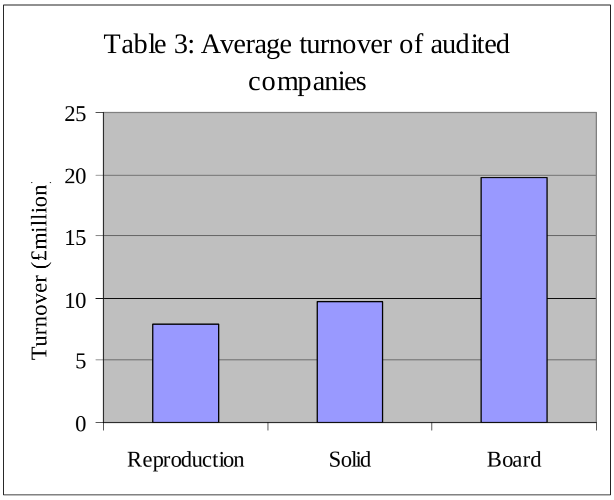


Table 3: Average turnover of audited companies

4.2.2 Size of company

The average turnover of participants was £11.68 million with a range from £1.4 to £72 million. Board material users were typically the largest in terms of turnover, but this size did not necessarily reflect on their coating operations due to their tendency to also produce un-coated items e.g. melamine faced chipboard product.

Combined company turnovers totalled £479 million – representing 6.8% of the sector’s estimated £7 billion turnover.

The number of employees averaged 201 with a range of 20 to 1200. The total number of employees at the audited companies was 8235 – representing 6.4% of sector's estimated 128,000 workforce.

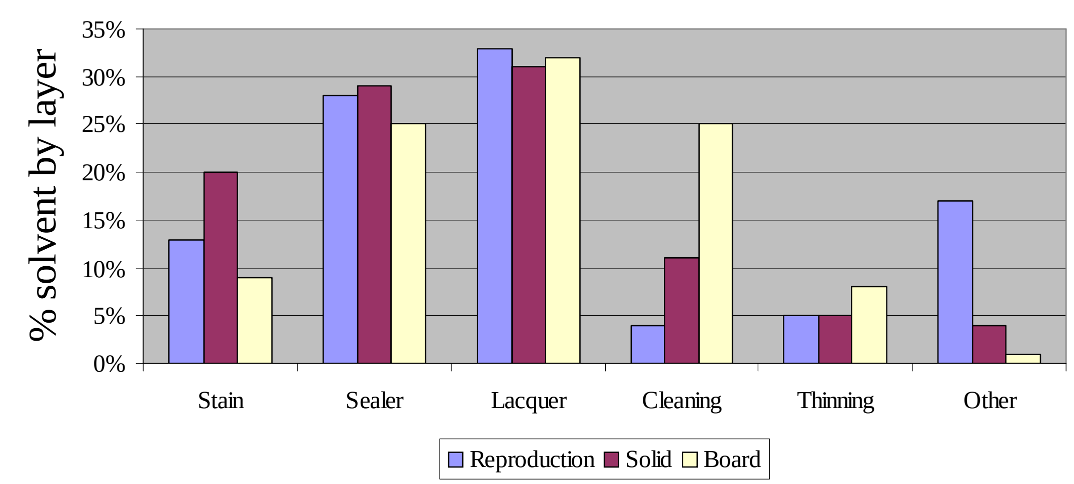
4.2.3 Coating spend

Audited companies spent an average of £112,650 p.a. on coatings – with a range of £22,000 to £506,000. The total spend was £4.62 million – some 9.2% of the sector's estimated £50 million p.a.. Coating spend averaged 1.48% of company turnover with a range from 0.2% to 4.2%

4.3 Coating layers

Table 4 shows the relative importance of the coating layers for each sub-sector.

Table 4: Coating layers by sub-sector



The most noticeable aspects were:

- Stain: board material companies consumed the least stain, reflecting the use of pre-printed foils
- Sealer and lacquer coats together account for the bulk of solvent use – 61% in reproduction, 60% solid timber and 57% in board material.
- Cleaning thinners: this area showed the largest degree of fluctuation. Cleaning accounted for just 4% of reproduction solvent use, in large part due to the inability of this sub-sector to switch to low solvent coatings. Therefore, the relative importance of cleaning thinners was low.

  Conversely, cleaning thinners accounted for 25% of board material solvent usage, partly reflecting the relatively low level of solvent use in typical board material coatings. In addition, a number of companies sprayed acid-catalysed coatings through automated application equipment. These systems consumed significant amounts of solvent through continuous belt cleaning and daily pipe flushing.

- Thinning: predominantly used by board material users, a reflection of the re-circulation systems on their automated machinery. The use of thinners had decreased noticeably over the past two years in all sub-sectors, due to improved housekeeping, training and the use of in-line heaters.
- "Other" coatings: these accounted for 17% of reproduction solvent use due to the presence of a variety of more unusual coatings. Half of the total was accounted for by colour coat, with the remaining solvent split between waxes, stipple and pullover.

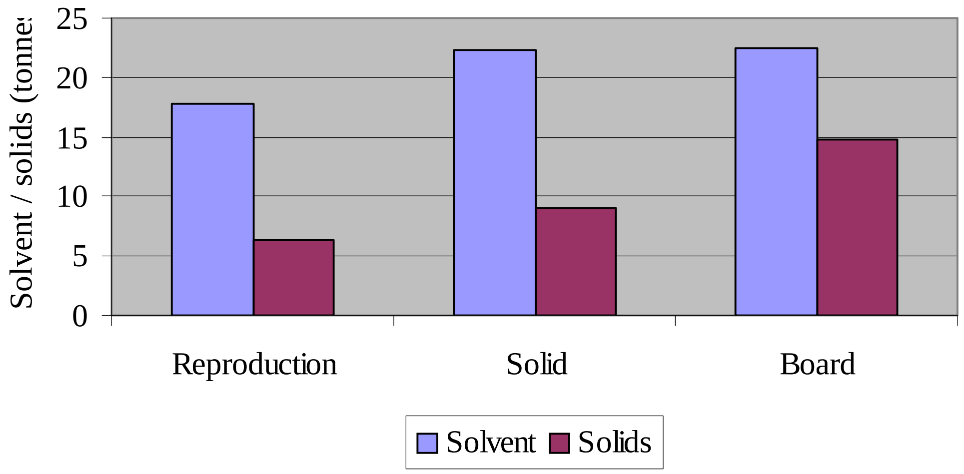
4.4 Use of solvent and solids

The audited companies used 870 tonnes of solvent and 430 tonnes of solids – giving a total solvent to solids ratio of 2.02:1.

17 of the companies were classed as "large" solvent users – i.e. 15 tonnes or more of solvent use per year. The other 24 were classed as "small" with solvent use of 5 to 15 tonnes.

The average amount of solvent used by companies in each sub-sector was fairly constant, ranging from 17.78 tonnes in reproduction to 22.52 tonnes in board material. A greater difference existed in the amount of solids being applied with a range of 6.31 to 14.72 tonnes respectively.

Table 5: Average use of solvent and solids

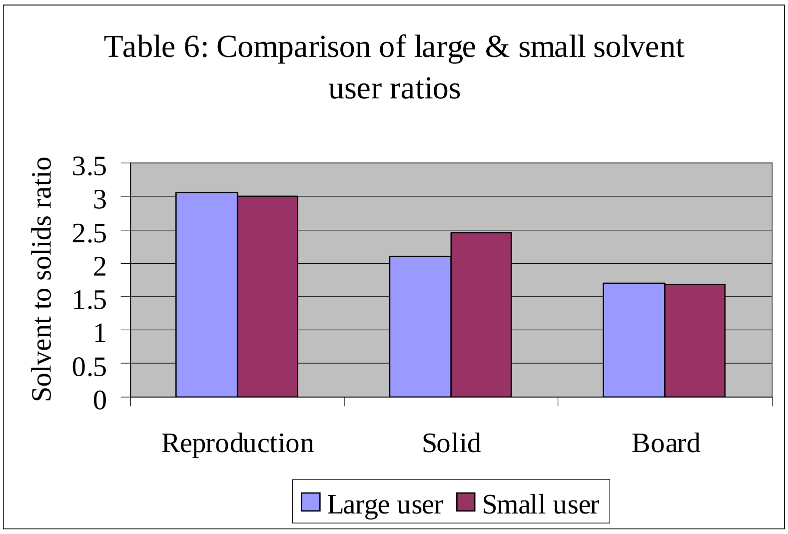


The consumption of solids provides a very useful measure for comparing coating operations. The whole aim of the coating process is to apply solids to the substrate. A given type of product will require a set level of solids and as production levels increase, so too will the total weight of solids that must be applied.

Thus, the ratio of solvent to solids is an excellent measure of the success of a particular company regarding solvent reduction initiatives over time – regardless of changes to production levels. It also allows a valid comparison to be drawn between coating operations of all sizes within a specific sub-sector.

4.5 Compliance

The UK process guidance note required that larger solvent users (>15 tonnes) pursuing the mass balance approach to have achieved a solvent to solids ratio of 1:1 by 1st April 1999. Smaller solvent users have until 2007 to achieve the more relaxed ratio of 1.6:1. Whilst mass balance represents only one of the three compliance options available, virtually all participant companies were pursuing it.



A comparison of solvent to solids ratios shows that reproduction companies were averaging 3.03:1, solid material users 2.39:1 and board material users 1.68:1.

It is interesting to note that larger solvent users were performing fractionally worse than smaller companies in two of the three sub-sectors. This was surprising as larger companies were expected to be able to achieve economies of scale, thereby allowing them to afford the control measures needed to achieve the more stringent targets that have been set for them.

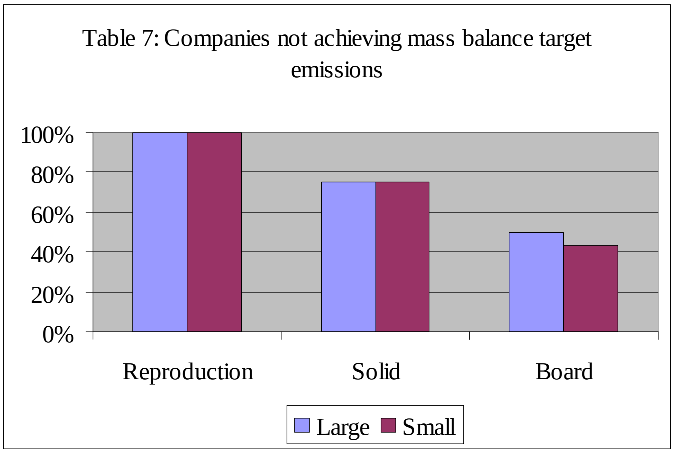


Table 7 shows that most companies were not compliant under the mass balance approach, with only 29% of larger solvent users reaching their target nearly two years after the passing of the deadline. The same percentage of smaller users were within their target ratio, though of course they have the extended deadline.

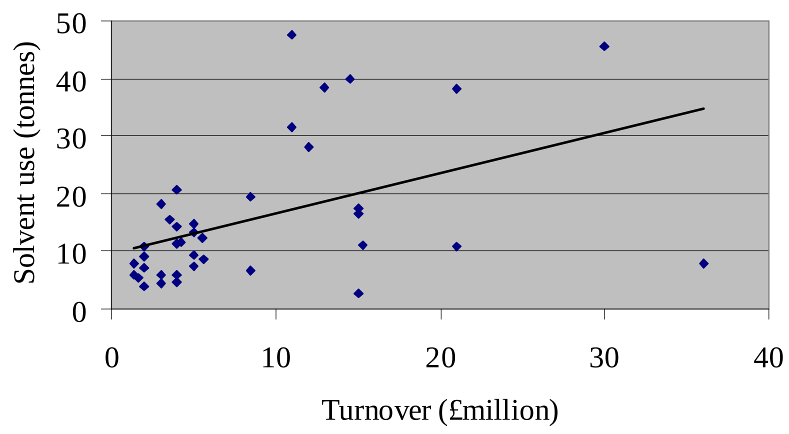
It was interesting to note that no reproduction manufacturers, large or small, had achieved compliance. The compliance rate rose to 25% for solid material users, both large and small.

The highest compliance rates were found in the board material using companies, where 43% of smaller companies and 50% of larger companies were achieving compliance.

4.6 Solvent use relative to turnover

Table 8 provides a guide to solvent use in relation to company turnover. On average, a turnover of £10 million equated with 17 tonnes of solvent use, £20 million with 22 tonnes and £30 million with 30 tonnes.

Table 8: Solvent use relative to turnover



4.7 Process upgrade costs

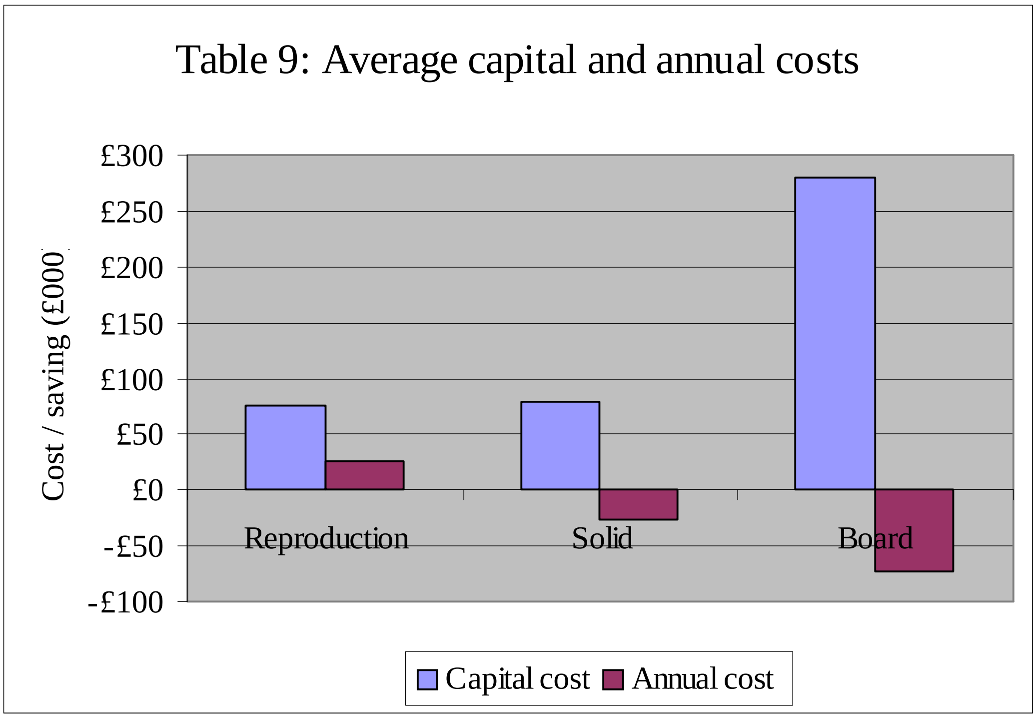
Audited companies had spent a significant amount on upgrade programmes between 1995 and 2000. Total capital expenditure among the 33 companies able to provide information totalled £4.81 million. This money was spent on items such as automatic application lines, spray equipment, drying tunnels and booths.

A further £565,000 was spent each year on solvent reduction consumables such as labour and material for trials and the additional cost of low solvent coatings.

Thus, total expenditure over five years was £7.63 million – an average of £231,000 per company. The majority of this cost was offset by annual savings of £1.46 million associated with reductions in labour and coating costs following the implementation of changes. These savings totalled £7.30 million over the five years – making the solvent reduction initiatives almost cost neutral for the sector as a whole.

However, it should be noted that the costs were highly sub-sector specific. The board sector experienced the highest capital costs of £280,000, but these led to annual savings of £73,000 – providing a payback period of around four years.

The reproduction sector fared worst, with capital expenditure averaging £77,000 per company compounded by annual costs of £26,000 – giving no financial pay-back for the upgrades.



When all costs and savings were considered over a five year period, reproduction manufacturers incurred an average cost of £204,000, solid timber companies saved £56,000 and board material users saved £87,000.

An analysis was also performed of the initial cost per tonne of VOC abated. In this scenario, it was assumed that all companies undertook their capital expenditure in year 1. This expenditure, plus the balance of the first year annual costs produced a year 1 total spend figure which was divided by the amount of solvent saved in that year.

Table 10: Initial cost per tonne of VOC abated	
Reproduction	£17,601
Solid timber	£8,224
Board material	£12,049
Average	£13,136

4.8 Solvent reduction initiatives

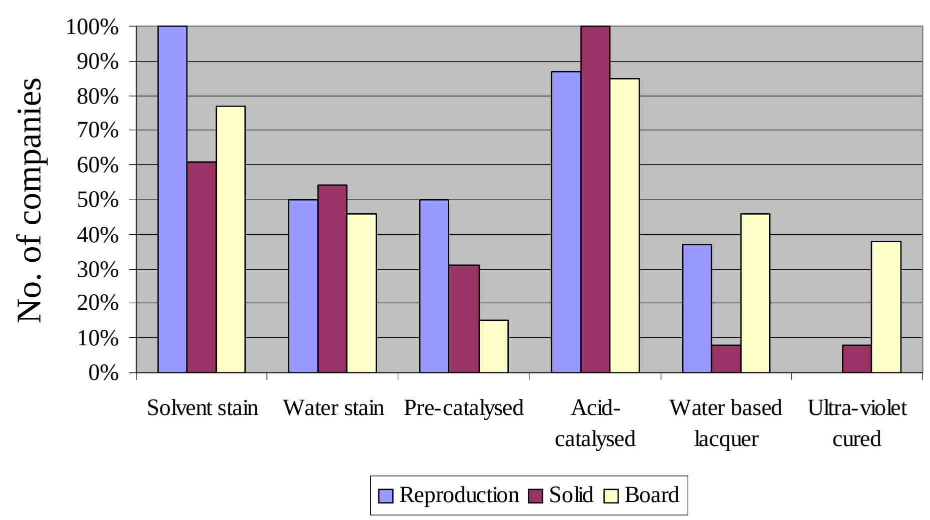
All companies had invested in high-efficiency spray equipment – typically high volume low pressure (HVLP) or air assisted airless (AAA). Where these companies were previously using conventional spray systems, most commented on the noticeable saving of raw material. However, many companies failed to optimise the use of this equipment as they did not keep a careful control of air and fluid pressures.

Automated application systems were present in 61% of board companies, 23% of solid timber and no reproduction manufacturers. A number of these systems were relatively old and most contributed to significant annual savings through the reduction of labour costs.

The single most cost effective solvent reduction method that virtually all companies had addressed in recent years concerned thinner usage. Cleaning thinners had been minimised through the use of lids on tins, cleaning procedures and the collection, reuse and recycling of dirty thinners. Thinning solvents had also been targeted and many companies with high solids coatings were using in-line heaters to reduce coating viscosity.

A significant amount of time and effort had been invested in coating reformulation. Table 11 provides a break-down of the main coatings used by the companies surveyed. Within each sub-sector, most companies were trying a variety of solutions. Thus, all reproduction manufacturers were using some solvent borne stain and half were also progressing with water borne alternatives.

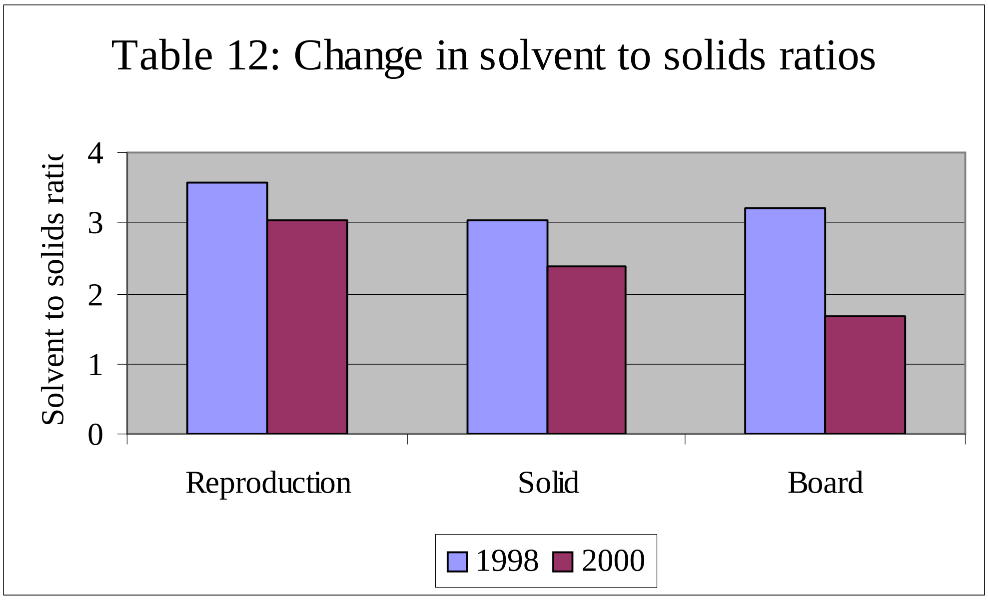
Table 11: Coating types



Most companies had switched from traditional pre-catalysed sealers and lacquers to acid-catalysed and water borne alternatives. However, the reproduction manufacturers were experiencing problems with this changeover – hence the fact that half of the companies retained at least some pre-catalysed coatings.

As might be expected, ultra-violet cured coatings were in greatest evidence with board material manufacturers. However, it was interesting to note that one solid timber manufacturer had recently installed a small line for flat panels which would previously have been coated by hand in three dimensional form.

The impact of these solvent reduction initiatives is shown in table 12. All three sub-sectors were starting from a similar point in 1998 – having average solvent to solids ratios ranging from 3.04 to 3.58:1. Over the course of two years, those using board materials progressed the most with a 48% drop in relative solvent use. Reproduction manufacturers made the least progress with a 15% improvement.



Between 1998 and 2000, the 41 companies had reduced their solvent consumption from 1,475 to 870 tonnes - a saving of 41% or 605 tonnes p.a.. During this period, solids use decreased by just 8% from 468 to 430 tonnes. The relative stability of this solids figure shows that the solvent reduction was due to proactive management rather than a simple decrease in production levels.

The greatest percentage reduction (47%) was achieved by the small solvent users rather than the larger companies (39%). This may appear surprising, but can be explained by the actions of a few companies, classed as large in 1998, that have made significant solvent savings – thus bringing them below the 15 tonnes threshold.

Average solvent content of the coating applied by participating companies ranged from 14% to 69% with an overall average of 53%. Admittedly, companies that participated in this project are likely to be some of the most proactive of authorised companies – hence their willingness to discuss their coating operations. However, it would not be unreasonable to assume a sector wide average solvent content for coatings of 60% in the year 2000.

It is likely that between 20 and 25 million litres of coatings were supplied in the year 2000. The average of 22.5 million litres equates with 13.5 million litres of solvent which would weigh 11,500 tonnes (assuming specific gravity of 0.85).

Discountable solvent can be removed from this total as it does not contribute to sectoral VOC emissions. The following section of this report estimates that the sector produces around 1,000 tonnes of discountable solvent p.a. – suggesting that sectoral VOC emissions were around 10,500 tonnes in the year 2000.

4.9 Generation of solvent waste

Audited companies consigned 136,400 litres of solvent waste off-site each year – which roughly equates with 98.5 tonnes of solvent (see “discountable solvent” explanation). A further 36,600 litres of thinners (26.4 tonnes of solvent) were recycled on site.

The vast majority of this material should have been cleaning thinners which were too dirty for further use. However, the combined volume of thinners reported as being purchased for cleaning was only 116,000 litres – leaving a shortfall of 20,000 litres on the amount needed to replace solvent sent off-site.

In reality, this shortfall would be higher as the 136,400 litres represents the amount remaining after use. Around 25% to 50% of the solvent might be expected to evaporate during the cleaning process.

It is likely that the volume of waste solvent being sent off-site was boosted by the inclusion of obsolete stock and two-pack coatings which had exceeded their pot-life. Some thinners intended for thinning may also have been used as cleaning solvent. In addition, some sites using automated machinery incorporating water back booths, had been mixing the effluent with their solvent waste streams.

The latter is an important point for those that were discounting solvent waste from their purchases as they should have been claiming a much lower percentage of solvent per litre.

Discountable solvent
Solvent becomes "discountable" when it is sent off-site for reuse or recovery for reuse. If a company sends waste thinners for recovery, the processor should be asked for an analysis of the average solvent content and records of volumes should always be retained under the Special Waste Regulations.   A company sending 10,000 litres off-site p.a. might expect an average solvent content of 85% - i.e. 8,500 litres of pure solvent waste. To convert this to tonnes of VOC, the volume must be multiplied by the specific gravity – typically 850g/l VOC. Thus the 10,000 litres would contain 7.2 tonnes of discountable solvent.   This discountable solvent may prove critical for those pursuing the mass balance approach to compliance.

The cost of solvent waste disposal averaged 28p per litre, though this varied greatly from 10p to 67p per litre. Some, but by no means all, of this difference can be explained by the volumes involved – suggesting that manufacturers should shop-around for quotations.

A small solvent recovery machine

20% of sites had a solvent recovery machine. These recovered 36,600 litres per year, leading to savings on virgin thinner purchases of around £47,580 (36,600 litres x £1.30) and £10,248 (36,600 litres x 28p) on disposal costs. Most companies were using recovery machines with a 25 litre capacity. Average cost was around £4500 with payback periods typically one year or less.

4.10 Empty tins

Virtually all coatings were supplied in 25 litre tins. These were not designed for reuse and they were considered problematic by all furniture manufacturers.

21% of tins were sent for scrap – 8% direct and 13% through the supplier. The remaining 79% were sent to landfill, 90% as general waste and 10% as special.

Only 56% of companies used can crushers – resulting in the transport of many tins with 25 litres of air inside.

As noted previously, the wood coatings industry consumes around £50 million worth of product every year. Average coating costs are around £2.50 per litre – meaning that 20 million litres are delivered p.a.. Over 99% of product is contained in 25 litre tins – suggesting that around 800,000 metal tins are used each year. With an average weight of 1300 grammes per tin, the sector will send 1,000 tonnes of metal off-site – with 800 tonnes going to landfill.

With furniture sites typically being charged £2 per tin, research into reusable containers could significantly improve the environmental and economic performance of both coating users and suppliers.

Scrap tins are an expensive problems for UK wood coaters

4.11 Extrapolation of project results

The figures for 1998 solvent consumption suggest that the companies participating in this survey account for around 10% of the UK's wood coating solvent use. This was reinforced by their coating spend in the year 2000, which accounted for around 9.2% of the sector's total.

If these companies do represent around 10% of total wood coating use, some interesting figures can be extrapolated from the results:

Solvent inputs

- On average, a turnover of £10 million equates with 17 tonnes of solvent use, £20 million with 22 tonnes and £30 million with 30 tonnes.
- Solvent consumption will typically be accounted for by stain (14%), sealer (27%), lacquer (32%), cleaning thinners (13%), thinning thinners (6%) and other uses (7%).
- Sectoral solvent emissions were probably around 10,500 tonnes in the year 2000

Empty coating tins

- The industry uses 800,000 tins per year generating 1,000 tonnes of metal - 800 tonnes of which goes to landfill.
- If furniture manufacturers are charged £2 per tin – this represents a cost of £1.6 million each year. Further costs are incurred through tin disposal
- 56% of tins (c.450,000) are sent off-site without crushing. These will contain 25 litres of air each, leading to 11,250m^3 of wasted space in skips. If a 10m^3 skip costs £80 per lift, this represents £90,000 of wasted expenditure on air each year.

Solvent waste

- Around 1.36 million litres of solvent waste are consigned off-site each year – representing 983 tonnes of potentially discountable solvent
- Around 366,000 litres recovered on-site – some 264 tonnes of solvent

Reproduction manufacturers are struggling to reduce solvent consumption

5 Benchmarks of solvent use

5.1 Introduction

There was a large variation in the degree of solvent reduction achieved by different wood coating users. Part of this variance can be explained by the nature of the relevant sub-sectors. However, there were also notable differences in performance between companies manufacturing similar products.

This chapter identifies benchmarks of solvent use – showing just what has been achieved by the best performers in the three sub-sectors. Wood coatings users are encouraged to compare their own performance with that of the best performer in their sub-sector in order to identify areas with improvement potential. Best practice information is provided to help companies address any performance gaps.

5.2 Solvent to solids ratio

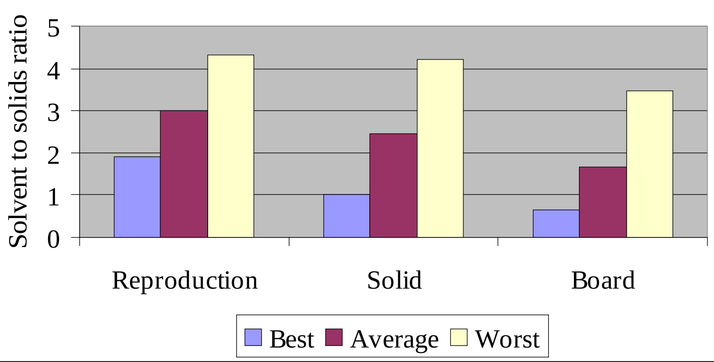
One of the most useful performance indicators is the ratio of solvent to solids. Wood coating operations are designed to transfer solids onto timber. The amount of solids required over a given period will reflect the level of production: the greater the throughput of work the larger the total of solids.

Each tonne of solids requires an amount of solvent to achieve this transfer. Therefore, the ratio of solvent to solids is one measure that is already adjusted to take account of variations in production levels.

Some 71% of small companies had a solvent to solids ratio above 1.6:1 and sizeable performance gaps existed between the best and worst performers in all sub-sectors.

With regard to small companies, ratios ranged from 1.9 to 4.33:1 in reproduction companies to 0.65 to 3.48:1 in board material.

Table 13: Small solvent users: solvent to solids ratios

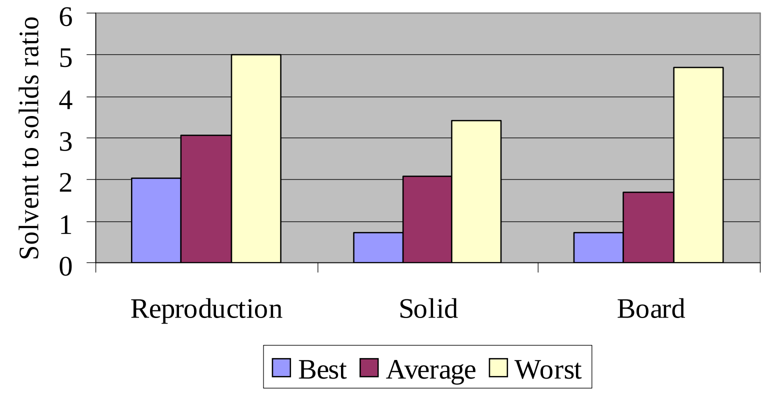


A similar spread of performance was evident with the larger solvent users a range from 0.72 to 5:1. Reproduction manufacturers were again achieving the least progress.

However, it should be noted that the worst performing reproduction manufacturer had invested significant amounts of time and effort in solvent reduction. All unnecessary solvent use had been eliminated, but the company was unable to switch to lower solvent coatings without compromising product quality. As with many in this sub-sector, the key to the product is quality and the continuation of existing product appearance. Departure from this formula would lead to closure.

The worst performing board user had potential to secure solvent reduction through the management of thinners. 40% of its solvent use resulted from the cleaning operations due to the use of acid-catalysed coatings in an automated application equipment.

Table 14: Large solvent users: solvent to solids ratio



5.3 Solvent waste

A wide variety of practices were observed with regard to solvent waste. Fortunately, no sites were pursuing a working practice that was used prior to the EPA – whereby spray lines were flushed through with solvent which was sprayed into the back of the booth.

However, some sites still disposed of their waste solvent into water back booth effluent. This increased the toxicity and disposal cost, as well as foregoing any chance for recovery &/or discounting.

The best performing sites had studied the cleaning operations of their various sprayers and condensed the best practice into a work instruction. This outlined variables such as the frequency of cleaning, amount of solvent to be used, potential for solvent reuse, methods to secure solvent capture and correct solvent waste storage practices.

These companies were typically using cleaning thinners at least twice. Spray lines were flushed through with “dirty” thinners by way of pre-wash – and then rinsed with clean thinners. The latter were retained for use as the pre-wash on the next occasion etc.

Spray guns were emptied into a screw-top 25 litre tin during the cleaning process. These were lidded, labelled and then stored in designated areas for the next cleaning operation. Thinners that were too dirty for reuse were either passed through an on-site solvent recovery machine or collected in 205 litre drums for off-site recovery.

It should be noted that these drums should be lidded after each batch of solvent has been added – rather than leaving a funnel in the opening for days on end. The latter practice leads to the evaporation of solvent, thereby reducing the amount that can be discounted. It also poses a risk to water resources in the event of a spillage.

Companies generating >1,000 litres of solvent waste each year should consider the use of on-site solvent recovery. At an average disposal cost of 28p per litre, coupled with a thinner purchase price of £1.30 per litre, a company generating 1,000 litres of solvent waste would save around £1,500 pa. – giving a payback period of around 3 years.

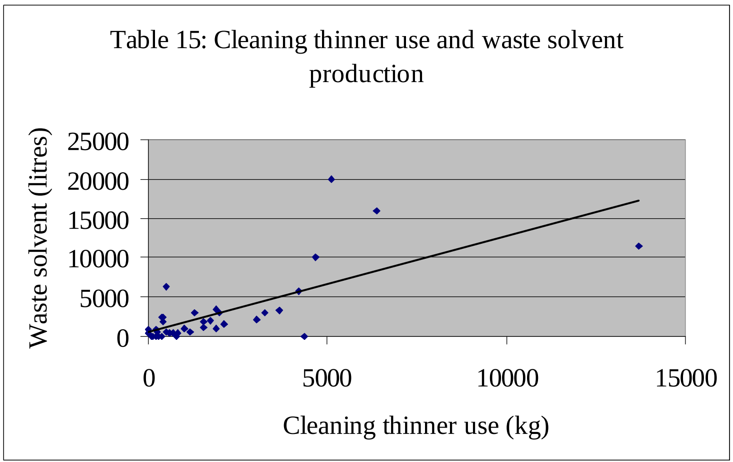


Table 15 plots an average rate of solvent waste generation relative to cleaning thinner use. The companies located significantly above the trend line were all producing significantly more solvent waste than the amount of cleaning thinners they were purchasing. This suggests that their waste streams also included obsolete coatings and two-pack coatings which had exceeded their shelf-life. Some site using automated machinery incorporating water back booths, had also been mixing the effluent with their solvent waste streams.

Companies located below the trend-line should investigate their rate of waste capture to ensure that solvent is not being allowed to evaporate unnecessarily.

5.4 Reproduction sub-sector practices

The high quality reproduction manufacturers had an average solvent to solids ratio of 3.58:1 in 1998 which dropped to 3.03:1 in the year 2000. None of the larger users had achieved their mass balance compliance target.

The vast majority of solvent reduction was accounted for by measures other than coating reformulation. Thinner reduction was a typical area of concentration, with all companies adopting the following measures:

- Insisting that lids were placed on all solvent borne containers. This was particularly important in hand finishing areas, where a multitude of stipple, pullover and stain tins were often in use. Frequent checks were also needed to ensure that lids were placed on pots of cleaning thinners containing guns and nozzles.
- Implementing cleaning procedures to specify the frequency of cleaning and the volume of thinners to be used per process, with thinner recapture, reuse and recycling.
- Reduction of thinning solvent. A given quantity of thinners were added to coatings by some sprayers largely out of habit. Only the highest solids coatings

should have issues associated with viscosity and these can be addressed through the use of in-line heaters.

The best performing companies made ongoing efforts to optimise the transfer efficiency of spray guns. If left to their own devices, some operators had a tendency to increase air and fluid pressures. Therefore, weekly checks were performed to ensure that pressures were in line with the company's operating procedures.

Other elements of good practice included:

- Two companies were using microlysed brown umber to make their stipple. This was a finer flour-type powder, which mixed more completely and did not settle. Less powder was required for each mix and the end product had a better consistency with the generation of less waste at the bottom of the pot.
- Introduction of a slightly distressed range – allowing slight surface blemishes to be passed-off as intentional.

All reproduction companies were struggling to implement low solvent coatings. The main issue was the need to maintain traditional product appearance, especially where customers were buying furniture to add to an existing collection. Problems were compounded by the complexity of the process in terms of the number of layers – where the alteration of one coating impacted upon the performance of the one above and below.

Some progress had been made with regard to a change from solvent borne to water borne stains – especially on lighter colours. However, problems were experienced in a number of areas:

- Real-wood veneers experienced problems where the glue of the veneer joint repelled water borne stains leading to lighter stripes on the surface.
- Carvings tended to accumulate water borne stains which would dribble out at a later time – leading to streaks. Such problems were not experienced with solvent stain which evaporated.
- Dark colours had a greater tendency to have a milky appearance.

Three companies had changed certain lines to water borne sealers. However, little progress had been made on the following:

- Colour coat: water borne alternatives were struggling to provide the light dusting of colour required
- Stipple: no water borne alternatives
- Lacquer: companies requiring a hand-finished look require the top coat of lacquer to remain relatively "soft" so that it can react with pullover to produce the desired appearance. Low solvent coatings such as acid-catalysed and water borne lacquers set too hard in a short period.

Greatest progress was made on new lines that were being introduced. These allowed the designers to work around the finish achievable using low solvent coatings.

Solvent stains lead to a positive grain strike on solid oak – i.e. a dark colouration. The same is not true for water borne versions.

It was interesting to note that customer education may have a part to play in facilitating the change to low solvent coatings. With high quality furniture, there is often a tendency to assume that the traditional method is the best. Consequently, some companies were very reluctant to admit that any change was taking place as customers might perceive the use of water based coatings as "cutting corners" or using inferior materials.

Therefore, it might be worthwhile providing literature to customers to show the efforts that have been put into researching and trialling low solvent coatings without compromising the appearance, durability or quality of the product. The environmental benefits of solvent reduction should also be made clear.

5.5 Solid timber sub-sector practices

Between 1998 and 2000, the solid timber manufacturers had progressed their solvent to solids ratio from 3.04 to 2.39:1. Only 25% of large sites had achieved compliance.

A number of manufacturers had made step-changes in their coating methods – with complete overhauls of their systems. The biggest change involved a company that reduced its solvent use from 29 to 8 tonnes per year – improving its ratio from 5.7 : 1 to 1 : 1. The capital cost of £455,000 was recouped through savings of £180,000 pa – derived from savings on labour (£120,000) and a reduction in material use (£60,000). Changes included:

- Switch from solvent to water borne stain
- Use of conveyors to carry furniture through the coating process. Sprayers had previously spent 40% of their time spraying – with the remainder being taken up by moving furniture to and from the booth. Conveyors allowed the company to change from nine booths and sprayers to three.
- Removal of the colour coating operation through the optimisation of staining.
- Increase in the solids level of sealer and lacquer – with the installation of a drying tunnel.
- Monitoring exercises to ensure optimum transfer efficiencies of spray guns.

Other examples of good practice within the sub-sector included:

- Manufacturer using robotic electrostatic spraying on chairs.

- The vast majority of coating has traditionally occurred on three dimensional shapes. A number of companies had been experimenting with their manufacturing process to allow the automated coating of flat panels prior to assembly. This allowed the use of roller coaters with acrylic based ultra-violet cured coatings, or the automated spraying of water borne or water borne UV. Benefits typically included much swifter coating, with lower labour costs and accelerated drying times.

5.6 Board material sub-sector practices

These companies had made the greatest solvent reduction progress with a change of solvent to solids ratios between 1998 and 2000 from 3.20 to 1.68:1. Some 50% of the large sites had achieved mass balance compliance.

As mentioned previously, 61% of companies had invested in automated application equipment. Those companies with the best ratios typically had at least a proportion of production passing through UV coating equipment. These were also the organisations making the biggest annual financial savings – in large part due to the reduced labour intensity of the process.

One problem identified by the audits was the spraying of acid-catalysed coatings through automated machinery. Where spraying occurred above a transport belt, a trough of solvent was typically used for belt cleaning – leading to high fugitive emissions. Cleaning thinners accounted for 39% and 34% of solvent use in two such companies.

Others overcame this problem by using two belts with a gap in between. Spraying occurred over this void, with the components supported by the belts at either end. A container was typically located within the void to catch the over-spray. Obviously, this was only possible with components of adequate length.

A lower technology solution was demonstrated by a company whose conveyor consisted of metal bars. Over-spray was allowed to accumulate for several months before the belt was dismantled and the coating was chipped off.

Those using water borne and ultra-violet cured coatings had no such problems. Over-spray from these materials was typically collected and reused.

6 Conclusions

This study has generated some very useful information on sectoral solvent use. It suggests that the sector purchases around 11,500 tonnes of solvent p.a. with 1,000 tonnes of this being sent off-site as solvent waste for recovery.

With regard to the 41 companies that participated in this study which participated in this study, a good degree of solvent reduction had been achieved. Their consumption fell by 41% or 605 tonnes p.a. between 1998 and 2000.

Significant expenditure was required to achieve this progress – totalling £7.63 million over five years. However, much of this sum was recouped by the £7.30 million savings that accrued over the five year period.

This picture changes when the facts are considered on a sub-sectoral basis. The reproduction manufacturers have been able to make the least progress and they have incurred a significant cost in the process. Between 1998 and 2000, the average solvent to solids ratio improved from 3.58 to 3.03:1 and these manufacturers incurred an average cost of £231,000 from 1995 to 2000.

None of the large reproduction manufacturers had been able to achieve compliance, having generally reached a plateau of between two and five times the mass balance allowance.

By contrast, the board sub-sector has progressed its solvent to solids ratio from 3.20 to 1.68:1 between 1998 and 2000, whilst making an average saving of £87,000 between 1995 and 2000. This had enabled 50% of large sites to achieve compliance.

These findings demonstrate the overly simplistic approach of the wood coating guidance note – trying to set the same target for processes which have little in common.

A much more logical approach would be to recognise the differences in the nature of the processes and have different sets of ratios to reflect the levels of solvent reduction that are actually achievable.

It is also worth noting that there is little if any scientific justification for the 1:1 and 1.6:1 ratios. These were arrived at by European officials considering a wide range of industrial sectors, rather than anyone with a knowledge of the furniture sector. This would help to explain why only 29% of large solvent users had achieved compliance.

Appendix 1 Requirements of the wood coatings process guidance note PG6/33

The revision of process guidance notes should occur every 4 years. The revision of the current version - PG6/33(97) – should be concluded in 2002. A summary of the 1997 guidance note is provided below. Whilst major changes are not expected in the revision process, companies should check that the requirements are still correct. Information can be obtained from BFM on 0207 724 0851.

The controls in PG6/33(97) can be split into two; "final compliance options" and "other clauses."

Final compliance options

All authorised solvent users must choose one final compliance option. This should have been in place by April 1999 for sites using >15 tonnes of solvent, whilst 5 to 15 tonnes users have until 2007. The options are:

- Compliant coatings – all coatings must have a solvent content not more than that specified in Clause 20, e.g. 435 g/l VOC for clear coatings applied by spray, roller or dipping techniques.
- Abatement technology to reduce VOC emission levels below 50 mg/m^3 (>15 tonnes) or to below 150 mg/m^3 (5 to 15 tonnes). Larger users could only meet such limits via unrealistically expensive "bolt on" abatement plant.
- Mass balance approach - sites must achieve a "target emission" related to the solids content of coatings:
    - 5 to 15 tonnes users can apply up to 1.6 times as much solvent as solids, i.e. 1.6:1 and they are allowed until 2007 to achieve such a ratio or better
    - 15 tonnes and upwards users can apply the same amount of solvent as solids, i.e. 1:1 - to be achieved by April 1999.

The mass balance is the approach that the majority of sites favour due to its relative flexibility and cost effectiveness. It allows the use of low solvent coatings where they are practical with the retention of solvent borne coats where essential.

Other clauses

Authorised processes must ensure that all other clauses of the guidance note were complied with by April 1999 - regardless of the size of site. Such clauses include:

- 24: Solvent inventory - records should be kept of the amount of solvent used.
- 45: Spray efficiency – use of high efficiency application systems such as high volume low pressure (<10 psi atomisation pressure) or airless air assisted.
- 47-52: Cleaning operations must be reviewed, with the use of water where possible.
- 68-72: General operational requirements relating to the need for maintenance, training and good housekeeping.

Appendix 2: Solvent reduction checklist

Design

- ☐ Are the design and sales teams aware of solvent reduction pressures?

Management

- ☐ Maintain a solvent inventory
- ☐ Chart the consumption of specific areas of operation, e.g. cleaning solvent use
- ☐ Compare the solvent use of specific lines and operators

Housekeeping

- ☐ Ensure lids are on all tins

Thinners

- ☐ Consider in-line heaters to overcome viscosity problems
- ☐ Implement cleaning procedures to minimise thinner use and maximise its reuse and recycling.

Spraying

- ☐ Remove conventional guns and ensure high transfer efficiency equipment is used
- ☐ Establish correct air and fluid pressures
- ☐ Conduct regular monitoring of actual pressures
- ☐ Ensure operators are trained on the optimum use of guns

Production issues

- ☐ Can 3-dimensional items be coated in the flat - is there scope for automated application?
- ☐ How much time do operators spend moving furniture - is there scope for an automated conveyor?
- ☐ Is it possible to switch to 205 litre containers for key coatings?
- ☐ If drying tunnels are needed, can they be fed from a wood burning boiler?

Solvent waste

- ☐ Are operators aware of the need to collect waste solvents?
- ☐ Are solvent wastes stored securely?
- ☐ Calculate the pay-back for on-site solvent recovery

References and further reading

- British Coatings Federation (2000) personal communication
- Department of the Environment (1993) Reducing emissions of VOCs and levels of ground level ozone: a UK strategy – HMSO
- DETR (1997) PG6/33(97) Wood coating processes - the wood coating process guidance note forms the basis of the legal controls applicable to sites using >5 tonnes of solvent in any 12 month period. NB it should be revised in 2001 and republished in 2002.
- DETR (2000) AQ1(00) Categories of process regulated by different local authorities
- Department of Trade and Industry (1996) Cost and Benefits of the Reduction of VOC Emissions - Annex on costs of control options for industry sectors. ERM and Chem-Systems
- Envirowise (1998) Solvent use in wooden furniture coating (EG130) - focuses on the importance of improving transfer efficiencies through the optimising of spraying techniques and technology.
- Envirowise (1999) Reducing solvent use in the furniture industry (GG177) – provides practical advice on a wide range of solvent reduction techniques. 5 case studies are included which saved 35 tonnes of solvent and £48,000 p.a.

BFM Ltd environmental management services

BFM Ltd is the trade association of the furniture manufacturing sector representing around 350 member companies involved in a range of furniture manufacturing sub-sectors such as domestic, contract, cabinet and upholstery.

For the past seven years the organisation has provided a variety of sector specific environmental management services for its member companies, including:

- Advice line – free advice on any environmental issues
- Update – monthly summary of environmental developments relevant to the sector
- Seminars and guidance notes – detailed information on key issues
- Policy level representation – ensuring that member views are voiced with regard to the development and review of environmental legislation.

For further information contact:

BFM Ltd

30 Harcourt Street, London W1H 2AA

Tel: 0207 724 0851 Fax: 0207 706 1924 www.bfm.org.uk

Biffaward Programme on Sustainable Resource Use

Background

Information about material resource flows through the UK economy is of fundamental importance to the cost effective management of the flows, especially at the stage when the resources become "waste". However, at present information is not adequate in terms of quality and quantity. This is the cause of considerable concern, given that the UK Government is finding it very difficult to meet even relatively unchallenging targets of waste reduction and resource recycling and businesses are faced with increasing costs of waste disposal.

In order to maximise the projects' full potential, data will be generated and classified in ways that are consistent both with each other and with the methodologies of other generators of resource flow / waste management data, e.g. the Environment Agency, Department for Environment, Food and Regional Affairs and the Office for National Statistics.

This entails the careful co-ordination of the projects and information sharing and mutual awareness between them. In addition to the projects having their own means of dissemination to their own constituencies, their data and information will be gathered together in a common format to facilitate policy making at corporate, regional and national levels.

Objectives

To provide accessible, well researched information about the flows of different resources through the UK economy. Based either singly or on a combination of regions, material streams or industry sectors.

Further information

For further information on this project or additional copies of this report, please contact Alistair Bromhead, Environmental Consultant at:
alistair@abromhead.freeserve.co.uk

Tel: 07932 674707

Fax: 0207 706 1924

Sponsor information

This project has been funded by Biffaward, a multi-million environmental fund which uses landfill tax credits donated by Biffa Waste Services.

Granyte Woodfinishes is a supplier of a range of wood coatings to the furniture sector

Viatec is a supplier of solvent recovery machinery, water evaporators and molecular dissectors.

BEVAN FUNNELL LIMITED

Bevan Funnell Ltd is a manufacturer of high quality English reproduction furniture, selling to customers around the world

William Bartlett and Son Ltd is a High Wycombe based company, established in 1864, manufacturing quality domestic furniture

Wood Bros (Furniture) Ltd is a manufacturer of high quality oak furniture

The money for this project has been contributed through the Landfill Tax Credit Scheme which is regulated by ENTRUST.