Guidance on VOC Substitution and Reduction for Activities Covered by the VOC Solvents Emissions Directive (Directive 1999/13/EC)

Guidance 10:

Coating of wooden surfaces

European Commission - DG Environment

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Content

1 Introduction

This guidance addresses coating of wooden surfaces, presenting options to substitute or reduce the use of VOC and its resulting emissions.

Table 1: Scope definition of the VOC Solvent Emissions Directive (SE Directive)

SE Directive – Scope definitions (Annex I)
The activity 'Coating of wooden surfaces' is defined as 'any activity in which a single or multiple application of a continuous film of a coating is applied to wooden surfaces'. The SE Directive covers installations in which this activity is taking place with an annual organic solvent consumption greater than 15 t

If the coating activity includes a step in which the same article is printed by whatever technique used, that printing step is considered part of the coating activity. However, printing activities operated as a separate activity are not included, but may be covered by the Directive if the printing activity falls within the scope thereof. This activity does not cover impregnation of wood (see guidance document 12).

The SE Directive lays down the following activity specific emission limit values for coating of wooden surfaces:

THE SE DIRECTIVE APPLIES TO COATING OF WOODEN SURFACES IF A SOLVENT CONSUMPTION OF 15 TONNES PER YEAR IS EXCEEDED

Table 2: Emission limit values of the SE Directive

Activity	Solvent consumption threshold [tonnes/year]	ELVs in waste gases [mg C/Nm³]	Fugitive emission values [% of solvent input]
Coating of wooden surfaces	15—25	100*	25
	> 25	50/75 **	20
Special provisions * Emission limit applies to coating application and drying processes operated under contained conditions. **The first value applies to drying processes, the second to coating application processes			

Instead of complying with the above ELVs, operators may choose to use a reduction scheme, following the specifications of Annex II (B) of the SE Directive.

Specific requirements apply for VOCs classified as CMR substances[1] as well as for halogenated VOCs that are assigned the risk phrases R40 or R68[2]. There is a general obligation to replace CMR substances– as far as possible – by less harmful substances or preparations within the shortest possible time. In the case of a mass flow ≥10 g/h for VOC classified as CMR substances or ≥100 g/h for halogenated[3] VOC with R40 the ELVs in waste gases are 2 and 20 mg/Nm³ respectively, and these also apply when a reduction scheme is being used.

National legislation may define lower thresholds for solvent consumption, stricter ELVs or additional requirements.

2 Summary of VOC substitution/reduction

The most important sources of solvent related VOC emissions depend on the process and products used and the subsequent drying process of the coated workpiece.

VOC REDUCTION CAN BE ACHIEVED MAINLY BY LOW VOC PAINTS, INCREASED PAINTING EFFICIENCY AND ABATEMENT TECHNOLOGY

Techniques to reduce or substitute VOC are:

- Use of low-VOC paints
- Improved painting efficiency in the coating process
- Use of abatement technology (especially thermal oxidation)

Other reduction options (e.g. powder coating) have a limited applicability in specific areas.

The operator, as part of implementing an effective VOC reduction strategy based on substitution (low VOC paints), must also optimise equipment performance and any influential non-painting process steps (such as surface preparation by grinding and wood drying) that influence the painting.

To optimise the coating process (and minimise emissions) all involved process-steps and the properties of wood have to fit together. Changes in the coating process (e.g. usage of water-borne paints) leads usually to changes in the application technology, grinding technology, different air filters etc.

1 CMR substances – carcinogenic (R45, R49), mutagenic (R46), or toxic to reproduction (R60, R61)
2 After the implementation of the SE Directive a revision of the R-phrase R40 took place. The original wording of R40 was: 'Possible risk of irreversible effects'. The new wording is: 'Limited evidence of a carcinogenic effect'. In the 'old' version mutagenity (cat 3) was included. This mutagenic effect is now covered separately under R68: 'Possible risk of irreversible effects'. This new risk phrase does not include carcinogenicity. The 'new' version of R40 is obviously less restrictive than the old version. Until the SE Directive is adapted to this change, a final decision on which version applies can only be given by the European Court
3 Halogenated organic solvents are hydrocarbons with one or more of the following halogens: fluorine, chlorine (e.g. trichloroethylene), bromine (e.g. n-propyl bromide) or iodine.

3 Description of the activity and related industry sectors

Wood coatings are an important sector within the coating industry. Wood coating activities include products for domestic and office furniture, window frames, doors, flooring, decking and other construction materials, fencing materials, toys, and components for vehicles etc. In general the basic reason for coating a wood substrate or object is to provide either an aesthetic or protective layer (or both).

Coatings can protect wood against damage by UV radiation, dampness and excessive temperature variations, as well as providing resistance to chemical attack and mechanical abrasion.

There is considerable variation in the properties of wooden substrates that require coating, since these encompass a wide variety of natural wood, as well as products made from wood particles (chipboards, oriented strand board, and fibreboards).

There are many different products produced where the coating of wooden surfaces is part of the production process. Therefore, only general statements can be made regarding VOC reduction options and site-specific factors need to be considered for each individual plant.

EU 15 Member States reported about 500 existing and 40 new installations in 2004, carrying out activities under the scope of activity 10 of Annex II A. [Implementation 2006].

4 Technical process description

4.1 Process flow and relevant associated VOC emissions

Pre-treatment, suitable for the type of wood and the coating process to be used, is an essential part of the finishing processes.

Wood coatings range widely in their VOC content and so emissions during coating can vary significantly. Water-borne products or VOC free products (e.g. powder coatings) as well as solvent-borne products are used. Individual sites (producing the same product) may use a combination of solvent free, low VOC, and solvent-based products.

Figure 1 gives an overview of typical process steps for the coating of wooden surfaces with related VOC emissions

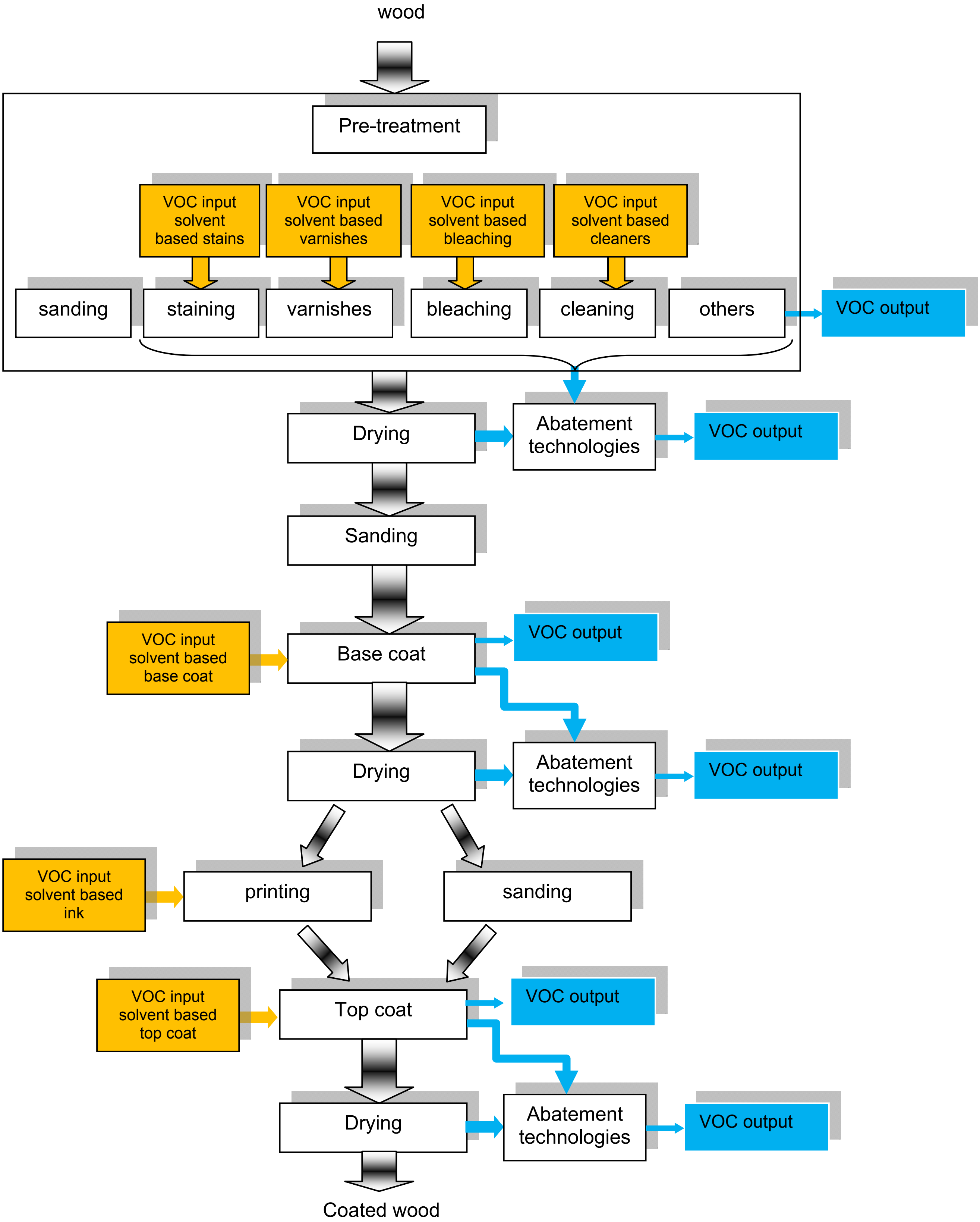

Figure 1: Main VOC input and output of coating processes of wooden surfaces

The major VOC emissions arise during the application and drying process of solvent-based coatings. Minor VOC emissions occur from mixing processes (for example of 2-component paints), cleaning of tools and equipment, storage of paints, wastes and other VOC-containing products used in the coating process but they can be minimised by 'good housekeeping practices' [BREF STS 2007, p 403 ff].

4.2 Application systems

The following systems are in use for the application of pre-treatments, base coats and topcoats [SE Directive 1999], [BREF STS 2007], [Twinning 2004]:

Table 3: Achievable application efficiency factors for different application systems

Application technique	Efficiency factor [%][4]	Remarks
Brush painting	95-100	Reduced uniformity of painted surface compared with other application techniques.
Spraying, conventional (High pressure compressed air)	30-60	High volume of overspray depending on geometry of painted workpiece. For most applications, efficiency is in the range of 30–45%.
Spraying HVLP (High Volume, Low Pressure)	40-75	Application of low viscosity wood stains, increasing use also for other paint systems.
Hot spraying	40-60	Application of paints with a high solid content, also applicable for hot wax spraying
Airless spray application	40-75	Bundling of spray-beam, therefore higher efficiency compared to conventional spraying
Air assisted airless technique	35-50	Bundling of spray-beam, therefore higher efficiency compared to conventional spraying
Spraying, electrostatically assisted wet lacquer	50-70	Electrical conductivity is required (minimum dampness of 8% or a conductive primer needed), can be used with any of the spraying techniques mentioned above.
Spraying, electrostatically assisted powder	80-95	Electrical conductivity required, Currently, only applicable for the coating of MDF[5] (only a few applications)
Curtain coating	95	Limited by workpiece's geometry
Rolling, flooding	95	Limited by workpiece's geometry; Reduced uniformity of painted surface (rolling)
Vacumat technique	95	Only applicable for narrow parts and edges, water-based paints and UV cured materials with a high solids content, also the workpiece's geometry has to be considered
Dipping/flooding	95-100	Limited by workpiece's geometry

4 Based on applicable paint input in process, not on solid paint on surface
5 Medium density fibreboard

4.3 Coatings

4.3.1 Pre-treatment

Pre – treatment is either done to improve the appearance of the wood or to prepare it for painting. The following products are in use for the pre-treatment of wooden surfaces:

- Stains and varnishes: For some applications this is the only coating step. These coatings fulfil protective (weather resistance) and aesthetic (colour) functions. Stains and varnishes can be divided into film producing (> 5µm) and non-film producing (< 5µm) products. Penetration below the surface of the wood is an important feature of these coatings.
- Bleaching: in general (waterborne) inorganic chemicals are used.
- Cleaning: Solvents are required to remove resin–residues. Water-based cleaning is seldom used because it would raise the water content of the wood and, for most applications, this should be below 10%.

Typical VOC contents of pre-treatment products are shown in the table below:

Table 4: Typical VOC contents of pre-treatment materials (source: [Twinning 2004] and own research)

Type	Remarks/ Main content	% VOC
Varnishes, stains Alkyd resin solvent based	Mainly transparent coatings to enhance wood properties	Up to 70%
Varnishes, stains Alkyd resin waterborne	Usability depending on kind of wood. Some (e.g. oak) tend to swell and/or to produce upright fibres more than others and this can prevent the use of waterborne glazes and stains	Up to 10%

6.1.2 Base coat & Topcoat

According to [SE Directive 1999]. [BREF STS 2007], [Twinning 2004] the following paints are used for coating of wooden surfaces:

Table 5: Typical VOC contents of paints

Type	% VOC	Type
Nitro cellulose paint (NC)	70 - 75	Solvent based
Acid curing paints	1C: 65–75 2C: 30 - 60	Solvent based
Polyurethane paints	pigmented: 35 – 60 clear coat: 65 – 70	Solvent based
Unsaturated polyester paints (UP)	12 - 15	Solvent based
Acrylic paints solvent based **conventional** **UV-curing**	65 – 75 up to 40	Solvent based
Acrylic paints water based	2 - 10	Water based
Powder coating	0	Solvent free
100% UV paints	0	Solvent free

5 Solvent use, emissions and environmental impact

5.1 Solvents used

The following VOC relevant products (containing organic solvents as defined in the SE Directive) are currently used for the coating of wooden surfaces:

- Pre-treatment agents
- Paints
- Inks

A wide range of different solvents is used in these products. Typical examples are white spirit, ethyl acetate, and xylene.

Solvent consumption and emission levels

Table 6: Typical solvent consumption for selected applied technology [BREF STS 2007 p. 360]

Application	VOC-emissions [g/m²]
High-pressure ('conventional') spraying using paint containing 65% solvents	80 – 100
High-efficient coating technology (e.g. rolling, flooding, electrostatic-airless spraying) using paint containing 65% solvents	40 – 60
High-efficient coating technology (e.g. rolling, flooding, electrostatic-airless spraying) using paint containing 20% solvents	10 – 20
High-efficient coating technology (e.g. rolling, flooding, electrostatic-airless spraying) using paint containing 5% solvents	2 – 5

Table 6 gives some approximate solvent consumption figures for a range of paint types and application methods. Because of the huge variety of objects painted, and the differing reasons for doing the coating, the stated ranges may not cover all existing processes.

Approximately 15% of industrial paints used in Germany in 2000 were used for coating wooden surfaces (this figure excludes industrial use of decorative paints) [Markt 99]. Austrian figures for 2006 and 2007[6] indicate a similar picture. The total volume of paints used for coating wooden surfaces in the EU-27 is estimated at approximately 400 kt.

Most companies using solvent-based paints use more than 15 t of solvents per year (SE Directive threshold). Approximately 480 installations that carried out coating of wood in EU 15 [Implementation 2006] were registered and authorised under the Directive in the period from 1999 – 2003.]. The total number of existing installations is unknown and would be difficult to estimate because some coating of wooden surfaces may be carried out as a part of many, various, industrial processes.

Fugitive emissions are significant in many plants using solvent-borne coatings, particularly if stack emissions are already treated with abatement systems. In these cases, fugitive emissions will constitute the bulk (90-95%) of emissions - based on (unpublished) solvent balances prepared by Bipro.

5.2 Key environmental and health issues

Process emissions of solvents, together with NOx emissions, are precursors of ground level ozone formation in the presence of sunlight. Existing occupational workplace limits should be taken into consideration.
Emissions of VOC to air may occur from:

6 Source: statistics of the industrial association of paint producers, not published.

- the storage of the solvents
- the coating processes
- drying processes

Contaminated water, produced by separating overspray from the waste air in a certain type of application cabinets, should be disposed as hazardous waste.

Spills and leaks from storage areas may result in emissions to soil and groundwater.

The process generates waste containing solvents which need to be disposed in a way that emissions to air, soil and groundwater are prevented or limited.

6 VOC Substitution

The following chapter describes potential substitutes for VOC (using low-VOC and VOC-free systems) and any associated application technologies and/or special conditions needed for their use, it also lists the advantages and disadvantages compared to systems that use solvents with a high VOC content.

6.1 VOC-free systems

This section describes the ways that VOC-free products or systems can be used to replace the organic solvents currently used.

6.1.2 Powder coatings

The usage of powder coatings for wooden surfaces at an industrial scale is limited to coating of MDF[7]. Research is ongoing but no example of coating for other wood types was found. The use of powder coatings requires investment in new application technology, and there are coating performance issues that may create barriers to the use of this technology.

6.2 VOC-reduced systems

If the complete substitution of organic solvents is impractical then changing to systems with a reduced VOC content, such as those described in this section, can decrease emissions.

VOC emissions from coating processes may be reduced by lowering the VOC content of paints, by increasing the efficiency of the coating process, or by a combination of these approaches. Low VOC systems are:

- Waterborne paints: 5 – 15% VOC
- High solids: 25 – 40 % VOC
- UV curing paints: 2 -5 % VOC

7 Medium Density Fibreboard

UV-curing coatings employ 'reactive solvents' that are chemically incorporated into the paint layer during the curing process. Completely VOC-free paints are rarely used for wood coating.

There are some obstacles to the use of all of these coating types:

a) Generic:

- Investment in different application technology - the coatings behave differently to solvent-borne coatings and this usually necessitates changes to application equipment.

- Changes to and/or investment in additional exhaust and drying technology - extraction and drying processes often have to be modified or replaced when using waterborne paints or high solids. In the case of UV-curing the drying process needs to be completely changed.

b) Specific:

- Potential adverse impacts on substrate properties (e.g. swelling of wood or production of upright fibres with water-borne coatings). These problems can sometimes be overcome by applying an initial coating using solvent-borne paints. The seriousness of the adverse impact of water-borne paints varies between different types of wood, and optimising any prior grinding stage can also reduce the impact.

- Corrosion of painting/drying equipment. Many parts of painting and drying equipment for solvent borne paints are made of carbon steel. Water-borne paints (in the presence of amines, which are often a component in such paints) cause increased corrosion of these parts.

7 Other VOC emission prevention measures and abatement techniques

Preventive measures, process improvements, and abatement techniques exist to reduce VOC emissions when the substitution of VOC, using the systems described in section 6, is not possible. The following measures are commonly applied for the coating of wooden surfaces:

7.1 Electrostatic coating

Electrostatic coating relies upon the use of conductivity of the paint and the object to be painted to increase the efficiency of painting. According to an IFF project [IFF Projekt Nr.: BW D 20007] the electrical resistance should be below $10^9\ \Omega$ on any area to be painted and the conductivity of the paint should be above 1 µS. Furthermore between grounding and the point of paint application, a wet film of paint is needed. Waterborne paints fulfil these criteria. Solvent-based paints can be modified (e.g. by using organic ammonia compounds).

With wooden substrates, there are a number of options for achieving the level

Of conductivity needed.

- Increasing moisture content to greater than 8% (however this is too high to be acceptable for many applications)
- Use of a conductive primer, applied using conventional spraying
- Use of conductive aggregates (like carbon black or ammonium phosphate) in the manufacture of the MDF.

Other approaches are under development but have not yet been used at industrial scale.

Electrostatic coating can be used with all available spraying techniques (e.g. compressed air, airless). Electrostatic coating using high-speed rotational bells is also possible and has been described in [IFF Projekt Nr.: BW D 20007]. An example of the use of this technology is described in section 9.1.

The maximum emission reduction which can be achieved by the implementation of electrostatic coating using water based paints compared to conventional coating (without end-of pipe treatment) can be estimated by the figures shown in table 6 (up to 98 g/m²).

In addition to the technical constraints mentioned previously, there are safety issues that must be resolved for each type of equipment (e.g. danger of electrical accidents for operator).

7.2 Improvement of waste air collection system

Leakage from waste air collection systems can lead to fugitive emissions of between 0.5 and 1.5% of the transported volume.

Therefore the installation of tightly fitting components and regular maintenance can lead to significant reduction of fugitive emissions.

7.3 Abatement technologies /End of pipe measures

Solvent and waterborne paints and other products for the coating of wooden surfaces contain a mixture of different solvents and therefore recovery and re-use of the solvents is not practical. This means that abatement based on recovery e.g. adsorption, condensation, is not economic compared with destruction techniques. However, adsorption can be used as a means for concentrating waste gas streams prior to destruction.

7.3.1 Waste air with high VOC concentration

The main abatement technologies for waste air with high[8] VOC concentrations are compared in the following table:

Table 7: Comparison of abatement technologies [BREF CWW 2003]

	Thermal oxidation[9]	Regenerative/ recuperative thermal oxidation	Catalytic thermal oxidation
Treatment temperature	800 – 1 000°C	800 – 1000°C	300 – 500°C
Typical air volume (Nm^3/h)	> 2 000 – 10 000	> 10 000 – 86 000	> 10 000 – 86 000
VOC concentration needed for auto - thermal operation	> $2g/m^3$	> $2g/m^3$	>$2g/m^3$
Max. VOC concentration	25 % LEL[10]	25 % LEL	25 % LEL
Natural gas volume needed for start up	3-5 kWh/ 1 000 Nm^3	5-8 kWh/ 1 000 Nm^3	1-2 kWh/ 1 000 Nm^3
Weight of equipment	> 5t	> 20 t	> 10 t
Limitations on waste gas composition	Not specific	Dust < 1 mg/m^3	Dust < 1 mg/m^3, no catalyst poison (e.g. organic S- or N-compounds.)
Typical clean gas specification (mg/m^3): **VOC** **NOx** **CO**	 < 20 < 100 < 100	 < 20 < 100 < 100	 < 20 < 50 < 50
Investment (€/1 000 m^3) based on max. size mentioned above	20 000	15 000	17 000

8 most of time above auto thermal threshold
9 non-regenerative/recuperative and non-catalytic
10 LEL = Lower Explosion Limit

Operational costs are highly dependent on the average concentration of VOC in the waste gas and the operation time of the plant (range from 1 shift 5 days per week to 24 hours per days 7 days a week) as well as on the type and cost of fuel needed for the operation – therefore typical costs are difficult to be determined.

With the above described technologies VOC reduction potentials > 99% are possible.

7.3.2 Waste air with medium to low VOC concentration

For large waste air volumes containing concentrations of less than 1 g/m³ absorption (using zeolite) can be used to concentrate the VOC. Continuous desorption is then used to generate a smaller and more concentrated, volume of (waste -) air and this air is then treated with one of the technologies mentioned in the previous section(most likely thermal oxidation). Investment costs are approximately € 20 000/1 000 m³.

7.4 Process improvements and operational measures

'Good housekeeping' can be used to minimise VOC-emissions from mixing processes (for example of 2-component paints), cleaning of tools and equipment, storage of paints, wastes and other VOC-containing products used in the coating process.

The VOC content of the air extracted from painting and drying operations may be a minor part of the total process arising; a significant proportion of the fugitive VOC emission arise from operations that are not directly involved with painting or drying, these include the waste air collection system (ventilators, flaps, folded spiral seam pipes and their connections etc.).

8 Summary of VOC emission reduction measures

The following table summarizes the VOC emission reduction measures discussed in chapters 6 and 7:

Table 8: Measures for VOC substitution and VOC reduction in coating of wooden surfaces

Objectives	Description
VOC-free Systems	Use of powder coating Use of VOC-free UV cured coatings
VOC-reduced Systems	Use of - UV-cured coatings (low VOC) - Waterborne coatings - High solids coatings (25 – 40% VOC)
Process Improvements	Improved painting efficiency (e.g. use of electrostatic painting) Optimisation of waste air collection system Good housekeeping (reduction of fugitive emissions)
Abatement Technologies	Absorption (to increasing VOC concentration in the waste air before thermal oxidation) Thermal oxidation (regenerative or recuperative) Catalytic oxidation

9 Good practice examples

9.1 Example 1: Replacing solvent-borne polyurethane paint by water-borne paint

The example shows the effects in term of VOC emissions reduction of replacing solvent-borne polyurethane paint by water-borne paint and introducing an electrostatic support to enable the automated painting of kitchen furniture (door fronts) with high quality requirements. All data are based on [IFF Project Nr. BW D 2007].

a) Technical data

Object being coated: Doors for kitchen furniture

Original process:

- First layer: basecoat 2-component polyurethane paint (airless automated equipment)
- Grinding
- Second layer: 2-component polyurethane texture finish (airless automated equipment).
- Third layer: 2-component polyurethane clear coat (airless automated equipment).

Modifications and results:

The second layer is replaced by the application of a water-borne textured finish, applied using high rotation bells. During testing, some minor modifications to the painting equipment were necessary:

- The carrying units (made of plastic) have to be replaced with metal parts
- paint used for the first layer was modified in order to achieve a conductivity of 10^9 Ω.

No changes were made regarding grinding. The solid content of the waterborne paint was 45%.

As an option (option 1) for further optimisation, the painted objects were wetted using a conductive waterborne solution before application of the second layer.

The key process parameters of the 3 process types are shown in Table 9:

Table 9: Example 1: Comparison of key figures before and after optimisation

Parameter	1) Original process	2) Waterborne paint	3) as 2) plus wetting (option 1)
Efficiency [%]	43 – 45	57 – 62	68 – 71
Paint consumption [g/ piece]	140 – 145	Appr. 83	Appr. 75
Paint on painted piece (solvent/water) [g/ piece]	Appr. 60	Appr. 51	Appr. 52
Paint on painted piece (solids) [g/ piece]	23 – 24	Appr. 24	Appr. 25
Emitted solvent [g/ piece]	70	4,3	3,8
Painting time [sec]	27	20	20

The results show that solvent emissions were substantially reduced by use of the waterborne coating, but that the dry film on painted pieces was essentially the same in all three cases.

Minor problems occurred and were solved during the test, none of them continued to be a problem. The availability of the equipment was > 97%. There was no need to change cleaning routines.

b) Economic data

Costs for the use of the waterborne coating as described above (without option 1) have been calculated as follows:

Investment: € 150 000 (2/3 on equipment, 1/3 on development, education of operators, and maintainance)

Savings:

1) Waste

The original process created waste (used paint) that represented a cost of € 117 per tonne. This number is based on an efficiency of 50% and a solid content of 50% plus 10% coagulation agent which equates to 0.28 t solid waste and a solid content of 60% of the waste).

Savings using waterborne paint as described above: 45% (€ 53/t)

2) Usage of paint

Increasing the efficiency (from 45% to 60%) leads to savings of 25% of the paint. Based on an average price of € 8/kg for both kinds of paints savings of appr. € 2 000 can be achieved.

Return on investment:
A reasonable volume of 75 tonnes of paints per year for a medium size plant

leads to a ROI of approximately 1 year.

c) VOC-reduction

The usage of 75 t of solvent borne paint (appr. 550 000 pieces painted) leads to emissions of ~ 37 500 kg VOC.

Painting the same number of pieces with waterborne paint reduces the VOC emissions down to 2 300 kg

9.2 Example 2: Substituting solvent based paints by water based paints

The second example describes the changes made in late 2007 in a company producing custom made furniture and the resulted reduction of VOC emissions by substituting solvent based paints by water based ones. All data provided by the company are based on the results of the first 6 months of 2008

a) Technical data

Object coated: Various furniture parts.

Parts with simple geometry are painted using automatic painting equipment (airless spraying), complex parts are painted by operators using airless spraying in a spray booth.

Substrate: MDF[64], 18 different kinds of wood.

Original process:

- First layer: 2-component polyurethane base-coat
- Grinding
- Second layer: predominantly 2-component polyurethane (with some production using high gloss special products)

Solid content of paint: 60%
Painting efficiency: 47%
Paint consumption: approximately 760 g/m²

Modifications and results:

The original automatic painting equipment has been replaced by a new one, air condition has been installed to provide constant temperature and humidity.

2/3 of the solvent borne paint has been replaced with water borne UV-curing paint (basecoat and topcoat).

All drying equipment for the automatic painted parts was replaced.

The cleaning agent has been replaced to meet the needs of the water-based paint and the cleaning of the belt carrying the parts to be painted was optimised to reduce the volume of cleaning agent. Nevertheless VOC´s are still needed to clean dry and half-dry residues of water borne paint.

Grinding has been modified (to use another type of grinding material).

The total capacity has been increased by 10%.

Table 10: Example 2: Comparison of key figures before and after change

Parameter	1) Original process	2) Waterborne paint
Area painted automatically [m²/year]	85 000	180 000
Area painted by hand [m²/year]	120 000	45 000
Total paint consumption [kg/year]	70 000	60 000
Thereof solvent borne paint	70 000	12 000
Thinner consumption [kg/year]	5 800	2 000
Total consumption of cleaning agent (VOC) [kg/year]	25 000	10 000
Efficiency [%]	47	48
Paint consumption [g/ m²]	760	520
Paint on painted piece (solvent/water) [g/ piece]	360	250
Emitted solvent for automated paint application [g/m²]	300	30

b) Economic data

Total investment: € 500 000 (without internal manpower).

Table 11: Example2: Changes in operational costs

Parameter	Additional costs (€/year)	Savings (€/year)
Grinding	+ 5 000	
Paint		- 3 000
Cleaning agent		-10 000
Waste		- 3 000

What we can observe in this case it that higher costs/kg of paint and cleaning agent are overcompensated by less volume consumed. Some significant increase in operational costs can be observed, even if it is not possible to quantify them precisely:

Manpower for grinding: + 30%

Energy consumption (electricity): +30%

Dust filters: +35%

Therefore a reasonable return on investment can only be achieved by the increased capacity.

c) VOC-reduction

Total emissions were reduced by 2/3 from approximately 60 t per year to 20 t per year despite the increase of painted surface of 10%.

d) Specific remarks

The planning process and tests required about one year. Leading operators were involved from the very beginning.

The new painting process has required modifications to the air conditioning and the grinding processes. Also the changed properties of the overspray dust caused problems and a significant increase in the consumption of dust filters.

Conclusion:

The example shows that for an investment of € 500 000 a reduction of 40 t VOC/year (= € 1 250 per t) was achievable. Marginal savings in operational cost (appr. minus € 10 000 per year) and an increase in capacity of 10 % were other economical effects. Apart from technical obstacles convincing and training of the operators were the major issues which were overcome by involving them into the process of change right from the beginning.

9.3 Example 3: Results of an overview study on furniture producing companies

The example shows the aggregated results of 41 furniture producing companies in the UK trying to reduce their VOC-emissions. All data is based on [BFM 2001]. Though the data is almost ten years old, the branch-specific experience is still interesting and actual for many companies.

The report of this study can be found at the following website: http://www.bfmenvironment.co.uk/

It lead to more or less the same conclusions as the individual case studies:

1) Substitution of paints is always related to changes in the main process (spraying).
2) Besides paints, cleaning agents are very important VOC-sources. Emissions can be reduced by either substitution or usage of closed cleaning equipment (e.g. for tools) and good housekeeping to avoid fugitive emissions.
3) Investments to reduce the VOC-input and emissions can be cost-neutral or even create savings if the grade of automation is high.

10 Emerging techniques and substitutes under development

Paints and coating technologies for wood surfaces are continuously being improved. The main focus has been on improving the efficiency of the painting process – particularly the consumption of paint (per m² or piece). The emerging techniques for improving coating efficiency provide benefits both in terms of lower costs for paint input, reduced emissions and less waste.

Three main areas:

- Technology improvements:
  Typical examples are automation (painting robots capable of following complex structures like in the car-industry), optimisation of layer thickness, electrostatic media (see below).

- Electrostatic spraying or high rotation bells:
  Materials and pre-painting operations are being refined to extend the applicability of electrostatic techniques (see section 0).

- Powder painting
  Powder painting, currently is only used for coating of MDF, research is aimed at improvements to layer thickness achievable, melting temperatures and film quality.

11 Information sources

[BFM 2001]
Benchmarking solvent use in the UK furniture manufacturing sector, BFM 2001
http://www.bfmenvironment.co.uk/images/BFM%20Benchmarking%20solvent%20use.pdf

[BREF STS 2007]
EU Commission: Reference Document on Best Available Techniques on Surface Treatment using organic solvents, August 2007

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[EFIC]
Lauwaert F., representative (2008, June 22), telephone interview
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