GUIDELINES

on implementation of VOC Solvents Emissions Directive (1999/13/EC)

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October 2010
Colophon

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Spletna publikacija, prva izdaja

GZS - Združenje lesne in pohištvene industrije, Ljubljana, 2010
Za založnika: Igor Milavec

Maloprodajna cena publikacije 0,0 EUR

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©Deutsche Forschungsgemeinschaft fuer Oberflaechenbehandlung, Germany

Spletna publikacija je izšla s finančno podporo Ministrstva za znanost in tehnologijo Republike Slovenije
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1. Introduction

1.1 Background for VOC-Guideline

Organic solvents are used in many industrial processes such as coating materials for wood or wood materials, metal, plastic and other, the serial coating of vehicles, repairing or cleaning processes.

The emitting volatile hydrocarbons in addition to the road resulting nitrogen oxides are seen as precursors for the formation of ground-level ozone. Ozone in Earth’s atmosphere plays a dual role. In the upper atmosphere, the stratosphere (above about 10 km), ozone has the vital function of a filter against the harmful ultraviolet component of solar radiation. At ground level (troposphere), ozone in high concentrations has the four main hazardous characteristics:

- Health hazard for people
- Damage to vegetation,
- Contributes to the greenhouse effect and
- Provides one of the most powerful oxidizing agent, the oxidation of many metals even at room temperature and is capable to deteriorate numerous organic compounds such as rubber

Both the volatile organic compounds and nitrogen oxides count to the cross-border air pollution components which have not only an effect at the source location but are spread over a wide area what lead to high ozone levels in neighbouring states. Therefore, to solve the ozone problem, both national and international action is required.

1.2 International Regulations and Agreements / EC-Guidelines

In December 1999 over 30 ECE member countries signed a UN-ECE protocol in Gothenburg with the aim to abate acidification, eutrophication and to reduce the ground-level ozone. In parallel with the initiative of the ECE states, the EU Commission submitted a draft for a directive on national emission ceilings in the summer of 1999. It is assumed that the long-term precursors VOCs and NOx must be reduced by 70 % to 80% compared to 1990 in Central Europe, in order to go permanently below the concentration of 120 mg/m³ ozone (8-hr funds), which is recommended by the World Health Organisation (WHO) to protect human health. Central control is to set national emission ceilings for each state.

Table 1 Emission ceilings for volatile organic compounds (thousands of tons per year) in European countries [1]

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>351</td>
<td>159 -</td>
<td>-55%</td>
</tr>
<tr>
<td>Belarus</td>
<td>533</td>
<td>309</td>
<td>-42%</td>
</tr>
<tr>
<td>Belgium</td>
<td>324</td>
<td>144</td>
<td>-56%</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>217</td>
<td>185</td>
<td>-15%</td>
</tr>
<tr>
<td>Croatia</td>
<td>105</td>
<td>90</td>
<td>-14%</td>
</tr>
<tr>
<td>Cyprus</td>
<td>18</td>
<td>14</td>
<td>-22%</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>435</td>
<td>220</td>
<td>-49%</td>
</tr>
<tr>
<td>Denmark</td>
<td>178</td>
<td>85</td>
<td>-52%</td>
</tr>
<tr>
<td>Finland</td>
<td>209</td>
<td>130</td>
<td>-38%</td>
</tr>
<tr>
<td>France</td>
<td>2957</td>
<td>1100</td>
<td>-63%</td>
</tr>
<tr>
<td>Germany</td>
<td>3195</td>
<td>995</td>
<td>-69%</td>
</tr>
<tr>
<td>Greece</td>
<td>373</td>
<td>261</td>
<td>-30%</td>
</tr>
</tbody>
</table>
The EC Solvents Directive (1999 / 13 / EC) [2] is an important step to reduce VOC precursor, which comes with more than 50% from the used solvents.

The European debate about this policy began already in 1990. In opposite to the UN ECE Protocol [1] and NEC Directive [3], which both follow assumptions related to effects and permit only a specific limited emission contribution to the precursors, the EU Solvent Directive makes direct requirements for each installation using solvents on an industrial scale. The aim is to reduce the emissions of organic compounds coming from an installation and to reduce the potential risks to human health. Europe-wide a reduction in VOC emissions by 50% compared to 1990s to be achieved in this area.


### 1.3 National Regulation and Agreements

#### 1.3.1 Germany

In Germany, the EU Solvent Directive was implemented into national law with the “Regulation of the implementation of the Directive 1999 / 13 / EC on the limitation of emissions of volatile organic compounds”. It was entered into force on 25 August 2001 and sets out in Article 1 the 31.

<table>
<thead>
<tr>
<th>Country</th>
<th>1999</th>
<th>2013</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hungary</td>
<td>205</td>
<td>137</td>
<td>-33%</td>
</tr>
<tr>
<td>Ireland</td>
<td>197</td>
<td>55</td>
<td>-72%</td>
</tr>
<tr>
<td>Italy</td>
<td>2213</td>
<td>1159</td>
<td>-48%</td>
</tr>
<tr>
<td>Latvia</td>
<td>152</td>
<td>136</td>
<td>-11%</td>
</tr>
<tr>
<td>Liechtenstein</td>
<td>1.56</td>
<td>0.86</td>
<td>-45%</td>
</tr>
<tr>
<td>Lithuania</td>
<td>103</td>
<td>92</td>
<td>-11%</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>20</td>
<td>9</td>
<td>-55%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>502</td>
<td>191</td>
<td>-62%</td>
</tr>
<tr>
<td>Norway</td>
<td>310</td>
<td>195</td>
<td>-37%</td>
</tr>
<tr>
<td>Poland</td>
<td>831</td>
<td>800</td>
<td>-4%</td>
</tr>
<tr>
<td>Portugal</td>
<td>640</td>
<td>202</td>
<td>-68%</td>
</tr>
<tr>
<td>Republic of Moldova</td>
<td>157</td>
<td>100</td>
<td>-36%</td>
</tr>
<tr>
<td>Romania</td>
<td>616</td>
<td>523</td>
<td>-15%</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>3566</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slovakia</td>
<td>149</td>
<td>140</td>
<td>-6%</td>
</tr>
<tr>
<td>Slovenia</td>
<td>42</td>
<td>40</td>
<td>-5%</td>
</tr>
<tr>
<td>Spain</td>
<td>1094</td>
<td>669</td>
<td>-39%</td>
</tr>
<tr>
<td>Sweden</td>
<td>526</td>
<td>241</td>
<td>-54%</td>
</tr>
<tr>
<td>Switzerland</td>
<td>292</td>
<td>144</td>
<td>-51%</td>
</tr>
<tr>
<td>Ukraine</td>
<td>1369</td>
<td>797</td>
<td>-42%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>2555</td>
<td>1200</td>
<td>-53%</td>
</tr>
<tr>
<td>European Community</td>
<td>15353</td>
<td>6600</td>
<td>-57%</td>
</tr>
</tbody>
</table>
emissions of volatile organic compounds in the use of organic solvents in certain plants - 31 BImSchV).

This affects certain plant species, in which organic solvents are used, if the annual solvent consumption exceeds certain thresholds. These include inter alia coating systems for various materials and products, printing, surface cleaning equipment, dry cleaning, for the conversion of rubber and equipment for the production of paints, adhesives, inks and pharmaceuticals. Overall, according to recent estimates, about 15,500 units are affected by the regulation. It also demands limits for health hazardous substances as halogenated compounds.


1.3.2 Slovenia

In Slovenia, the basic decree, implementing the European VOC directive into national legislation is called

"Uredba o mejnih vrednostih emisije hlapnih organskih spojin v zrak iz naprav, v katerih se uporabljajo organska topila" and was issued in the Slovenian Official Journal „Uradni list RS, št. 112/2005 z dne 15. 12. 2005“. [6]


by clicking hyperlinks named “Hlapne organske snovi (HOS)” and “Hlapne organske snovi (HOS) NOVO November 2009”.

1.3.3 Greece

So for this we have the European Council Law about the VOC which is Directive no 1999/13/EK (14780/2/2003-C5-0019/2004-2002/0301 (COD)

You can find this on site [9]

We have also for Greece the Law no FEK 832/ 2-7-2002 which is describing the measures that the companies should take in order to reduce emission.

1.3.4 Cyprus

In Cyprus they have the European rule as direct law and they provide with the rule 14 the way to count the emission. You can find this on Internet on site [11]


But also they can find the Greek Guideline that we prepare in TTR site very soon.

1.4 Special requests for wood coating

The activity of surface coating application is officially called “Surface protection of wooden surfaces” and described as »Any activity where a protection coating is applied on surfaces of wood or wooden products, in one or more layers«.

In the European Guideline the Decree is to be implemented so far as the installation is operated above the solvent consumption thresholds of 15 tonnes/pa. The emission limit values in waste gases for the wood coating activity are:

### Table 2 Special limits for wood coating

<table>
<thead>
<tr>
<th>Activity</th>
<th>Threshold value for solvent consumption (Threshold value for solvent consumption)</th>
<th>Emission limit values for waste gases (mg C/Nm³)</th>
<th>Emission limit values for fugitives (Percentage of solvent input)</th>
<th>Special provisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood coating</td>
<td>(&gt; 15)</td>
<td>15 – 25</td>
<td>100¹)</td>
<td>25*</td>
</tr>
<tr>
<td></td>
<td>&gt; 25</td>
<td>&gt; 25</td>
<td>50²)/75³</td>
<td>20*</td>
</tr>
</tbody>
</table>

¹) Emission limit applies to coating application and drying processes operated under contained conditions.
²) The value applies to drying processes under contained conditions.
³) The value applies to coating processes under contained conditions.

* only in Slovenia and Germany. In Slovenia, all VOCs in uncleaned waste gasses have to be added to fugitive emissions (see Table 3).

In some countries so in Germany and Slovenia the regulations are stronger as in the European Guideline.

In Greece in the Law no FEK 832/ 2-7-2002 there is a part with a reduction program. In that program gives the opportunity to the enterprise to use any type of equipment in order to reduce the emission. It also gives the opportunity to use other materials even if those are in the improvement stage.
All the enterprises are called to give a time schedule in which they give the periods of the improvements that there going to follow.

Table 3 Differences for thresholds and emission limit values for wood coating processes in Europe

<table>
<thead>
<tr>
<th></th>
<th>31. BImSchV (Germany) Slovenian “Uredba”</th>
<th>European Guideline 1999/13/EG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold for solvent consumption</td>
<td>5 t/a (only in Germany)</td>
<td>15 t/a</td>
</tr>
<tr>
<td>Emission limite value (&gt; 25t/a)</td>
<td>50 mg/Cm$^3$ (Coating + Drying)</td>
<td>50 mg/Cm$^3$ (Drying)</td>
</tr>
<tr>
<td></td>
<td>20 mg/Cm$^3$ (waste gas combustion)</td>
<td>75 mg/Cm$^3$ (Coating)</td>
</tr>
<tr>
<td>Contained gases</td>
<td>Under contained conditions, the VOCs in the captured uncleaned waste gasses are added to fugitive emissions.</td>
<td>No difference between cleaned and non-cleaned gases, contained gases are not counted as fugitives!!!</td>
</tr>
<tr>
<td>Allowed mass stream for CMT-substances</td>
<td>2.5 g/h in collected waste gas (1mg/m$^3$)</td>
<td>10 g/h in collected waste gas (2 mg/m$^3$)</td>
</tr>
<tr>
<td>R 40 substances</td>
<td>100 g/h in 20 mg/m$^3$</td>
<td>100 g/h in 20 mg/m$^3$</td>
</tr>
</tbody>
</table>

So in Germany even installations with a solvent consumption of more than 5t/year have to deliver a solvent mass balance to the authorities.

Installations with a solvent consumption between 5 and 15t can apply a simplified reduction scheme. It means they are obliged to apply only solvent poor products with a certain limit value of VOC.

**Simplified reduction scheme for German installations:**

- Coating products for flat substrates: VOC-content □ 250 g/l
- Coating products for other substrates: VOC-content □ 450 g/l
- Aqueous wood stains: VOC-content max. 300 g/l

The special Slovenian and German requests concerning the fugitive emissions complicate things. In practice this means that in the field of the coating of wood there is not even a single one Slovenian company that can implement the Directive “normally”. Even if they perform all measures at the beginning of the pipe line (change of materials, new techniques, etc.) and lower their emission values below the limit, they will still have fugitive emission values of 100 %, because usually they do not clean waste gases.

So, the only possibility for all the companies with a solvent consumption > 15t is that they ask for approval of a Solvent Reduction Plan (also called solvent management plan). In fact, all they did so, and they got temporary approvals.

It's aim is to reduce the content of solvents in the applied products and an increase of the solid contents of the products. Than a target emission value is counted and compared with the annual solvent balance.

**The target emission value should be calculated as follows:**

\[
\text{(the target emission value)} = \frac{(\text{annual reference emission}) \times (\text{percentage})}{(\text{the annual reference emission})} = \frac{(\text{the total mass of solids in the quantity of coating and/or ink, varnish or adhesive consumed in a year is determined}) \times \text{multiplication factor)}
\]
Table 4  
Calculation assumptions for a solvent reduction plan

<table>
<thead>
<tr>
<th>Installation</th>
<th>Activity</th>
<th>Threshold (solvent consumption threshold in tonnes/year)</th>
<th>Multiplication factor</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.1</td>
<td>Protection of wooden surfaces</td>
<td>5 – 15</td>
<td>4</td>
<td>(25+15)%</td>
</tr>
<tr>
<td>9.2</td>
<td></td>
<td>&gt; 15–25</td>
<td>4</td>
<td>(25+15)%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 25</td>
<td>3</td>
<td>(20+5)%</td>
</tr>
</tbody>
</table>

(1) Multiplication factor for German installations, for application methods with the transfer efficiency (yield) of > 85%, like for instance roller coating, the factor of 4 may also be used.

Concerning the multiplication factors the German demands are also stronger than in the original EU VOC directive (only factor of 4 is mentioned there). There were a lot of efforts, to change this, or to get longer prolongations of the deadlines.

Further links on "How to establish a reduction plan can be found under:

[12]  
http://www.i-kon.org/ikon_downloads/jot-008-0072-1_Bregau_IKon.pdf (german version)

[13]  
http://www.berlin.de/imperia/md/content/bacharlottenburg-wilmersdorf/verwaltung/umwelt/holzbeschichten.pdf?start&ts=1239876594&file=holzbesc
hichten.pdf


1.5 European Deadlines

- New built installations are to be registered and allowed before their initial operation
- Existing installations-
  1. Existing installations have to comply with Articles 5, 8 and 9 latest until 31 October 2007
  2. All existing installations must be registered or approved until 31. October 2007
  3. Do the to be authorized or registered facilities intend to apply a reduction plan in accordance with Annex II B, then it must be communicated to the competent authorities until 31. October 2005.

1.5.1 Deadlines in Germany

25. August 2003  Deadline for the information of not license requiring plants to the competent authority.
31. October 2004 New plans: have to meet the limit values of the final stage, using a reduction plan
    Old installations: deadline for the announcement of a reduction plan
31. October 2005 Old plants have to meet the limit values of intermediate stage if using a reduction plan
31. October 2007 Compliance with any requirements of the 31. BImSchV
    End of the transitional period for the existing waste gas cleaning devices
1.5.2 Deadlines in Greece, Cyprus and Slovenia:

The deadlines were principally the same as in the EU directive.

So the deadline for the implementation of VOC-guideline in Greece and Cyprus was the 31.10.2007.

Slovenia enacted some amendments:

The first amendment [16] ("Uredba o spremembah in dopolnitvah Uredbe o mejnih vrednostih emisije hlapnih organskih spojin v zrak iz naprav, v katerih se uporabljajo organska topila«, issued in “Uradni list RS, št. 37/2007 z dne 23. 4. 2007”) was for the activity of wood coating extremely important:

Several new articles were added (although not specially mentioned, they were intended mainly for the wood coating activity). The main point of this article was that the final implementation of the Slovenian VOC decree may be prolonged till 31st October 2010 (that is implementation of the reduction scheme), only in specific cases, under strictly determined conditions (special elaborate, proving the lack of alternative materials, etc.). Mainly all of the Slovenian wood companies that prepared (and got temporarily approved) reduction schemes, asked for prolongation. Another important change was the change of multiplication factor of 3 (see table and remarks above) into “4”, that is the same as in the EU directive.

The most important web pages, when one can find almost all important information regarding legislation on VOC emission are [17] (including BREF documents) and [18] with further hyperlinks.

1.6 Level of implementation into action in European Countries

The EC Member States are required to report the implementation and success of the EC Directive, according to Article 11 of the Directive every three years following a questionnaire, prepared by the EU Commission:

1.6.1 Germany

In Germany the Federal Environmental Agency published this report every two years./19/ http://www.bmu.de/luftreinhaltung/downloads/doc/37150.php


Up to the end of the nineties in Germany a marked reduction success by almost 50% could be achieved – mainly from the transport sector. Reductions in solvent use with a part of about 40% from lacquer application and coating processes have not been reached in essences.

New figures published by EPA show, that the target caused by diminishing actions can just be achieved by 2010 but after this year, a further increase of VOC emissions coming from solvent use or coating processes is predicted, while the emissions from other sectors will further decrease a further increase of VOC-emission

In 2020 only the painting will contribute 30% of the total VOC-emission, solvent use in addition to coating processes 76 % as it is shown in the table.
Table 5  

<table>
<thead>
<tr>
<th>Area</th>
<th>Emissions</th>
<th>2000</th>
<th>2001</th>
<th>Forecast 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application of paints and varnishes</td>
<td></td>
<td>284 109</td>
<td>291 157</td>
<td>262 576</td>
</tr>
<tr>
<td>Printing Industry</td>
<td></td>
<td>90 786</td>
<td>98 981</td>
<td>92 596</td>
</tr>
<tr>
<td>Surface cleaning dry cleaning</td>
<td></td>
<td>35 467</td>
<td>42 687</td>
<td>35 741</td>
</tr>
<tr>
<td>Manufacturing / processing chemical products</td>
<td></td>
<td>35 908</td>
<td>37 180</td>
<td>38 177</td>
</tr>
<tr>
<td>Application of adhesives</td>
<td></td>
<td>23 388</td>
<td>20 794</td>
<td>18 694</td>
</tr>
<tr>
<td>Other Applications / Household</td>
<td></td>
<td>263 147</td>
<td>262 224</td>
<td>286. 291</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>732 805</td>
<td>753 023</td>
<td>734 075</td>
</tr>
</tbody>
</table>

Table 6  

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic</td>
<td>1.461 kt</td>
<td>45,1</td>
<td>742 kt</td>
<td>332 kt</td>
<td>198 kt</td>
<td>152 kt</td>
<td>114 kt</td>
<td>10,8</td>
</tr>
<tr>
<td>Combustible circle</td>
<td>227 kt</td>
<td>7,0</td>
<td>88 kt</td>
<td>66 kt</td>
<td>46 kt</td>
<td>37 kt</td>
<td>32 kt</td>
<td>3,0</td>
</tr>
<tr>
<td>Industrial processes</td>
<td>160 kt</td>
<td>4,9</td>
<td>136 kt</td>
<td>49 kt</td>
<td>51 kt</td>
<td>47 kt</td>
<td>45 kt</td>
<td>4,3</td>
</tr>
<tr>
<td>Power stations</td>
<td>25 kt</td>
<td>0,8</td>
<td>20 kt</td>
<td>11 kt</td>
<td>11 kt</td>
<td>11 kt</td>
<td>11 kt</td>
<td>1,0</td>
</tr>
<tr>
<td>FCKW and Halones</td>
<td>53 kt</td>
<td>1,6</td>
<td>8 kt</td>
<td>2 kt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Households</td>
<td>118 kt</td>
<td>3,6</td>
<td>60 kt</td>
<td>79 kt</td>
<td>80 kt</td>
<td>56 kt</td>
<td>49 kt</td>
<td>4,7</td>
</tr>
<tr>
<td>Solvent consumption</td>
<td>1.197 kt</td>
<td>36,9</td>
<td>1.090 kt</td>
<td>822 kt</td>
<td>743 kt</td>
<td>685 kt</td>
<td>800 kt</td>
<td>76,0</td>
</tr>
<tr>
<td>Lacquer application</td>
<td>417 kt</td>
<td>12,9</td>
<td>372 kt</td>
<td>314 kt</td>
<td>346 kt</td>
<td>275 kt</td>
<td>319 kt</td>
<td>30,3</td>
</tr>
<tr>
<td>- Others</td>
<td>780 kt</td>
<td>24,1</td>
<td>718 kt</td>
<td>508 kt</td>
<td>397 kt</td>
<td>410 kt</td>
<td>481 kt</td>
<td>45,7</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td>3.241 kt</td>
<td>100</td>
<td>2.143 kt</td>
<td>1.358 kt</td>
<td>1.128 kt</td>
<td>987 kt</td>
<td>1.052 kt</td>
<td>100</td>
</tr>
<tr>
<td>Target emissions acc. to NEC</td>
<td>995 kt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>741 kt</td>
</tr>
</tbody>
</table>

The table is very significant and shows the further increase in action just in the paint processing.

1.6.1.1 Situation in the German Wood Coating Industry:

In Germany there are about 28,000 wood-processing companies. The vast majority are small and medium-sized companies. Thus, for example 2008 12 plants after 9.1 and 6 devices to 9.2 had registered in the state of Saxony of which 4 presented a reduction plan. Of the plant acc. to 9.1 no reduction plan was announced. / Table LfUGL /

In the Land of North Rhine Westphalia, there are much more installations for coating furniture [23]. Here in 2007 96 facilities for wood coating (total 9.1 9.2) were registered. However, it is very difficult to get information about the actual number of previously submitted reduction plans, Of 1269 plants in all branches 1159 installations worked 2007 with simplified proofs (solvent consumption <5t), 90 had specific reduction plans announced (solvent consumption> 15 tons) and 20 follow a simplified reduction scheme (solvent consumption of 5-15t).
Problems in the implementation of VOC Directive are caused by the following main points [23]:

• Low number of responses due to the economic situation of the operator and the complexity of the regulation, great need for advice

• Lack of data on plants, since many small to medium-sized enterprises by the requirements of 31 BImSchV are overwhelmed

• "Reduction Plan" and "solvent balance" are used as instruments to achieve these goals in practice

• Variety of measures to reduce solvent present

By means of a questionnaire 60 germane enterprises were asked about their situation: Form 12 firms of the wood coating branch we got an answer:

Musical instruments (1), Doors (2), Interiors (3), Furniture (6). The solvent consumption was as following: 5-15t (4), 15-25t (3), > 25t (5). The solvent consumption didn't depend on the kind of products.

Main sources of emissions were: solvent borne lacquers, cleaners and thinners.

The most common methods to get the compliance to the guideline were:

- Reduction plans with replacement of solvent borne lacquers by Hydro-UV or 100% UV-lacquers for roller coating
  Announced reduction plan: 4  Planned: 4
- Waste gas cleaning:
  Planned: 2
- Outsourcing of the coating step to other firms: 1

Generally it can be estimated for Germany, that the majority of enterprises have already fulfilled the demands of the VOC-Guidelines even if they are much stronger in Germany than in the other countries.

However it has occurred that the observance of the Carbon limit concentrations for Emissions couldn’t be held in some cases, even when water based lacquers or high solid systems are applied. The reason is the heavy volatile hydrogen carbonics, which are part of coating systems and evaporating also under room conditions.

This problem will become virulent when the emission measurements will be performed from 2013. [24]

http://www.baufachinformation.de/zeitschriftenartikel.jsp?z=2009079016012- Implementation of solvent directive in the German wood coating industry

1.6.2 Slovenia

Situation within the field of industrial coating application, for 2009:

In 2009 the activity 9.1 (wood coating application, as stated in Slovenian VOC Decree) had the following shares among all installations and emissions (dry cleanings not included in this statistics):

• Number of installations (not companies!): 58 out of total 265 (21.9 %)
• Emissions: 733 377 kg out of 4 051 472 kg (18.1%)

In 2008:

• Share of 9.1 installations 22.8 %
• Share of 9.1 emissions 22.6 %
Mainly all of Slovenian wood companies that prepared (and got temporarily approved) reduction schemes, asked for prolongation. Another important change was the change of multiplication factor of 3 (see table and remarks above) into “4”, that is the same as in the EU directive.

Important data are also on [25] (the companies that have to comply with the decree) http://www.arso.gov.si/zrak/emisije%20snovi%20v%20zrak/emisije%20iz%20naprav/


In the following table, there are official data on the current situation regarding VOCs in the field of wood coating activity (installations 9.1 as classified in the Slovenian Decree and which are in the official evidence of the installations). The data, also for other installation types are accessible on the web site [30]


<table>
<thead>
<tr>
<th>No.</th>
<th>Company name</th>
<th>Current status</th>
<th>Valid till</th>
<th>My (not official remark)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BREST-POHIŠTVO d.o.o. CERKNICA</td>
<td>potrdilo 1 Nzhos</td>
<td>17.9.2012</td>
<td>Complies with the requirements of the Slovenian VOC Decree</td>
</tr>
<tr>
<td>2</td>
<td>ELAN MARINE d.o.o.</td>
<td>odločba 2 Nzhos</td>
<td>31.10.2010</td>
<td>The company does not collaborate within the frame of the CORNET VOClessWOOD project, neither with the Furniture and Wood Processing Association at the Slovenian Chamber of Commerce. So, we do not have insight into their situation.</td>
</tr>
<tr>
<td>3</td>
<td>GORENJE NOTRANJA OPREMA, d.o.o.</td>
<td>IPPC odločba 3 Nzhos</td>
<td>31.10.2010</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>JAVOR POHIŠTVO d.o.o.</td>
<td>odločba Nzhos</td>
<td>31.10.2010</td>
<td>They are just around the limit</td>
</tr>
<tr>
<td>5</td>
<td>JAVOR POHIŠTVO d.o.o.</td>
<td>odločba Nzhos</td>
<td>31.10.2010</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>JERA MIX d.o.o.</td>
<td>odločba Nzhos</td>
<td>31.10.2010</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>LIKO POHIŠTVO d.o.o. - v likvidaciji</td>
<td>odločba Nzhos</td>
<td>31.10.2010</td>
<td>They already succeeded to fulfill the requirements from the Solvent reduction scheme. So, the company complies with the requirements of the Slovenian VOC Decree</td>
</tr>
<tr>
<td>8</td>
<td>LIKO POHIŠTVO d.o.o. - v likvidaciji</td>
<td>odločba Nzhos</td>
<td>31.10.2010</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>LIKO VRATA d.o.o.</td>
<td>odločba Nzhos</td>
<td>31.10.2010</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>LIP POLJCANE d.d.</td>
<td>odločba Nzhos</td>
<td>31.10.2010</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>LIP RADOMLJE d.d. - v likvidaciji</td>
<td>odločba Nzhos</td>
<td>31.10.2010</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>LIPA AJDOVŠCINA d.d. - v likvidaciji</td>
<td>odločba Nzhos</td>
<td>31.10.2010</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>MENINA d.d.</td>
<td>potrdilo Nzhos</td>
<td>27.2.2013</td>
<td>Complies with the requirements of the Slovenian VOC Decree</td>
</tr>
<tr>
<td>14</td>
<td>MURALES d.d. LJUTOMER</td>
<td>odločba Nzhos</td>
<td>31.10.2010</td>
<td></td>
</tr>
</tbody>
</table>
Majority of the companies have approved the Solvent reduction schemes (approval valid till 31.10.2010). After 31.10.2010 they should fulfil the requirements from the solvent reduction scheme. But as shown later and by the remarks in the last column of the table, in general (with some exceptions) they will not succeed. It is a question what is going to happen. The inspectors may come any day after this day and decide for a fine or in the worst case, they may close down the installation. More on this problem is written below.

In the first half of the year 2010 the questionnaire on the situation in the companies was performed. In the following table there are main issues for the companies we got a reply from. Warning: some data are unfortunately incomplete!

In 2009 and 2010 visits to some companies were performed, in order to go into into more details, to study specific situations:

1. extract from the visit to Stilles

VOC directive requirements were given. The most important problems which should be solved are:
1) The problem of acetone emission from wood stains 2) Forthcoming modernisation and optimisation of lacquering technology in the next years. For quality decision about right technology and investment additional information about trends, novel technologies and coating systems are welcome.

2. extract from the visit to Lip Radomlje

---

<table>
<thead>
<tr>
<th>No.</th>
<th>Company</th>
<th>Type of Decision</th>
<th>Date</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>NOLIK d.d.</td>
<td>odločba Nzhos</td>
<td>31.10.2010</td>
<td>The company does not collaborate within the frame of the CORNET VOClessWOOD project, neither with the Furniture and Wood Processing Association at the Slovenian Chamber of Commerce. So, we do not have insight into their situation.</td>
</tr>
<tr>
<td>16</td>
<td>NOVEM CAR interior design d.o.o.</td>
<td>4 Vloga</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>NOVOLES d.d. STRAŽA</td>
<td>odločba Nzhos</td>
<td>31.10.2010</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>PARON d.o.o.</td>
<td>odločba Nzhos</td>
<td>31.10.2010</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>PODGORJE d.o.o. ŠENTJERNEJ</td>
<td>odločba Nzhos</td>
<td>31.10.2010</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Pohištvena industrija GARANT d.d., Požega</td>
<td>odločba Nzhos</td>
<td>31.10.2010</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>ROGAŠKA LES d.o.o.</td>
<td>potrdilo Nzhos</td>
<td>11.4.2013</td>
<td>Complies with the requirements of the Slovenian VOC Decree</td>
</tr>
<tr>
<td>22</td>
<td>STILLES d.o.o.</td>
<td>odločba Nzhos</td>
<td>31.10.2010</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>SVEA LESNA INDUSTRIJA LITIJA d.d.</td>
<td>odločba Nzhos</td>
<td>31.10.2010</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>TRIIS d.o.o., ŽELEZNIKI</td>
<td>odločba Nzhos</td>
<td>31.10.2010</td>
<td></td>
</tr>
</tbody>
</table>

The legend:

1. “Potrdilo Nzhos” – the installation complies with the requirements from the approved solvent reduction scheme

2. “Odločba Nzhos” – approved solvent reduction scheme; till the written date (“Valid till” the company should achieve the approved emissions (consumption), as requested by the solvent reduction scheme

3. “IPPC odločba Nzhos” – the installation is also in the IPPC evidence (large installation)

4. “Vloga” – the installation is in the process of adding into the register of installations
The most important problem which should be solved is the problem of suitable water based coatings for oak and beech substrates, which won’t cause colour changes and excessive swelling. Also final surface appearance as it is usual for NC coatings is welcome. In spite of many probes with several commercial coating products the problem still remains.

3. extract from the visit to Gorenje Notranja oprema:

The problem of acetone emissions from wood stains is quite remarkable but not the most important one. Acetone will remain in some quantity as long as NC lacquering will be present. The target emission is 80 t per year. This target should be reached firstly by replacement of the major quantity of the existing coatings materials with high gloss acrylic foils (plates). The second choice will be waterborne materials. NC lacquering will remain in minor quantity for some special purposes. UV hardened lacquer systems are not problematic. A lot of efforts are put into testing of different new waterborne materials to assure the most reliable quality of final surface. There exist also investment plans of production line modernisation. The information on existing and novel coatings materials is welcome.

4. extract from the visit to Triis Železniki:

This is one of very rare positive examples. High investments and a lot of activities will very likely in achieving of the requirements quite soon after the deadline for the complete implementation of the solvent reduction plan – 31.10.2010: at the end of 2010 or in the beginning of 2011.

5. extract from the visit to Murales Ljutomer:

A lot of problems! Still many activities have to be done. No chances to implement the requirements from the solvent reduction plan till the deadline at the end of October this year.

It has to be added, that in October 2010, additional efforts in some most critical companies are going on, in order to comply with the Slovenian VOC decree requirements. It seems that in at least some cases, installation of active carbon filters to reduce concentrations of organic carbon in waste gasses is a realistic option.

Table 8 State of implementation of VOC- guideline in Slovenia

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Activity - product</th>
<th>Target emission of VOC's (consumption/ input) (kg)</th>
<th>Current consumption of VOCs (kg)</th>
<th>Complying with the solvent reduction scheme till 31.10.10</th>
<th>Why NOT?</th>
<th>When yes?</th>
<th>How (the most important one)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>GORENJE NOTRANJA OPREMA, d.o.o.</td>
<td>Application of coatings on kitchen and bathroom furniture (spraying, roller / UV, staining)</td>
<td>81 825 (when 226 tonnes per year are used)</td>
<td>130 675</td>
<td>NO</td>
<td>No appropriate waterborne materials on the market</td>
<td>Most likely till 2012</td>
<td>New alternative materials (foils), outsourcing, Waterbornes</td>
</tr>
<tr>
<td>JAVOR POHIŠTVO d.o.o.</td>
<td>Application of coatings on chairs (dipp coating, spraying, electrostatic spraying) waterborne stain and polyurethane (PU) solventbornes</td>
<td>15 000</td>
<td>13 401</td>
<td>YES</td>
<td></td>
<td>Substantial decrease of the production, solventborne stains not used any more</td>
<td></td>
</tr>
<tr>
<td>JAVOR POHIŠTVO d.o.o.</td>
<td>Spraying of PU on chairs</td>
<td>18 500</td>
<td>36 395</td>
<td>NO</td>
<td></td>
<td>waterbornes</td>
<td></td>
</tr>
<tr>
<td>JERA MIX d.o.o.</td>
<td>Flat pieces</td>
<td>50 000</td>
<td>29 000</td>
<td>YES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LIKO POHIŠTVO d.o.o.</td>
<td>Application on chairs and beds</td>
<td></td>
<td>YES</td>
<td></td>
<td></td>
<td>Electrostatic spraying, waterbornes, but</td>
<td></td>
</tr>
<tr>
<td>Company</td>
<td>Products</td>
<td>Automation</td>
<td>Waterborne Alternative</td>
<td>Notes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>------------</td>
<td>------------------------</td>
<td>----------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LIKO POHIŠTVO d.o.o. - v likvidaciji (Verd)</td>
<td>Application on doors</td>
<td>YES</td>
<td>waterbornes</td>
<td>End of production</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lip Bled d.o.o.</td>
<td>Products made of solid spruce and beech wood</td>
<td>5 000</td>
<td>10 862</td>
<td>YES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LIP POLJČANE d.d.</td>
<td>Furniture for children, PU and waterbornes, spraying and electrostatic spraying</td>
<td>26 200</td>
<td>28 500</td>
<td>End of production</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lip Radomlje d.d. v likvidaciji</td>
<td>Chairs, tables, etc. – a lot of solid oak wood is used</td>
<td>23 781</td>
<td>55 940</td>
<td>No suitable waterborne alternative for oak and similar wood</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LIPA AJDOVŠCINA d.d. - v likvidaciji</td>
<td>Flat and 3-D (chairs) pieces; spraying: waterborne stains, PU, nitro, acrylic, waterborne lacquers</td>
<td>40 851</td>
<td>20 963</td>
<td>Waterborne, oils</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MURALES d.d.</td>
<td>Chairs, tables, etc. – by spraying with nitro, PU and waterbornes</td>
<td>27 860</td>
<td>40 100</td>
<td>End of 2011, if suitable waterborne alternatives appear</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOLIK STOLIK d.o.o.</td>
<td>Massive chairs made of beech wood</td>
<td>49 009</td>
<td>53 048</td>
<td>End of production</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOVOLES d.d. STRAŢA</td>
<td>Spraying, dip coating, roller /UV of furniture, chairs, garden furniture</td>
<td>?</td>
<td>21 328</td>
<td>Not good alternative materials, production in small series</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PARON D.O.O.</td>
<td>Application of coatings on furniture made of solid wood, also</td>
<td>25 000</td>
<td>15 452</td>
<td>Switch to oils and waterbornes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* the company is in fact below the threshold limit – it is not in the register and in the table above!
1.6.3 Greece and Cyprus

The problem in Greece and Cyprus is that usually they have law for everything but no action….So there only the large scale companies take measures but the majority of small and medium enterprises are not taken any measures to reduce the VOC emission.

The problems in Greece and Cyprus are quite different from the other countries as Slovenia and Germany.

In some cases of smaller enterprises even the simplest actions for health protection are not warranted, so as spraying cabins or exhaustion systems for the workers.

1.7 Interaction of enterprises with administration (duties and rights)

1.7.1 Germany

In Germany the cooperation with the authorities is estimated very different and it depends on the federal state. So 2-3 of the asked enterprises were content with the controlling authorities, 5 enterprises didn't answer this question and 3 reported difficulties as following:

- Centralization of different installation parts at several locations to and evaluation as one entity
- Non-acceptance of passed back solvents and denial of a lowering of the solvent consumption with this part in the solvent balance with the argument that the real VOC-content of the wastes cannot be determined.

UBA [31] and IHD have measured many solvent contents of the waste products.
GUIDELINES on implementation of VOC Solvents Emissions Directive, October 2010

Table 9 Industry standard VOC-content in wastes [31]

<table>
<thead>
<tr>
<th>Kind of waste</th>
<th>Solvent content [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>solvent based muds, halogene free</td>
<td>15</td>
</tr>
<tr>
<td>cured leftovers from paints and lacquers</td>
<td>2</td>
</tr>
<tr>
<td>cleaners / thinners</td>
<td>85</td>
</tr>
<tr>
<td>aqueous muds, containing paints and lacquers</td>
<td>30</td>
</tr>
<tr>
<td>destillation residues without halogenic organics</td>
<td>15</td>
</tr>
</tbody>
</table>

Conclusion:

- Sealed storage of wastes can lead to a higher content of solvents, measurement can be worthfull to optimize the mass balance
- Alternation of VOC-content within one production line can be appreciable
- Strong alternation of measured values because of phase separation of the samples (homogenizing of lacquer muds often very difficult
- Calculation of an average value basing on several measurements over a certain time and product variety
- Discharged solvents are allowed to be substracted from the mass balance

1.7.2 Slovenia

In 2010, a lot of efforts to get into a contact with administration and responsible persons (including the Minister for spatial planning and environment) were carried out, predominantly by the Furniture and Wood Processing Association at the Slovenian Chamber of Commerce. The companies
wanted to explain the current situation and wanted to hear what is going to happen if they are not going to be able to implement VOC decree requirements till the end of October 2010.

So, on the 25th May 2010 there was a meeting of the leadership of the Furniture and Wood Processing Association at the Slovenian Chamber of Commerce, representatives of some companies, Biotechnical faculty – Department of Wood Science & Technology and representatives of the Ministry of the Environment and Spatial Planning and of the The Environmental Agency of the Republic of Slovenia.

On the meeting, it was stated that around 10 companies (2700 employees) do not see a realistic possibility to implement the solvent reduction plan till 31st October this year. It was agreed that each individual company should prepare a realistic opinion on what to do (till the date (when?) after the deadline), taking into account realistic financial plan. The purpose of the reports is to enable the administration better insight into realistic specific situations. It seems that in some cases waterbornes or other materials will simply not be available. The companies should put more focus on studying “the end of pipe abatement technologies”, as suggested by the administration. The companies should check again the current BREF/BAT situation: [http://eippcb.jrc.ec.europa.eu/reference][32]

The next meeting was on the 16th June. The company representatives reported orally on their situations in details. Again, the following problems were stressed: there are still not any adequate alternative materials on the market, to reach the highest quality and for specific cases (the highest gloss, coatings for oak wood, 3D products...). Therefore, the Ministry and the Agency representatives suggested consideration of end-of-pipe abatement technologies. It was also stressed, that due to the global crisis, current situation in the companies is very bad and it is the question where to find finances to perform the necessary high investments.

Conclusions of the meeting:
- The “problematic companies” have to apply for prolongation to remain in the register of installations
- End-of-pipe abatement technologies should be considered in details
- The companies that will not implement the solvent reduction plans till the deadline have to prepare statements on their activities after the deadline (including financial plans). Nevertheless, the companies will be regarded as not implementing the law after the deadline, with all possible consequences!

1.7.3 Cyprus and Greece

All the above mention are the duties of the enterprises that have to follow. The rights of the companies are that can take some money grants through the European Union projects.

1.8 General problems in the field of Wood coating

Even if there are many technical solutions to meet the requirements of the VOC-Guideline a lot of problems for the wood coating branch are remaining as there are:
- High gloss
- Trend colours
- High quality demands on the surfaces
- High part of manual treatment
- Different spraying devices, distributed over the whole area of an enterprise so it is difficult to collect the waste gases
- Extremely small batches with many changes of colours
- 3d-surfaces and stamped surfaces
- High part of cleaning substances and thinners
2. **VOC-Balance**

Once a year enterprises have to calculate a solvent mass balance in order to prove if the installation underlies the restrictions of the VOC-Directive. German and Slovenian Installations of wood coating which fall under point 9.1 have to calculate a mass balance every three years.

Therefore the following terms are to determine:

- **Solvent consumption:** \( LV = I_1 - O_8 \)
- **Emission** \( E = F + O_{1.1} \)
- **Fugitive emissions:** \( F = I_1 - O_{1.1} - O_5 - O_6 - O_7 - O_8 \) or \( F = I_1 - O_1 - O_5 - O_6 - O_7 - O_8 \)

with

- \( I_1 \) = Quantity of organic solvents at the input of the procedure (calculated by the purchased amounts and VOC-declaration on the bottles or measured)
- \( I_2 \) solvents from in-house recovery, which shall be reused
- \( O_1 \) = Emission from chimneys
- \( O_{1.1} \) Output, emissions in collected, treated waste gases (only if waste gas cleaning available)
- \( O_{1.2} \) Output; emissions in collected non treated waste gases (in case of German and Slovenian wood coating, collected non cleaned gas emissions are treated as fugitives)
- \( O_2 \) = Organic compounds that we are loosing in water and effluent
- \( O_3 \) = Quantity that remains on the products as residue, contamination
- \( O_4 \) = Diffuse emission from the air conditioning, through doors, windows.
- \( O_5 \) = Organic compounds that we manage to destroy by chemical reactions, recovery (only if the wastes are cleaned or recycled)
- \( O_6 \) = Organic compounds that we manage to collect as wastes, mud and liquids
- \( O_7 \) = Organic compounds that we sell with the product
- \( O_8 \) = stored organic compounds from recovery, inapplicable if no in-house recovery
- \( O_9 \) = Organic compounds that that release with other ways (exceptional cases)

### Calculation of the VOC value of a product

**generally:**

\[
\text{VOC-Value (g/l)} = \frac{\text{mass of volatile part} - \text{mass water}}{\text{volumen coating material} - \text{volumen water}}
\]

**Coating materials for wood acc. to DIN 11890:**

\[
\text{VOC-value (g/l)} = (100 - \text{nfa} - \text{mw}) \times r \times s \times 10
\]

- \( nfa \) non volatile part (%)
- \( mw \) water part (%)
- \( r \) density of coating material (g/ml)

*Picture 2*  Calculation of the VOC- content in a product
A working EXCEL-Tool can be found under [33]: [http://www.pius-info.de/files/voc_tool_e.xls](http://www.pius-info.de/files/voc_tool_e.xls)

### Solvent Balance 2008 without water based lacquers

<table>
<thead>
<tr>
<th>kg/a</th>
<th>Total annual (lacquers, thinners)</th>
</tr>
</thead>
<tbody>
<tr>
<td>55.518</td>
<td>svOC (Diff. to nFA + VOC)</td>
</tr>
<tr>
<td>41.924</td>
<td>VOC-content</td>
</tr>
<tr>
<td>24.5%</td>
<td>Solid content</td>
</tr>
<tr>
<td>75.5%</td>
<td>VOC-Anteil</td>
</tr>
<tr>
<td>26.150</td>
<td>diffuse emission O4</td>
</tr>
<tr>
<td></td>
<td>collected emission O1</td>
</tr>
<tr>
<td></td>
<td>- in cleaned gas O1.1</td>
</tr>
<tr>
<td></td>
<td>- in collected, non cleaned gas O1.2</td>
</tr>
<tr>
<td>Solid content</td>
<td>13.594</td>
</tr>
<tr>
<td>Solvent Input I1:</td>
<td>41.924</td>
</tr>
<tr>
<td></td>
<td>solvent from the product O7:</td>
</tr>
<tr>
<td></td>
<td>recovered solvent I2:</td>
</tr>
<tr>
<td></td>
<td>solvent for recovery O8:</td>
</tr>
<tr>
<td></td>
<td>solvent rests in product O3:</td>
</tr>
<tr>
<td></td>
<td>solvent in effluent O2</td>
</tr>
<tr>
<td></td>
<td>solvent in waste O6</td>
</tr>
<tr>
<td></td>
<td>solvent (miscellaneous) O9</td>
</tr>
<tr>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

### Total Solvent Emission 26.150

- **Targetemission from 01.01.2013**: 21.750 Range > 5 -15 t/a Solvent consumption
- **Targetemission from 01.11.2007**: 16.313 Range > 15 -25 t/a Solvent consumption
- **Targetemission from 01.11.2007**: 10.196 Range > 25 t/a Solvent consumption

*Without reduction plan, the limit of the target emission cannot be kept!!*

**Picture 3**  
**Example for an EXCEL Tool for calculation**

### Establishment of a VOC-Balance, problems with the data collection can occur:

- Availability of the purchasing amounts and consumption rates
- Declaration of VOC-contents and solid contents of the products
- Not only solvents, but other volatile substances such as softeners are to be taken into consideration
• Lack of data about the recovered solvents
• Incertitude about the VOC-content in the wastes, effluents, outlet air, contents are very alternating

3 Current situation in the field of wood finishing (state of the art) and possibilities to decrease VOC consumption and emissions

Typical working steps of a wood coating process that may cause emissions of VOC are:

<table>
<thead>
<tr>
<th>Step Description</th>
<th>VOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage of lacquers and thinners and transport</td>
<td></td>
</tr>
<tr>
<td>Adjustment of lacquer viscosity, mixing with thinners</td>
<td></td>
</tr>
<tr>
<td>Pre-treatment with Sanding, Staining, Glazing</td>
<td></td>
</tr>
<tr>
<td>Priming</td>
<td></td>
</tr>
<tr>
<td>Sanding</td>
<td></td>
</tr>
<tr>
<td>Topcoat</td>
<td></td>
</tr>
<tr>
<td>Cleaning</td>
<td></td>
</tr>
<tr>
<td>Disposal of wastes</td>
<td></td>
</tr>
</tbody>
</table>

According to the Directive 1999/13/ EC VOC are defined as organic substances with a vapour pressure of \( \geq 0,01 \) kPa at 293,15 K or the particular local conditions.

The solvent consumption is the total amount of organic solvents, which are applied in the production process during the time period of one year, less the amount of volatile organics, being recovered, for re-use.
The picture below shows the principle ways of solvent reduction during the process of wood coating.

![Simplified production scheme of wood coating](picture5)

Therefore we have several technical options to reduce VOC in an industrial plant. First, at the INPUT by use of Low emission products (high solids, waterborne coatings, natural coatings as oils or waxes, powder coatings) or second, at the OUTPUT by Waste Air cleaning (Thermo / catalytic waste air combustion, photo oxidative waste air cleaning, bio filters)

In crafts enterprises like carpenter’s workshop technical options to reduce VOC are more likely to be found at the INPUT of the production.

The following table shows an overview on VOC-contents of common coating products:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Powder coating</td>
<td>0 % solvent</td>
</tr>
<tr>
<td>Waterbased coating, UV-hardening</td>
<td>2 % solvent 40 % solid</td>
</tr>
<tr>
<td>Hot spraying wax</td>
<td>1 % solvent</td>
</tr>
<tr>
<td>Hard wax</td>
<td>16 % solvent</td>
</tr>
<tr>
<td>UV-coating, solvent free</td>
<td>0 % solvent 100 % solid</td>
</tr>
</tbody>
</table>

![VOC-contents of common coating products](picture6)

### 3.1. Low emitting products

#### 3.1.1 High Solids

**Definition:**
- Paints with solid content > 60 w % up to 85 w %
- Binder must be chemically modified to lower intrinsic viscosity
- Additives are often used to increase cross linking
**Binders:**
Alkyd resins, polyester resins, polyurethanes, acrylic resins, epoxy resins

**Application:**
Conventional spray guns, heated spraying systems

### Table 10  Advantages of high solid lacquers

<table>
<thead>
<tr>
<th>Pollution Prevention Benefits</th>
<th>Surface quality</th>
<th>Operational Benefits</th>
<th>Economic benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce solvent in coatings (low VOC)</td>
<td>Improve abrasion and mar resistance</td>
<td>Can apply thick or thin coat</td>
<td>Decreases energy costs associated with reduced curing times</td>
</tr>
<tr>
<td>Have less overspray compared to conventional coatings</td>
<td>Same as conventional coatings</td>
<td>Have easy colour blending or changing</td>
<td>Reduce number of spray applications to achieve a given film thickness</td>
</tr>
<tr>
<td>Reduces environmental, safety and odour problems</td>
<td></td>
<td>Are compatible with conventional and electro-static equipment</td>
<td></td>
</tr>
<tr>
<td>Reduce fire hazards</td>
<td></td>
<td></td>
<td>Reduce inventory</td>
</tr>
</tbody>
</table>

**Disadvantages – unsolved problems**
- Generally requires high cure temperatures
- Is sensitive to inadequate cleaning of substrate
- Is extremely sensitive to temperature and humidity
- Is difficult to control film thickness
- Has tacky overspray; difficult to clean
- Might require paint heater in system
- Has narrow "time-temperature-cure" window
- Cannot use dip or flow coating
- Is difficult to repair
- Solvent use not completely eliminated
- Has shorter pot-life than conventional coatings

**Markets**
- 2K- liquid coatings widely used for auto and appliance coating
- Wood coating: 100% UV-High solids, if plane samples have to be coated

**Cost and Implementation Issues:**
- Capital cost for application equipment similar to low solid coatings
- Coating systems itself slightly more expensive
3.1.2 Waterborne Coatings

Definition:
Contain up to 80 % water as solvent, small amounts of other solvents (Glycol ether)

Binders:
All types of resins available, additives are often used to increase cross linking

Types:
- Water-soluble (VOC < 10 to 15%)
- Water dispersible (VOC < 5%)
- Emulsions
- Water based alkyds

Application:
Comparable with solvent borne coatings
Depending on the requirements different products are available today:

Table 11 Use of water borne coatings:

<table>
<thead>
<tr>
<th>Products</th>
<th>Substrates</th>
<th>Kind of application</th>
<th>Furniture and others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparent opaque, or fully pigmented</td>
<td>Wood Veneers (oak, beech, pine, Cherie), plywood MDF Decorpaperfoils Plastics</td>
<td>Roller coating Spraying Curtain coating</td>
<td>Kitchen Bathrooms School office Windows Doors Stairs Floorings etc.</td>
</tr>
</tbody>
</table>

Sorts of Waterbornes:

3.1.2.1 1K-waterbornes, physically drying, not self - cross linking (NSV)
- Have been the first lacquers for industrial coating of wood and wood based materials
- Replace typical NC-Lacquers
- Regularly built from Acrylic dispersions or polyacrylates
- For furniture surfaces with low quality requirements (reverse sides, as primers)

Do not fulfill the demanded parameters for furniture surfaces acc. to DIN 68861/part 1!!!

3.1.2.2 1K- waterbornes, physically drying, self-cross-linking (SV)
- Regularly built from acrylic dispersions, cross linking with chemical hardeners (Dihydrazide) or complexing with metal-amine-complexes
- Fulfill the demanded parameters for furniture surfaces acc. to DIN 68861m Part 1B and the IKEA-Parameter R4 and R2 (IOS-MAT-0066/20.01.2006)
- Used as primers, top- or multilayer coatings for furniture and chairs
- Can be coated with conventional solvent borne NC- or PUR-lacquers after sanding the surface

A good alternative for the solvent containig NC-products !!

3.1.2.3 1K-UV-curing waterbornes, physically or non physically drying
In the seventies: Beginning of development, former coalescent problematic, non-physically drying, sticky layers, dust embeddings

In the eighties: Mixtures of physically drying acrylates with UV-curing oligomers prevented the sticky surfaces, but mixtures often not stable.

Today: 3. generation of UV-curing PUR-dispersions (for 10 – 12 years), physically drying, non-sticky films, mostly without co-solvents or reactive thinners, high elastic but hard, easy to matt

Application:
- No pot life
- Application viscosity often about 30 – 40 s (4mm)
- Drying at 40 – 45 °C in 6 – 12 min. followed by UV-hardening (Hg-high-pressure-lamp, 80 W/cm), feed 3 – 5 min.

Surface Properties:
- Gloss from blunt matt to medium gloss
- Resistance against chemicals acc. to DIN 68861, part 1B fulfilled

Use:
- Transparent and pigmented, as primers or topcoats
- Furniture for Kitchens, Bathrooms, Living and sleeping rooms, stairs, claddings, doors and chairs

3.1.2.4 2K-Polyurethane (PUR)-waterbornes, with Polyisocyanate as hardener

Originally it seemed to be impossible to produce aqueous polyurethanes because of reaction between hydroxyl groups from water with Polyisocyanate, building CO₂-film. At the end of eighties first products came up with the development of subtle, aqueous, coalescent with emulating properties (polyacrylates). Side reactions could be reduced drastically.

Application:
- Very short pot life (2 – 4 hours), less than in solvent-based!!
- Viscosity is not influenced, hardener Polyisocyanate must be added shortly before application, short increase of viscosity, followed by a decrease after 10 to 20 minutes, in dependence on the product
- Mixing with hand causes a bad filming and resistance of the lacquer films
- Automatic mixing demanded!
- Drying time at room conditions: (23°C/50%) 12 – 16 hours
- Forced drying (40 – 45°C): 6 – 8 hours
- Drying time with chemical curing: 5 – 7 days

Surface Properties:
- As well as solvent based systems

Use:
- Transparent and pigmented, as substitutes for solvent borne PUR-lacquers
- Kitchens and offices furniture

3.1.2.5 2K–PUR-UV-curing waterbornes (Dual Cure Systems)

Have been developed to reduce long time drying 2K-PUR-Systems. Combination of UV-hardening and hydroxyl groups containing filmbildners (Polyisocyanate)
Drying time (forced drying at 40 – 45 °C): 6 – 20 minutes, depending on the profiles of the sample (flat or 3D)

Used in industrial kitchen production

### 3.1.2.6 Advantages of Waterborne- Coatings

**Table 12 Advantages of Waterborne - Coatings**

<table>
<thead>
<tr>
<th>Pollution prevention benefits</th>
<th>Surface quality</th>
<th>Operational benefits</th>
<th>Economic benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eliminates or reduces solvent in coating (little or no VOC)</td>
<td>Has good to excellent surface properties</td>
<td>Can apply thick or thin coat</td>
<td>Can recover and reuse some waterborne paints, increasing transfer efficiency</td>
</tr>
<tr>
<td>Uses water for cleanup</td>
<td>Gloss</td>
<td>Has easy colour blending or changing</td>
<td>Higher solid content causes less lacquer consumption /m2</td>
</tr>
<tr>
<td>Reduces toxicity and odour, resulting in improved worker safety and comfort</td>
<td>Rub resistance</td>
<td>Is compatible with conventional and electrostatic application equipment</td>
<td></td>
</tr>
<tr>
<td>Minimizes or eliminates disposal of hazardous waste</td>
<td>Anti-sealing effects</td>
<td>Has good storage life Can be stacked shortly after application and drying</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non-yellowing films</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 3.1.2.7 Disadvantages of waterborne coatings

- High surface tension of water
- Corrosion of storage tanks and transfer piping, and "flash rusting" of metal substrates
- Is complex to convert solvent-borne coating line, i.e., stainless steel, plastic lines, valves and other ancillary equipment are needed
- Swelling of wooden substrates
- Needs energy and space for drying
- Has tendency to foam
- Requires clean surface for high quality application; surface must be free of oil and dust
- Requires longer drying times or increased oven temperatures
- Has difficulty obtaining high gloss finish
- Has difficult cleanup once coating is cured
- Has higher cost per litre on an equivalent solid content basis compared with conventional coating (but applied amounts may be less)
- Does not have many resins available for waterborne formulations

### 3.1.2.8 Markets for of waterborne coatings

Increasing importance, even in wood coating, depending also on new drying technologies.
3.1.2.9 Cost and implementation issues for waterborne coatings

- More expensive than conventional coatings
- Costs for application equipment tends to be greater (stainless steel to protect against corrosion in storage tanks, pipelines)
- Special drying technologies necessary
- Smoothing of the wooden surface to remove swollen fibres

3.1.2.10 Application challenges with waterborne coatings

Application of waterbornes demands a complete rethinking by users!

- Application at ideal climate conditions (20 – 23°C, 65% rel. air humidity, if higher a delay of curing a delay of curing is to be expected)
- Temperature of the lacquer and substrates (20 – 23°C, if below 20°C, problems with filming)
- Wood moisture (8 – 12 %, if below, drying to quick, problems with filming)
- High surface tension demands other spraying pressures
- Swelling of the wooden surface caused by water
- Thin primer layers (60 – 80g wet application) needed higher sanding effort

“Doubling of the applied amount: forefouls time of drying!”

- Warming up of the substrate hinders swelling
- Sanding of the surface with smoother paper (180 – 220 PK)
- Very clean surfaces necessary otherwise bad wetting
- Time periods of penetration of water into the wood surface may last between:
  - A few seconds on fresh-sanded pinewood
  - Up to a quarter of an hour on oak veneer surfaces
  - Longer than one hour on MDF surfaces
- Spreading process of the surface may substantially be influenced by a forced lacquer-drying procedure

3.1.2.11 Problems with wooden substrates of waterborne coatings

- Cause swelling of the surface
- Enhances sanding efforts
- Can have poor penetration and adhesion properties, particularly with emulsion coatings on porous surfaces
- Alkaline pH reacts with ingredients of wood (oak – green colour, pine - yellow colour)
- Adhesion problems on knotholes, age of pine wood has an influence
- Waterbornes have a lower “lightning behaviour” which is not problematic for bright woods,
- Dark wood (cherry, mahogany) need a stain or coloured lacquer layer to equal and give the right lightening behaviour

3.1.2.12 Factors which influences coating and swelling of the surfaces

- Species of wood, wood moisture
- Kind and time of pre-treatment
- Roughness of the material surface
- Composition, viscosity and surface tension of the liquid phase
- Chemical composition of binder and additives
- Time periods for water to penetrate into the surface
3.1.2.13 Recommended application conditions for 1K Waterbornes:

- Application amount: 80 – 90 g/m²
- Application temperature: 23°C
- Rel. air humidity: 50%
- Drying parameters: supply air 20 – 50°C
- Rel. air humidity of supply air: 70%
- Flow rate on the lacquer surface: 0.5 – 1.2 m/s
- Lacquer ready to staple: 15 – 30 min (dust dry)
  45 – 60 min ready to sanding
  8 – 12 hours ready to staple

4.2.2.14 Further information material for water borne lacquers for wood coating

http://www.3p-icc.de/media/e6f0f074935538afffff81c8ac14422e.pdf - water based lacquers for kitchen furniture, German version
http://www.3p-icc.de/media/7136f4a2d2106c01f81d5ac14422f.pdf - water-borne lacquers, overview, English version
http://www.3p-icc.de/media/W%C3%8ssrige-UV-%C3%9Charte-Lacke-%C3%9Crne-%C3%9Cberblick-04-09-2008.pdf UV-curing water based lacquers
http://www.bayercoatings.de/bms/db-rsc/bms_rsc_cas.nsf/files/_Presseinformationen/$file/Holz_Polyurethanlacke_Irle_Presseinfo.pdf, water based polyurethanes (German version)

3.1.3 Natural coating systems (Oils and waxes)

Definition:
Coating systems, basing on natural mostly oxidative drying raw materials

Binders:
- Drying vegetable oils (linseed oil, wood oil, saflor oil)
- Semi drying vegetable oils (soybean oil, rape oil)
- Non-drying vegetable oils (olive oil, coconut oil)
- Naturally waxes (beeswax, carnauba wax)
- Shellac

Application:
- Very easy
- Spraying, roller coating, curtain coating possible
- Hot spraying cartridge pistol recommended for hot wax spraying

Use:
Not for all purposes
High-quality massive wood furniture (doors, furniture for sleeping rooms, living rooms, kitchens

Advantages:
- Environmental friendly
- Easy to repair surfaces
- Wood stays visible in it’s structure and colour
- Open porous coating
Disadvantages:
- Not for high resistance surfaces
- Up to now hardly applied on industrial scale because of long drying times
- Oxidative drying oils are self inflammable, special attention has to be paid on contaminated materials and equipment

Never work with NC-lacquers and oils or waxes at one spraying device!!

Costs and implementation issues: I
- Not more expensive than conventional coatings
- Costs for application equipment lower or similar
- Special drying technologies necessary, if used in industrial scale

3.1.3.2 Further information material for application of natural based coating systems

http://www.3p-icc.de/media/5e55d0a1e71c9bdeff86ecac144221.pdf, surface coating of parquets and wooden floorings

3.1.4 Powder Coatings

Definition: 100% resin in dry, powdered form
Works on principle of opposite charges attract
Powder coated surface is pulled through an oven where powder melts and fuses into a smooth coating

Binders:

Thermo set resins
Crosslink to form a permanent film that withstands heat and cannot be remelted
- Epoxies lack ultraviolet resistance not recommended for outdoor use
- Epoxy Polyester-Hybrids used for decorative applications, more resistant to light, lower surface hardness
- Urethane polyesters formulated with polyester hydroxyl resin combined with blocked isocyanate hardeners exhibit outstanding thin film appearance and toughness as well as good weathering properties.
- Acrylic-urethane coatings acrylic resins cross-linked with blocked isocyanates excellent colour, gloss, hardness, weather ability and chemical resistance, and excellent thin film appearance, less flexible than polyesters.

Thermoplastic resins:
Melt and flow, when heat is applied, but do not undergo a change in molecular structure, can be remelted after they have been applied
- Polyethylene often used as coatings for laboratory equipment.
- Polypropylene surfaces might be exposed to chemicals.
- **Nylon** excellent abrasion, wear and impact resistance, commonly used as a mechanical coating for sliding and rotating bearing applications in appliances, farm equipment and textile machinery

- **PVC** good durability as well as flexibility; dishwasher trays are an example of a product coated with PVC

- **Thermoplastic polyester** good exterior durability and weather ability. The coating does not usually require a primer for good adhesion to most metals. These materials are often used on outdoor metal furniture

### New Developments for wood coating

- **Lower-Temperature Cures**: Powder coatings with very high reactivity have been developed to cure at temperatures as low as 121°C

- **UV powder coatings**: Much less thermal exposure to the surface, advantages of UV-cured surfaces (higher quality and resistances)

  **Limitations:** Yellow shades are difficult to cure and are, at present state of the art, best avoided. The production of fully flat matt finishes has also not as yet been demonstrated. With regard to the curing line, it is important that the curing equipment be installed in such a way that objects of different geometries can be cured, so as to ensure full flexibility of production. Here creative solutions must be found if the technology is to realise its full potential in the manufacturing industry

- **Conductive wooden substrates (MDF) for Electrostatic spraying**
Table 13  Application methods for powder coatings

<table>
<thead>
<tr>
<th>Characteristic of Work piece</th>
<th>Electrostatic Spray</th>
<th>Fluidized Bed or Electrostatic Fluidized Bed</th>
<th>Flame Spray</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>Larger</td>
<td>Smaller</td>
<td>Not limited</td>
</tr>
<tr>
<td>Material</td>
<td>Metallic, must be conductive</td>
<td>Any, except wood, not necessarily conductive</td>
<td>Any, not necessarily conductive</td>
</tr>
<tr>
<td>Aesthetic Value</td>
<td>High</td>
<td>Low, not suitable for decorative purposes</td>
<td>Low, not suitable for decorative purposes</td>
</tr>
<tr>
<td>Temperature Resistance</td>
<td>Relatively high</td>
<td>High</td>
<td>Not relevant</td>
</tr>
<tr>
<td>Type of Coatings</td>
<td>Thermoplasts and thermosets</td>
<td>Thermoplasts and thermosets</td>
<td>Thermoplasts only</td>
</tr>
<tr>
<td>Colour Change</td>
<td>Difficult</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>Capital Investment</td>
<td>Moderate to high</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>Energy consumption</td>
<td>Only post heating</td>
<td>Preheating and often post heating</td>
<td>Low, no preheating or post heating</td>
</tr>
<tr>
<td>Coating wastes</td>
<td>Very little</td>
<td>Very little</td>
<td>Depends on the work piece geometry</td>
</tr>
</tbody>
</table>

Advantages:
Reduces cost due to
- No solvents
- No solvent flash required
- No coatings mix room needed
- Minimal oven length
- Low ventilation required
- Less floor space, two thirds to three quarters of wet paint systems less floor space, two thirds to three quarters of wet paint systems
- Improves finish quality and surface durability
- Good corrosion resistance
- Coating utilization efficiency 95 – 99 %
- Coating utilization efficiency 95 – 99 %
- Saves energy
- Variety of resins available
- No hazardous overspray, waste, sludge or contaminated water

Disadvantages
- Powder manufacturing limitations at small amounts, control of texture size and distribution is limited
- Metallic powder coatings not as attractive as liquids
- Recirculation system creates negative pressure in booth
- Needs gentle air stream to apply powder
- Enhances Faraday Cage effect
- Difficult to achieve thin films below 1.0 to 1.5 mm
- Colour change difficult
- Needs cool dry storage area substrates
- Heat requirement, restrictions on
- Substrates must be pre-treated
Markets:
- Metal-finishing appliances
- Lawn and garden, architectural applications

Ongoing research and development of lower temperature, UV-curable powder coating materials demonstrates the viability and tangible features and benefits of this market. The result is steady growth of powder on wood applications. According to a recent report by The Fredonia Group, demand for powder coatings in the U.S. alone is forecast to increase to 505 million lb in 2005 (from 140 million lb in 1990), due in great part to “suppliers rapidly expanding the functional range of powders into wood and plastics, which is opening new applications for these coatings.”

Cost and Implementation Issues
- To introduce powder coating to an existing paint line, a capital investment in special equipment must be made.
- Pre-treatment of the part to be coated also needs to be quite thorough, which can add to the overall cost.
- For entirely new lines, however, investment in powder application equipment is comparable to that of equipment for liquid coatings (VT DEC).
- In addition, the cost of producing a finished coating is typically lower with powder coating than conventional coating because maintenance and operating costs are less, particularly for operations that use a single colour.

3.2 Coating technologies with improved efficiency

The coating of wooden surfaces with new emission poor materials is a very complex process, which depends on many influences as seen in the picture below.

Besides the coating materials technological factors contribute decisively to the surface qualities. There are a great number of application technologies for wood coating processes existing.

Beside the conventional application methods like roller coating, curtain coating and the conventional painting, new spraying technologies with and without pressure have been developed with the aim to increase the regularity of the surface, the independence of the sample geometry and the transfer efficiency.

Electrostatic spraying application was developed particular for 3D-application (chairs, tables).
### Table 14  Overview on application technologies for wood coating

<table>
<thead>
<tr>
<th>Application method</th>
<th>Transfer efficiency [%]</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
</table>
| Conventional painting              | 95-100                  | • High transfer efficiency  
• Easy and cheap                                                                        | • Limited regularity of the surfaces  
• Takes a lot of time                                                               |
| Curtain coating, roller coating     | 95                      | • High transfer efficiency                                                | • Limited by geometry of the products                                          |
| Conventional spraying               | 30-60                   | • High surface quality  
• Can be exactly adapted on the substrate  
• Good for small series  
• Easy and cheap                                                                       | • High amount of over spray  
• Only materials with low solid content  
• Low efficiency                                                                     |
| Hot spraying                        | 40-60                   | • High surface quality  
• Shorter drying times  
• Also for high viscous materials  
• Saving of solvents  
• Good colouring and brilliance                                                       | • Cruder nebulization  
• Slower working speed  
• Only for lacquers with high solid content                                                |
| Airless spraying                    | 40-75                   | • No bubbles on the surface  
• Less lacquer consumption as Air mix  
• Low spraying exhalation  
• Very quickly coating of great areas                                                  | • Staining and patination not possible with high pressure spraying  
• Difficult to adjust the applied quantity                                               |
| Air mix spraying                    | 35-50                   | • Low spraying exhalation  
• Easy to adjust applied quantity  
• Also for materials with higher solid contents                                        | • Cruder nebulization as with airless spraying  
• Only for high quantities  
• Much material needed for filling the pumps and tubes                                   |
| HVLP-spraying                       | 60-80                   | • High efficiency  
• Low spraying exhalation  
• Low energy consumption  
• Ideal for small areas and repairing  
• Also for edges, corners and cavities  
• Good for low viscous materials                                                      | • Cruder nebulization as with conventional spraying  
• Viscosity of the lacquer must be adapted to the spraying pressure and pistol  
• Slower working speed                                                                 |
| Electrostatic spraying, Powder      | 50-70                   | • Shorter application time  
• Equal layer thickness  
• Perfect coating of edges  
• Hardly solvent consumption                                                          | • Needs electric conductible substrates  
• Needs higher protection measures because of electric charging                       |
| Electrostatic spraying, Powder      | 80-95                   | • High transfer efficiency  
• Overspray can be reused                                                            | • Needs electric conductible substrates, currently only for MDF possible         |

The following link gives a more detailed overview on the several spraying application methods

Influence factors on the quality of coated surfaces

**Lacquer properties**
- Additives
- Binders
- Viscosity
- Temperature
- Filmbildners
- Solution
- Emulsion
- Defoamers
- Dispersion

**Drying technology**
- Air temperature and moisture
- Air velocity
- Heat transfer
- Influence on the curing process

**Application**
- Airless
- Airmix
- Roller coating
- Multilayer-
  Composition on solvent borne primers

**Lacquer surface**
- Intensification
- Brilliance
- Optic / Haptic mech. / chem. resistance
- Air embeddings
- Interferences
- Discoloration
- Loss of brilliance

**Substrate Wood**
- Wood density and porosity
- Ingredients
- Temperature
- Wood moisture
- Surface roughness

**Room climate**
- Gentle
- Forced

**Water penetration time**

**Number of sanding steps**
3.3 Drying technologies

As is generally known, the limit values to be complied with in any place where spray application must be used (e.g. lacquer-coating of profiled parts, lacquer-coating of finished parts) can only be observed – according to current knowledge – by applying waterborne coating systems.

Meanwhile, materials on a waterborne basis with several resins are available whose surface properties are hardly inferior to the solvent-containing coating materials or are even superior to them. In spite of this, waterborne lacquers only become accepted in the furniture industry extremely slowly. Their main disadvantage is seen in the correlation between water as a thinner and the hygroscopic properties of all wood-based materials as the substrate, whereas swelling processes narrow the technological window and require pre-treatment adapted to the respective substrate, e.g. by sanding as well as by intensive intermediate sanding in applying multi-layer coating.

Hence, the swelling effects of the wood surface remain to be the fundamental hindrance for the swift market introduction of waterborne lacquers. Beside the right preparation of the substrate and working under defined climate conditions /1/ a quick drying can lower the swelling effect.

Within the last years numerous forced varnish-drying methods have been developed, which shall ensure a gentle drying of the varnish surface. Meanwhile a great variety of combinations of forced drying came into existence, however not being evaluated scientifically regarding their effectiveness as well as possible reductions for use.

A neutral, manufacturer independent analysis on advantages and disadvantages of the special drying methods was given by a research project carried out by IHD. /…/ , comparing all the just available drying technologies for waterborne lacquers.

Drying technologies can base on the following principles:

Convection

Jet Drying is beside the flat channel the most spread quick drying method for drying water lacquers and a pure convection drying. Tempered and filtered air is blown regularly on the surface of the substrate with air velocities from 1 to 30 m/s. This leads to a strong turbulent flow directly on the surface of the work piece. The escaping air is mixed with fresh air and recirculated to the process in order to avoid saturation with steam. The air moisture, setting up herewith strongly depends on the water amount to be evaporated and the outer climate influences. In order to get a faster and more specific drying the jet dryer is supplied in some cases with infrared radiators which can be adapted to the substrate.

Drying with demisted air

This principle is basing on extremely dried and warmed air, detracting water from the lacquer. One can differ between cold and adsorption drying.

Cold drying was specially developed for water born lacquers and bases on condensation in freezing out the water from air by means of a heat exchanger. The adsorption drying is used rarely because of the more intensive demands for attendance. Here moisture is adsorbed by special hygroscopic materials, which only have a certain capacity. By means of condensation and adsorption relative air moisture up to 10% can be realized. Because of circulation the process can be driven very economically. /19/

A special kind of condensation drying is the Hydrex method also named Hygrex- or Dry air method. Concerning the air circulation it is similar to the jet dryer with the advantage that a pure circulation process is possible by the condensation of the moisture. This can be reached by use of two cooling aggregates which one being busy freezing the water from air and the other defrosting meanwhile. The dehumidification of the air assures a consistent relative air moisture at every time in the drying area what makes the system independent from weather influences.
For industrial pants from 6m lengths a gradual increase of the vapour pressure decline provides for a gentle and regular drying.

**Thermal radiation**

Thermal radiation caused by electromagnetic waves as special kind of energy, which can be emitted or absorbed by matters. General the degree of efficiency of aligned radiation is much higher than convection because of no fluid is needed for the heat transport. So the energy transfer also can take place in vacuum.

The spectra of infrared radiation lie between 0,780 and 1000 µm and is therefore not visible to human eye. Men notice infrared radiation as warmth.

Materials differ in their absorption capacity. For water a radiation with a wavelength of 3,4 µm is the optimum. In order to activate different materials several spectral ranges are available.

**Table 15: Spectral areas of infrared radiation**

<table>
<thead>
<tr>
<th>Name</th>
<th>Short name</th>
<th>DIN</th>
<th>Wave length area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Near Infrared</td>
<td>NIR</td>
<td>IR-A</td>
<td>0,78 – 1,4 µm</td>
</tr>
<tr>
<td>Short waved Infrared</td>
<td>SWIR</td>
<td>IR-B</td>
<td>1,4 – 3 µm</td>
</tr>
<tr>
<td>Middle waved Infrared</td>
<td>MWIR</td>
<td>IR-C</td>
<td>3 – 8 µm</td>
</tr>
<tr>
<td>Long waved Infrared / Thermal Infrared</td>
<td>LWIR / TIR</td>
<td>IR-C</td>
<td>8 – 15 µm</td>
</tr>
<tr>
<td>Far Infrared</td>
<td>FIR</td>
<td></td>
<td>15 – 1000 µm</td>
</tr>
</tbody>
</table>

For installation engineering infrared radiation is applied as single lacquer drying method only in few cases. More often it is used in combination with jet dryers or flat flash channel where IR carries the warming up and jet dryer the transport of the evaporated water.

A special kind of thermal radiation dryer is the so-called OIR-Dryer. It has been extra conceived for waterbornes and works with infrared radiators with emission spectra particularly tuned to the absorption curve of water molecules and being directly regulated. Coincidentally cooled air with low velocity (0,5 to 1,5 m/s) is blown across the substrate. The air is cooled down in a separate cooling aggregate what increases the air humidity to 90%. Because of this high humidity convection can only go on very slowly inside the dryer what prevent the surface from early filming and forming a skin. The lacquer is dried from inside to outside. This allows a gentle drying for smooth surfaces.

**Dielectrical drying**

Dielectrical radiation differs from infrared in the frequencies, means that whole molecules can be activated but not only molecule bonding. A polar molecule structure as it is given in water is the precondition for a drying process in an electrical changing field. Electrical dipoles line up themselves in the alternating electrical field and start to rotate. This causes inner frictions and a warming up of the water what activates evaporation. By this step only warming up can be initiated. Dielectrical drying must as well as infrared drying be combined with a step to transport the moisture away.

Examples for dielectrical drying are microwave drying and drying in a high frequent stray field.

A microwave dryer produces highly frequented electromagnetic waves in a range of, 2,45 GHz with wavelength of about 12 cm (industrial applications) by means of magnetic field tubes, the so-called magnetrons. The degree of efficiency is influenced by the strength of the microwave field, the frequency and the corresponding loss value of the lacquer system. The field strength can be directly regulated by the power spectrum of the magnetron. The magnetrons have to be aligned in a way that the most regular power can be given onto the surface.
Differing from microwave systems dryers working with highly frequented stray field the field is built up without magnetic field between stick electrodes switched in row. The frequency for this method is 27.12 MHz (German value) with a wavelength of about 11m. The warming up of the lacquer layer takes place capacitive where the in- and outlet must be insulated from radiation. Because of the much longer wavelength it is less complicated as with microwave radiation. Simultaneously with the action of the high frequency field the substrate is passed by a stream of warm air (about 30°C) in counter current to the direction of the feed motion.

The total efficiency of this drying system is between 65 to 70 %.

A short overview is given in the following table. More detailed information about the principles of the technologies can be received in a special brochure from the German Association DFO “Guideline of forced drying methods for water borne lacquers” or here:

http://www.egl-online.de/deutsch/pdf/5087-mo/02-03-02.pdf
http://www.wave-tec.de/Artikel%20JOT.pdf

<table>
<thead>
<tr>
<th>Table 16</th>
<th>Summary of drying technologies for water borne coatings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>Advantages</td>
</tr>
</tbody>
</table>
| Jet Dryer (JET) and Jet Dryer combined with infrared dryer (JET/IR) | • Reasonable price for purchase  
• Low energy consumption  
• Further savings potential by heat exchange  
• Good surface resistance properties  
• JET also usable for gloss and coloured lacquers | • Small technological window  
• Desiccation cracks or enhance  
• Influenced by climate and air humidity outside of the dryer  
• Integrated infrared furthermore diminishing the technological window and degrades optical and haptic properties  
• IR not applicable for brilliant and gloss lacquers or dark colours |
| Hydrex Dryer combined with Jet Dryer (HYD) / (JET) | • Gentle drying  
Excellent optical and haptic properties  
• No influence of atmospheric environment  
• Also applicable for brilliant and gloss lacquers or dark colours | • Longer drying periods and plants  
• Dirt and dust embeddings  
• Lower mechanical resistance of the surfaces  
• Long acceleration time for dehumidification  
• Drying from outside to inside, skin forming possible  
• Must be combined with JET |
<table>
<thead>
<tr>
<th>Microwave dryer followed by Jet dryer (MIW) + (JET) and Microwave dryer followed by combined Jet-Infrared dryer (MIW) + (JET-IR) (Tested with transparent lacquers)</th>
<th>• Strong shortened drying time  • Drying occurs from inside to outside  • No skin formation  • No acceleration time  • Relative high mechanical resistance</th>
<th>• High investment costs  • Inhomogeneous field distribution  • Inhomogeneous heating  • Complete substrate heat through  • Mobilisation of moisture from the inner substrate to the surface, water embeddings in the lacquer  • Enhanced roughness of the surface  • Combination with IR lowers roughness but limits the technological window  • Metal and conductive materials may not be used!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Microwave dryer with integrated jet dryer <strong>MIW /JET</strong> (Tested with pigmented and brilliant lacquers)</td>
<td>• Strong shortened drying time by integrated air circulation  • Short length of drying facility because of samples move in a shuttle mode  • System is compact, mobile and can be applied also in small firms  • Variable switching on and off of magnetrons and JET-drying  • More gentle drying possible with better optical results  • Also applicable for brilliant and gloss lacquers or dark colours</td>
<td>• Complete substrate heat through  • Mobilisation of moisture from the inner substrate to the surface not avoided anytime  • Results can differ in dependence of lacquer composition  • Metal and conductive materials</td>
</tr>
<tr>
<td>Oriented infrared dryer with integrated jet dryer <strong>OIR / JET</strong></td>
<td>• Comparable economic combination of pre-drying and jet-drying  • Gentle drying of the lacquer film from inside to outside  • Only surface heating  • Independent from atmospheric environment  • Also applicable for organic solvents!</td>
<td>• High investing and energy consumption costs  • Long acceleration time  • IR-energy can not be adjusted to the amount of drying material  • Seemed not to be applicable for brilliant lacquers</td>
</tr>
<tr>
<td>High frequency dryer <strong>HF</strong></td>
<td>• High energy efficiency  • Low costs for electricity  • No acceleration time  • Equal heating of the surface  • Only heating of the outer layers</td>
<td>• Technology under development  • High investing costs  • Only conductive substrates  • Technology and drying times strongly depend on the lacquer composition  • Additives which increase conductivity seem to be of advantage  • Must be combined with JET or other thermal step in order to evaporate rest solvents  • Combination of HF/JET or HF+DTK are recommended</td>
</tr>
</tbody>
</table>
Generally a definitely classification turned out to be very difficult because of no technology proved to be the ultimate best one for every use. Rather every technology featured as well advantages as disadvantages for several parameters.

Generally two main tendencies clarified: Slow and gentle drying, reached with Hydrex leads to beautiful and smooth optic and haptic but increases chemical and mechanical resistance of the surfaces.

Thermally forced drying (IR, Microwave) results in highly resistant but rougher surfaces with less feel so finally the need of the user must help to decide.

OIR mostly combines both tendencies.

HF- technology seems to be auspicious, but not fully developed.

Furthermore the drying also depends on lacquer composition and additives.

Finally a recommendation of the best technology can only be given concerning the special conditions and necessities of each applicant. Therefore the results and the built up cost model can be an important help as well for small traders as for industrial applicants.
3.4. Waste air cleaning

If the reduction of emissions at the input of the production line isn’t possible what may occur because of the particular product quality requirements, which can only be secured by solvent borne lacquers, and the target emissions of a reduction plan cannot be kept, a waste air cleaning is necessary.

Concerning the investigated wood coating plants must be estimated, that the predominantly number of enterprises will not need or cannot afford an expensive thermal waste gas cleaning because of the small flow rates. For this purposes special new technologies, basing on oxidative catalytic processes have been developed and are under investigation.

3.4.1 Thermal / catalytic waste air combustion

During the thermal waste gas cleaning, the harmful substances (VOCs) shall react at ignition temperature preferably completely with Oxygen to inorganic reaction products like Carbon dioxide and Hydrogen.

In order to decrease the necessary activation temperature, the calcinations chambers are run with catalysts (catalytic post combustion KNV) or with ceramic heat exchangers (regenerative post combustion RNV)

Cleaning waste air catalytically is, if around the sinking of operating costs, the most economical alternative in the form of additional energy it goes.
The advantage lies in the low operating costs by low burning temperatures

Precondition
For pollutants which can be burned by means of use of a catalyst
Usable, if no catalyst poisons (sulphur, heavy metal, silicones), are contained in the waste air.

Example: Adsorptionsrad + TNV: Kitchen production:
- Waste air flow: 19.500 – 63.500 Nm³/h
- Raw gas concentration: about 700 mg C/m³
- Reduction of the relative moisture of the raw gas flow from 95% to < 50% by heating
- Transfer to Adsorptionsrad: Dedusting to <50 mg C/m³
- Disposal of the concentrated Desorption flow in the TNV: max. 20 mg C/m³, 100 mg/m³ CO, 100 mg/m³ NOx

Quelle: Fa. Eisenmann 2003

Example: Adsorptionsrad + TNV: Kitchen production

The catalytic cleaning waste air plant is suitable for businesses with:
- Little to middle waste air crowd 50 to 30.000 M³/h
- Little to middle concentration of pollutants 0.5 to 20 g/M³
- Continuously production process (one by the hour or on a daily basis)

It is mainly applied in:
Synthetic material industry, solution processing chemical industry, printeries and businesses, which deal with floor renovation, not so often in the wood and wood, based industry.

Here the concentration of carboxylic substances in the waste air is often not so high. Therefore they must be concentrated before being cleaned. Otherwise it leads to high risk of unnecessary energy consumption, evaporation of carbon dioxide and cause more damage to environment than the VOC itself.

In the following part some of the alternative developments of waste gas cleaning for low concentrations are summarized:

Table 19 Survey on waste gas cleaning technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Use</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active carbon filter</td>
<td>Up to 800000 Nm3/h in combination with RNV/TNV with high loading with Carbon</td>
<td>Low investment, low energy consumption, Often combined with TNV or/and RNV</td>
<td>Hazardous waste, low durability, high running costs</td>
</tr>
<tr>
<td>Adsorption technology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bio filter</td>
<td>Up to 2g / m³ VOC at big volume currents</td>
<td>Simple technology, low energy consumption, low running costs</td>
<td>Dedusting often not sufficient</td>
</tr>
<tr>
<td><a href="http://www.hesse-">http://www.hesse-</a></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method</td>
<td>Description</td>
<td>Applications</td>
<td>Advantages</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Biofilter (ind_biofilter)</td>
<td>For higher VOC concentrations (&gt;5g/m³) and lower gas streams a combination of bio filter and adsorber is recommended. Used for nitrocellulose varnishes and polyesters.</td>
<td>Low investment costs (20 – 30%) and by 50% lower operating costs opposite the catalytic combustion process. Good for low gas concentrations.</td>
<td>Need a lot of space and daily care. Oxygen and nutrients concentration have to be kept. Need time to adapt if coating process changes to other products.</td>
</tr>
<tr>
<td>Thermal post combustion (TNV)</td>
<td>For volume streams from 2.000 - 120.000 Nm³/h for higher volume streams several reactors are run parallel.</td>
<td>Technical perfect. Very high cleaning rate at high volume streams and high concentration of organic carbon.</td>
<td>High investing enormous energy consumption operating temperature &gt;800°C.</td>
</tr>
<tr>
<td>Regenerative post combustion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catalytic treatment (KNV)</td>
<td>Autothermal operation from 3-5 g/Nm³. Suitable for low to middle loadings.</td>
<td>Energetically more favourable as TNV. With high volume streams and high concentration of organic carbon.</td>
<td>High investing enormous energy consumption operating temperature 350 - 450°C.</td>
</tr>
</tbody>
</table>
| Catalytic treatment with pre-concentration of VOC in the waste air streams | For C-concentrations from 10 – 1000 mg/m³:  
  - Outlet-air from water lacquer dryers  
  - Outlet-air from spraying cabins for water based or solvent based lacquers | Needs low space, suitable for back fitting of plants. Essential lower operating temperature and therefore energetically more favourable as TNV and KNV. Insensitive against alternating concentrations. Can be combined with other technologies. | Regular maintenance necessary (Time period of several years) Systems has to be adapted to the special recommends of a producer No known example in the field of wood coating. |
| OWL-Ozone-low-temperature-catalysis        | For C-concentrations up to 1000 mg/m³. Multi-shift operation.                                                                                | Essential lower operating temperature and therefore energetically more favourable as TNV and KNV.                                                   | Regular maintenance necessary (Time period of several years) Systems has to be adapted to the special recommends of a producer No known example in the field of wood coating. |
| NEOTREAT technology                        |                                                                                                                                             |                                                                                                  |                                                                                                                                                                                                            |
3.5 Further possibilities to reduce VOC-emissions

- Abdication of coating steps
- Use of closed cleaning, filling and draining systems
- Use of emission poor cleaners
- Storage of rests and dusts in closed bins
- Closed mixing bins
- Recuperation of wastes and cleaners
- Intensification of the cooperation between lacquer producers, producers of application and drying technologies, coating plants and end-consumers

3.6 Case studies and examples from practice – further guidance

Case studies and examples from practice can be found under the following links:

www.umweltnet.at/filemanager/download/10976

http://www.lfu.bayern.de/luft/fachinformationen/loesemittel/doc/holzbeschichtung_teil_2.pdf

(here typical applications like chair coating, furniture coating of plane products, bureau furniture, kitchens, parquets, doors and windows and stairs are shown)

3.7 List of producers of technology and coating systems


http://shop.farbeundlacke.de/econtent/catalog/shop/farbe___lack/buecher/FARBE-UND-LACK-Edition/Holzbeschichtung - overview on the wood coating process, materials, technologies (only in German)

3.7.1 Coating systems – water based lacquers:

http://www.3h-lacke.de/en/index.html
http://www.klumpp-coatings.com/
http://www.hesse-lignal.de/internet_en.html
http://www.remmers.de/Die-VOC-Richtlinie.458.0.html
http://www.brillux-industrial-coatings.com/
http://www.becker-acroma.com/de/Germany
http://www.clou-shop.eu/?gclid=CN7zte6R0KQCFZYL3godRi9UDq
http://www.lacke-und-farben.de/index.php?id=242
http://www.brillux-industrial-coatings.com/
http://www.adler-lacke.com
http://www.dow.com/products/product_list_product_page?industry=1000306&application=1120207
http://www.basf-coatings.de/en_UK/products/eci_start.xml

Field Applied UV Cured Topcoats for Wood, Jo Ann Arceneaux, Ph.D., Cytec Industries Inc., Smyrna, GA
http://www.helios-group.eu/eng

Remark from the Slovenian partners:

There is quite a number of (smaller) coating producers in Slovenia. However, there is only one that is internationally important, that is Helios Group that owns various (previously independent) coating producing companies in Slovenia and abroad. Up to our knowledge, the company claims that they can offer solutions (paints) that can meet all demands of VOC directive. However, in reality, some specific questions (VOC compliant materials to achieve high gloss for the highest quality furniture products, paints for oak and similar solid wood) have not been really solved yet. One of the reason is also, that the quantities of such materials demanded by the market are rather low and that they earn enough with “classical” waterbornes.
HELIOŠ, Tovarna barv, lakov in umetnih smol Količevo, d.o.o., Količevo 65, 1230 Domžale, Slovenia (http://www.helios.si/eng)

JUB kemična industrija d.o.o., Dol pri Ljubljani 28, SI-1262 Dol pri Ljubljani, Slovenia (http://www.jub.si/en/)

CHEMCOLOR SEVNICA d.o.o., Dolnje Brezovo 35, SI-8290 Sevnica, Slovenia (http://www.chemcolor.si/eng/)

ETE d.o.o. Ljubljana, Letališka cesta 33, 1000 Ljubljana, Slovenia (http://www.ete.si) *

*it should be noted that there are some other smaller paint (also waterborne) producing companies in Slovenia and that the ETE company is not producing paints, but equipment, including for cleaning the waste gasses

Articles, gained on the 6. PRA Wood Coating Conference 2008, in Amsterdam:

New Fast Drying Waterborne Two Pack Urethane Coatings for Industrial Wood Finishes, Dr Jaap Akkerman*, Dirk Mestach, Adriaan Sanderse, Richard Esser and Jan Goossen Nuplex Resins, The Netherlands

Specially Engineered Acrylic Hybrids: A New Technology Platform for Low VOC Decorative Coatings, Dr Anne Koller, Rohm and Haas, France

New Acrylic Binder Technologies for Water-based Exterior Wood Coatings, Roland Baumstark* & Arno Tuchbreiter, BASF, Germany

High Clarity Low Gloss Waterborne Lacquers for Wood, David J. Kent*, C. Tunice & C. Lindemeyer, Grace, Germany

UV/EB Coatings – VOC Compliant High Performance Solutions for Indoor and Outdoor Wood Applications, Dr Xavier Deruyttere, Cytec Surface Specialties, Belgium

Performance of Clear Coatings on Wood for Exterior Applications, Florian Tscherner*, Gerhard Gruell & Harald Bruckner, Holzforschung, Austria

Articles, gained on the 7. PRA Wood Coating Conference 2010, in Amsterdam:


New Developments on Waterborne Resins for Two Component Urethane Coatings; J Akkerman, J Goossen, A Sanderse*; Nuplex Resins

Waterbased Field Applied UV Curable Topcoats for Wood Flooring; S Smeets; Cytec

Eco Compliant and Low Emission Concept with Enhanced Flooring Properties; M Roelands*, G Satgurunathan, R Swaans; DSM NeoResins+

Self-Crosslinking Polyurethane Dispersion; N Musche; Lubrizol

Nanotechnology to Advance Eco Friendly Wood Coatings; D Burgard*, M Herold, K Steingröver; Buhler PARTEC GmbH

Further articles

3.7.2 Coating systems – natural coating systems – high solid systems:

http://www.hesse-lignal.de/internet_en.html
http://www.clou-shop.eu/?gclid=CN7zte6R0KQCFZYL3godRi9UDg
http://www.livos.co.uk/
http://www.leinos.de/
http://www.biopin.com/
http://www.auro.de/EN/index.php
http://www.absenproligna.de/downloads/Solid_Prospekt

Further Articles to natural coating systems:


3.7.3 Coating systems – powder coatings:

http://www.brillux-industrial-coatings.com/
www.tiger-coatings.com/index.php?id=393&tx_pressdownload...43

Articles, gained on the 6. PRA Wood Coating Conference 2008, in Amsterdam:

The Consolidation of Powder Coatings on MDF Using High-Speed Scanning Lasers, Peter Kaczmar, TRADA Technology, UK

Novel Natural Wood Effect with UV Curable Powder Coatings, Ryan Schwarb Keyland Polymer, USA

Further articles:


3.7.4. Application technology
Further articles:

3.7.5 Drying and curing technology

Articles, gained on the 6. PRA Wood Coating Conference 2008, in Amsterdam:
Drying Technologies for Waterborne Coatings, Dr Christiane Swaboda*, Rico Emmler & Detlef Kleber, Institute of Wood Technology Dresden, Germany

Further articles:
Leitfaden zum Einsatz forciertes Trocknungsverfahren für die Applikation von Wasserlacken auf Holz und Holzwerkstoffen, published by DFO

3.7.6 Waste gas cleaning – abatement technology

http://www.pureairsolutions.nl/$38/$39/$396/$398
Some further literature and links on waste gas cleaning:
Further Look at tables in chapter 4.5.

Further articles:
http://www.hdt-essen.de/htd/pressemitteilungen/pressemitteilung88778461.html

List of firms who have successfully implemented new technology
http://www.maja-moebel.de/maja/en/
http://www.wehrsdorfer.de/
See data above, in the tables.

Links to books and revues on wood coating
J.G.Nienhuis M.Sc., SHR, The Netherlands, Review on drying and curing techniques of coatings
Jorge Prieto, Jürgen Keine, Holzbeschichtung, Vinzentz-Verlag, 2008,
List and links of other projects concerning VOC- guideline

Auftraggeber: Umweltbundesamt (Forschungskennzeichen 3708 42 305)
Durchführung: Ökopol GmbH - Institut für Ökologie und Politik, Hamburg
Kooperationspartner: Universität Stuttgart, IER Institut für Energiewirtschaft und Rationelle Energieanwendung
Laufzeit: Oktober 2008 - September 2010
http://www.oekopol.de/de/aktuell/520_VOC_31Bimsch.php

ECOVARN, Development of a High-Performance, Regulation-compliant and Inexpensive Water-borne Wood Coating (FP7-SME-2008-2-243603)

ZERO-VOC, Monitoring and controlling Volatile Organic Compound (VOC) emissions by using novel on-line FTIR/iPAS technology (www.zero-voc.eu)

List and links to more advice
http://www.lcslcs.de/english/index.html
www.ihd-dresden.de
http://www.materialeffizienz.de/
4 LITERATURE

/1/ PROTOCOL TO THE 1979 CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION TO ABATE ACIDIFICATION, EUTROPHICATION AND GROUND-LEVEL OZONE
http://www.unece.org/env/lrtap/multi_h1.htm


/7/ "Uradni list RS, št. 37/2007 z dne 23. 4. 2007"


/10/ http://81.186.166.197/nomoi/832.pdf


/12/ http://www.i-kon.org/ikon/__downloads/jot-008-0072-1_Bregau_IKon.pdf (german version)


/14/ http://www.lfu.bayern.de/luft/fachinformationen/loesemittel/doc/reduzierungsplanleitfaden_inter.pdf


/16/ ("Uredba o spremembah in dopolnitvah Uredbe o mejnih vrednostih emisije hlapnih organskih spojin v zrak iz naprav, v katerih se uporabljajo organska topila", issued in "Uradni list RS, št. 37/2007 z dne 23. 4. 2007")
important information regarding legislation on VOC emission are
http://okolje.arso.gov.si/ippc/

http://www.arso.gov.si/zrak/


http://www.umweltbundesamt.de/technik-verfahren-sicherheit/nachhaltige-produktion/loesemittelanwendungen.htm

Thomas May: „Ausgehverbot für Lösemittel“

Umsetzung der 31. BImSchV aus Sicht der Umweltverwaltung
Aktuelles, Erfahrungen, Auslegung

Implementation of solvent directive in the German wood coating industry

(the companies that have to comply with the decree)

http://okolje.arso.gov.si/ozon_fplini/predpisi.php?page=1&id=0
http://okolje.arso.gov.si/ozon_fplini/predpisi.php?page=3&id=0

http://www.arso.gov.si/zrak/


http://www.umweltbundesamt.org/fpdf-I/2312.pdf


http://www.pius-info.de/files/voc_tool_e.xls


Schrübers, H. „Runter mit VOC-Emissionen und Kosten“, JOT 2.2008
GUIDELINES on implementation of VOC Solvents Emissions Directive, October 2010

http://www.i-kon.org/ikon/_downloads/jpt-008-0072-1_Bregau_IKon.pdf

/37/http://www.lfu.bayern.de/luft/fachinformationen/loesemittel/doc/holzbeschichtung_tei1_1.pdf


SOURCES OF INFORMATION:

EC guidelines for the implementation of the Solvent Directive;

BREF for surface treatment:
http://ec.europa.eu/environment/air/pollutants/stationary/solvents.htm
http://circa.europa.eu/Public/irc/env/voc/library
http://rod.eionet.europa.eu/obligations/157
www.epa.gov/nrmrl/pubs/600sr00043/600sr00043.pdf
http://www.pcimag.com/Articles/Feature_Article/cce9b265f615e010VgnVCM100000f932a8c0

TECHNOLOGY END OF PIPE (biofiltration, active carbon)
http://www.ete.si/
http://www.rippert.de/appbox/modules/cutecms/?key=start
http://www.esotech.si/
http://www.pureairsolutions.nl/$38/$39/$396/$398