TECHNOLOGY
GUIDELINES
FOR
VEHICLE
REFINISHES

A guide to
Best Available Technique
prepared by the
CEPE
Technical Committee
Vehicle Refinishes
These updated guidelines for vehicle refinishing and the coating of commercial transport replace the CEPE guidelines originally published in 1992 (CEPE 1992), and 1994 (CEPE 1994). They have been prepared by the CEPE Technical Committee Vehicle Refinishes, in which the major paint suppliers to the European refinishing industry are represented. The target of this paper is to set out Best Available Technique (BAT) for the industry. In doing this, the following four principles have been adopted:

- **a.** The processes described must represent the minimum risk to health;
- **b.** The quality of the refinish coating must be comparable to that of the original coating of the new vehicle;
- **c.** Flexibility of application must be sufficient to enable the refinisher to produce good quality over the full range of conditions encountered in practice;
- **d.** The process must achieve the required reduction in solvent emissions without generating new environmental hazards.

The proposals described below fulfil these principles, with the important additional advantage that they do not lead to significant increases in process cost.
The VOC Directive sets out targets for solvent emission reduction in the European Union. It applies to a wide range of industrial processes, including painting in contained plant, as well as paint manufacture. It does not apply to non-contained painting processes, such as the maintenance of buildings, bridges etc..

The key features of the Directive for vehicle refinishing are shown in Table 1. The figures refer to all the products used in the painting process, from surface cleaning to final finishing and polishing.

### Table 1: The Directive - key targets for vehicle refinishing

<table>
<thead>
<tr>
<th></th>
<th>Interim stage</th>
<th>Final stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum average solvent content (excluding water)</td>
<td>64.3%</td>
<td>54.5%</td>
</tr>
<tr>
<td>Corresponding emissions reduction</td>
<td>40%</td>
<td>60%</td>
</tr>
<tr>
<td>Date for new installations</td>
<td>10/2001</td>
<td>10/2004</td>
</tr>
<tr>
<td>Date for existing installations</td>
<td>10/2005</td>
<td>10/2007</td>
</tr>
<tr>
<td>Threshold solvent use per year</td>
<td>500 kg</td>
<td>500 kg</td>
</tr>
</tbody>
</table>

Unlike earlier regulations in California (SCAQMD 1988) and in the UK (PG6/34 1997), it does not specify a list of VOC limits for products. Instead (see Appendix D) it uses a model to determine the target maximum solvent content. In fact, the existing VOC lists in the UK and in the Californian rule cited already meet the final stage target (see Appendix B). In contrast, the proposed American national rule (EPA 1998) does not meet the target for the interim stage.

One other difference from earlier regulations is the absence of targets for emission reduction from process or equipment changes, such as the use of efficient spray guns. For this reason, savings from these sources are shown separately in the discussion below (see section 3.3, page 8).

In sharp contrast with rules in the USA, the smaller workshops are excluded from the scope of the Directive. The threshold is set at 500 kg solvent per annum, and compares with a current UK threshold of 1000 kg.

The target for these changes is 2004 for new body shops, 2007 for existing ones (there is an earlier intermediate step, with an average solvent content of 64.3%).

The legal basis of the Directive is article 130s(1) of the Treaty of Rome. This means that it sets minimum standards for national regulations, but that Member States may choose to adopt stricter rules.
2. Why Are Solvent Emissions a Problem?

Traffic emissions are the most important source of air pollution. Both petrol and diesel vehicles emit a variety of pollutants: nitrogen oxides (NOx), carbon monoxide (CO), and particulates as well as volatile organic compounds (VOC’s). All of these affect air quality.

Large amounts of VOC are also emitted from natural sources, for example pine forests. A further important source is solvent from painting processes.

The action of sunlight on NOx and VOC’s leads to the formation of ground level ozone, a secondary long range pollutant, which can impact on rural areas at some distance from the original source of emission. Ozone can irritate the eyes and lungs, causing breathing difficulties, and may reduce resistance to infection. Ozone can also damage some vegetation, crops and trees.

High levels of ozone are normally observed on still, sunny, summer days, when the air is already polluted with NOx and VOC’s (e.g. urban areas with traffic). Because of the time required for the chemical reactions to take place, ozone formation tends to be downwind of the pollution. The resulting smog may persist for several days and can be transported over long distances. (See e.g. DETR 1998, WHO 1998.)
The effect of incorporating water into the paint is frequently misunderstood. A number of the new product technologies that are being developed use water to replace organic solvent. However, in estimating the emissions from such products the key question remains the ratio of organic solvent emissions to solid paint. The water has no direct effect on this ratio. For example, a paint containing organic solvent could be diluted with water to a lower percentage of solvent. In spite of the apparent reduction of organic solvent, the emissions remain the same. This is explained with an example in Appendix A.

The product standards for low solvent content are shown in table 2. Definitions of the different product types are given in Appendix C.

3. OPPORTUNITIES FOR SOLVENT EMISSION REDUCTION

Solvent emission reduction can be achieved both by the use of appropriate products, and by organisational means. Coatings and cleaning solvents with reduced solvent content fall into the first category, and the reduction of the amount of cleaning solvents, and the use of efficient application techniques, in the second. Each of these is discussed below. Emission abatement processes are a theoretical option for emission control, although they are generally inappropriate to the small scale of installations in this sector. They are also discussed below. The regulation of stack emission concentration limits is ineffective in this sector, as concentrations are already close to typical control values.

3.1 Coatings and cleaning solvents with reduced solvent content

Solvents perform an essential role in coatings, allowing their viscosity to be controlled for application, and assisting the integration and flow-out of the wet paint film. However, they play no role in the final, hardened film, and so source reduction of the solvent is particularly important. Source reduction is also capable of achieving about 80% of the emissions reduction, where all the reduction procedures described in these guidelines are used. The most fundamental measure of the emissions from a painting process is the mass of organic solvent emitted per unit area of painted surface. Since the properties of the film depend on the application of a certain film thickness, this corresponds to the mass of solvent emitted per unit volume of paint solids. As this is very difficult to measure, surrogate units are used. These are grams of organic solvent per litre of ready-for-use paint, excluding water.
The VOC content should be measured using the methods described in ISO 11890-1 and -2. Note that this method will give inaccurate results when volatile reactive diluents are used, as for example in stopper and body filler. In such cases, ASTM D 3960-96, which permits a reaction period before the sample is heated, will give results which accurately reflect practice.

In the case of cleaning solvent, which contains no solids, the VOC value is calculated including water.

Wash primers with a high solvent content are necessary to achieve adhesion of subsequent coats on difficult, bare metal surfaces such as aluminium, zinc plated, or galvanised metals. On other substrates an adhesion primer or precoat is satisfactory.

Although products with lower solvent content are already available, they do not yet fulfil all end use requirements. The CEPE Group Refinishing believe that it should be possible to reduce the solvent in all of these products to a value of 250 g/l, while satisfying all end use requirements, and are committed to seeking to achieving this by 2007.

A combined average value for the solvent content of the basecoat and clearcoat was recommended in the 1992 Guidelines. Subsequently, it has been demonstrated that solvent emission reduction is strongly dependent on the VOC value for the basecoat. Hence in these Guidelines, separate values are recommended.

In the case of a limited number of Special Products, the target VOC values cannot be achieved by current technology. These Special Products are defined in Appendix C. Where Special Products are described as “Additives”, the VOC limit for Special Products applies to the additive, which is itself blended with coatings which comply with the limits appropriate to their type.

### Table 2: The CEPE guideline VOC values

<table>
<thead>
<tr>
<th>VOC content</th>
<th>Actual values in 1992 (from CEPE 1994)</th>
<th>Proposed limits, g/l (a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gunwash</td>
<td>850</td>
<td>850</td>
</tr>
<tr>
<td>Precleaner</td>
<td>850</td>
<td>200 (b)</td>
</tr>
<tr>
<td>Stopper and body filler</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>Wash primer (c)</td>
<td>780</td>
<td>780</td>
</tr>
<tr>
<td>Precoat, primer, primer surfacer, surfaecer, filler</td>
<td>600-720</td>
<td>540 (d)</td>
</tr>
<tr>
<td>1 coat Topcoat</td>
<td>600-720</td>
<td>420</td>
</tr>
<tr>
<td>Basecoat (e)</td>
<td>800</td>
<td>420</td>
</tr>
<tr>
<td>Clearcoat</td>
<td>600</td>
<td>420</td>
</tr>
<tr>
<td>Special coatings (f)</td>
<td>840</td>
<td>840</td>
</tr>
<tr>
<td>Average Solvent %</td>
<td>ca. 75%</td>
<td>ca. 50%</td>
</tr>
</tbody>
</table>
The Directive proposes a reduction in emissions in two stages, corresponding to the two targets in Table 1. However, since the publication of the original CEPE guidelines, products meeting the stage 2 standards have become widely available. Some Member States may consider that sufficient progress has been made in the last few years for a single step to the lowest VOC levels to be practicable.

Where it is preferred to retain a two step regulatory framework, CEPE recommend that the same standards are adopted, but for only certain product classes. For example, a change to low solvent precleaner and basecoat is sufficient to meet the Directive’s interim targets. This is preferable to setting intermediate limit values for products, which lead to extra training costs for the user, and extra logistics costs for the supply chain.

3.2 Reduction of cleaning solvents

Solvents are required in the vehicle refinishing process for cleaning spray guns and equipment, and also for preparing surfaces prior to painting. The requirements in the two cases are significantly different, and will be discussed separately. There is no requirement in the painting process for chlorinated solvents, though in some countries these are still used in paint strippers. These are discussed below in section 4, emissions to water.

So far, no substitute has been found for the use of solvents for spray gun cleaning. To minimise emissions in the cleaning process, all spray guns and equipment should be cleaned in enclosed equipment designed for the purpose, in which the dirty solvent is collected for recycling. Many suitable designs are available and in widespread use. This process reduces emissions by around 80% compared with open cleaning.

The solvent is typically used several times before being discarded. Dirty solvent is collected (by a specialist service, or by the distributor who supplies the paints), and is re-distilled at a central facility. It is then returned through the distribution system for re-use.

Solvent is also required for the preparation of surfaces prior to painting. This is to remove grease, and possible traces of silicone. In many cases it is possible to replace the use of pure solvent by a solvent/water mixture, with consequential reduction in emissions. Such products are called ‘Pre-cleaner’ in table 2 above. A further reduction in emissions can be achieved by dispensing the precleaner from small spray bottles, or by the use of disposable wipes.

Depending on the substrate and the process, pure solvent may be needed in place of reduced VOC precleaners. When this is necessary, the use of spray bottles or disposable wipes is recommended.

All full and partially full containers which hold materials or waste containing organic solvents should be stored tightly lidded. Solvent-soaked wiping cloths should be held in enclosed containers after use. A supply of absorbent material should be held at site for use in the event of spillages of organic solvents. Such spillages should be cleaned up immediately and the collected material should be held in an enclosed container pending removal from the site.
3.3 Efficient application techniques

Almost all refinishing paint products, with the exception of small amounts of stopper and putty, are applied using a spray gun. Brush application is still used to a small extent in the painting of commercial vehicles.

During spraying, only part of the spray mist coalesces on the surface being painted, to form the paint film. The percentage that contributes to film formation is called the transfer efficiency. Using conventional high-pressure, air assisted spray equipment (3 - 6 bar), the transfer efficiency can be 50% or less. Improvement in the transfer efficiency leads to reduced emissions, although the effect is much smaller than that produced by the use of low solvent coatings (see Table 3). Several types of spraying equipment are available that offer improved transfer efficiency (see also VDI 1998). These include:

- Reduced pressure (e.g. high volume low pressure (HVLP)) spray
- Airless spray
- Air assisted airless spray

Electrostatic assistance can significantly increase the transfer efficiency in many production line spraying processes. For most refinishing work, however, its use is not practicable, as the necessary static electrical charge damages the vehicle’s engine management system and other electronic components. (Ondratschek 1994)

3.4 Overall emission reduction

This shows that the average solvent content (excluding water) comes down from ca. 75% to ca. 50%. Using this data, the reduction of emissions can be calculated, assuming no change in the quantity of solid paint required. However, use of the most efficient spray application equipment will reduce the quantity of paint by around 20%, with a corresponding further reduction in emissions. Also, full enclosure has been demonstrated to save at least 80% of emissions from gun washing. The combined effects of these measures are set out in detail in Appendix B. The results are shown in Table 3. The overall saving of 69% of emissions is at least as good as the likely outcome from the widespread adoption of abatement, and is achieved at much lower cost.

Table 3:

<table>
<thead>
<tr>
<th>Solvent reduction achieved by the CEPE guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual status 1992</td>
</tr>
<tr>
<td>Overall process solvent content</td>
</tr>
<tr>
<td>Emission reduction</td>
</tr>
<tr>
<td>- due to reduced paint solvent</td>
</tr>
<tr>
<td>- due to use of enclosed gunwash</td>
</tr>
<tr>
<td>- due to use of HVLP</td>
</tr>
<tr>
<td>VOC emission reduction</td>
</tr>
</tbody>
</table>

It should be added that products meeting the standards set in these guidelines are available now.
3.5 Emission abatement processes

Normally, this approach is less desirable than source reduction. An authoritative statement of this view is made in the 1991 declaration of Maastricht:

'Reduction of VOC’s may be achieved in different ways. Emission control via abatement equipment (end-of-pipe technology) is usually a short term option which is nevertheless necessary in a number of specific cases. Another way is product substitution (or, in general, prevention), which is (sometimes) a longer term option. This option is to be preferred from the viewpoint of sustainable development. Sometimes a combination of the two is possible.' (Maastricht 1991)

Nevertheless, in principle emissions can be reduced using abatement processes, including incineration, using either catalytic converters or thermal processes; adsorption processes; and biological treatment.

Incineration presents a number of problems. The refinishing process only operates intermittently, and seldom more than 8-10 hours a day, whereas thermal incineration requires a steady, preferably continuous, load. Catalytic units reach their operating temperature much faster, but this still takes 15 minutes, which is a similar order of time to the spraying cycle. Air movement rates are high (24,000 m³/hour), so that short term peak VOC concentrations in the exhaust air seldom exceed 150 mg/m³ (as carbon). This means that it is necessary to add very high levels of supplementary fuel to maintain combustion, with the unacceptable consequence of high carbon dioxide and some nitrogen oxide emissions. Energy recovery and reuse are unlikely to be economically interesting in such relatively small installations. Overall, by this route, the cost of abatement, including capital costs, is in the region of Euro 17,000 per ton of solvent.

Installation costs are around Euro 20/m³/hour - Euro 0.5 mio for a spraybooth installation, and out of reach of a refinisher. A further cost that must be considered is that of emissions monitoring, which is required to ensure that the equipment is functioning correctly. Finally, the sensitivity of catalysts to contamination should be mentioned. Up to 3mg/m³ of particulates from the spraying process pass through the filters, and this is enough to reduce the working life of the catalyst significantly.

Adsorption of solvent by activated carbon is promoted by some regional legislation - for example, in Greece (Law of 6th February 1996) and in the Italian Region of Piedmont. This is more suited to intermittent operation, and installation costs are reasonably low. There are, however, some notable disadvantages. First, the relatively low concentration of solvent on the exhaust gases means that the percentage removed is at best no higher than that achieved by source reduction (section 3.1). Then, the regular replacement and disposal of the filter medium can be problematic. The re-generation of activated carbon using steam, unless it is carried out by a properly equipped reprocessor, transfers the environmental impact from the air to the aqueous environment. In practice, incineration of the solvent-laden carbon is often preferred. Running costs are high - of the order of Euro 12,000 per ton of solvent. Regular monitoring of the exhaust gases for solvent concentration is required, which increases the cost further. It is essential that the operator changes the carbon canister as soon as the solvent levels start to rise. This is required not only to prevent emissions, but to reduce the risk of spontaneous combustion, that has been recorded in such installations (Naujokas 1985).
Adsorption processes based on absorbents other than carbon have been described. These require a higher capital expenditure than the carbon adsorption approach, of the order of double the cost of a non-abated spray booth. While they overcome the fire risk, they have the same limited efficiency, due to the low solvent concentration in the exhaust air, and the same requirement for regular monitoring. Overall, they represent a higher cost approach to control, with no compensating environmental benefits compared with source reduction.

In principle, biological degradation of the solvent offers a route to low impact abatement. Again, the intermittent operation, and the difficulty of transferring the low VOC concentrations in the exhaust air efficiently to the water phase, make it difficult to see that such a process could be practical. It also requires a level of technical control that would be difficult for a typical bodyshop to achieve. Certainly, there is little evidence for the uptake of biological abatement in the industrial coatings field.

4. LIQUID WASTE AND EMISSIONS TO WATER

Wastes from spray gun washings and paint residues present a potential risk to the aqueous environment.

Residues from solvent borne paint must never be allowed into drains. The solvent in such wastes is valuable as a cleaning solvent. The waste should be collected for distillation and recovery of the solvent by an approved process. If recovery is for any reason impossible, they must be disposed of according to national laws.

In the case of waterborne paints, it is possible to use coagulants to treat liquid waste. Generally, any waste generated by coagulation should be considered as hazardous waste, as such to be disposed of via an authorised waste carrier. The liquid phase generated under controlled process conditions might be used again for cleaning purposes (e.g. spray-guns and other equipment). Under no circumstances should this liquid phase be disposed of into the public sewer system without obtaining specific advance authorisation from the local or national authority.

At one time, paint strippers based on methylene chloride were widely used. Their use is now much more restricted, as damaged panels are more usually replaced, rather than being beaten out, stripped, and repainted. The repair of veteran cars is, however, one area of continued use.

It is normal to wash off residues of stripper with water, and this gives rise to the risk of contaminating drains. As methylene chloride is only slowly broken down, this risk extends to the possible pollution of rivers and drinking water supplies.

For these reasons, the use of such strippers should be minimised. Where they are used, all residues should be carefully collected, using an absorbent material such as vermiculite, and disposed of according to national laws. Under no circumstances should these wastes be allowed to enter the public sewer system.
5. SOLID DISPOSAL

Solid waste from the painting process may carry residues of dried paint, or of paint and solvent. Waste containing dried paint, such as masking paper or spray booth filters, may still be classified as hazardous in the European Waste Catalogue (OJ 1994), for example if topcoats containing lead or primers containing zinc chromate have been used. This is very commonly the case in the coating of commercial vehicles, but can be avoided in the case of private cars, where lead and chromate free alternatives are available.

Waste containing solvent, such as dirty rags, is classified as hazardous under the Directive, and must be disposed of according to national laws. In the case of empty cans, schemes for the collection exist in several countries. They are shredded, the steel is separated from the dried paint for recycling, and the dried paint residue is incinerated.

6. CONTROL OF OCCUPATIONAL EXPOSURE

In considering occupational exposure, it is important to distinguish between the hazard:

*the intrinsic property of a chemical agent with the potential to cause harm*

and the risk:

*the likelihood that the potential for harm will be attained under the conditions of use/or exposure* (OJ 1997)

The following is an overview of the most common hazards, and how the resulting risks are controlled. It should first be emphasised, though, that national laws concerning the control of occupational exposure must always be followed. Also, for each product, the supplier’s health and safety data sheet describes the hazards that are specific to the product.

The advice below concerns the most common hazards of refinish products. These are mainly associated with:
- solvent vapour
- particulates
- isocyanates

and are dealt with separately, together with typical measures for risk control.

**Solvent vapour**

Exposure to organic solvent vapours above the occupational exposure limits (OEL’s) may result in adverse health effects such as irritation of the mucous membrane and respiratory system and adverse effect on kidney, liver and central nervous system. Symptoms include headache, dizziness, fatigue, muscular weakness, drowsiness and, in extreme cases, loss of consciousness.
A further hazard that is recognised in some, but not all Member States, is organo-psycho syndrome (OPS). This is a general deterioration of mental and/or psychic functions - for example, emotional disturbances like depression and loss of concentration or short time memory, believed to be caused by long-term exposure to solvents.

Solvent exposure can occur:
- during paint mixing
- during surface cleaning prior to painting
- during spray application

The risk to health can be effectively eliminated by minimising exposure. The most important means of doing this is to provide satisfactorily general and local ventilation. In particular, a spray booth with an extraction rate of up to 6 m³/second is recommended. The unnecessary release of solvent during surface cleaning can be prevented by the measures described in section 3.2. Covering any solvent containers when not in use prevents solvent evaporation into the breathing zone.

 Normally, these control methods will be sufficient. An activated carbon face mask may be needed if large areas must be solvent cleaned. During spraying, an air fed mask must always be worn. This will of course further reduce solvent exposure, but its purpose is mainly to control particulates and isocyanates - see below.

**Particulates**

The spraying process generates a mist of particles, many of which are too large to present any health hazard. A proportion, however, (those with a particle size below 10 microns) can enter the lungs and cause CURS (chronic unspecific respiratory syndrome). That means that the deposition over time of particles on the inner surfaces provokes a chronic inflammation of the bronchial and smaller airways and can lead to a syndrome like asthma. The OEL for such particulates can be exceeded, even in well ventilation spray booths (TAK/VdL 1987). The use of an air fed respirator during spraying is the best way of controlling this risk. Alternatively a filter mask equipped with a combined particle and vapour filter is possible for short periods. All respirators must conform to national standards, and, where regulations require, be approved by the national authorities.

Particulates can also be inhaled from dust generated during the flattening of surfaces with abrasive paper. This is best controlled by efficient general downdraft ventilation, supplemented by local extraction.

**Isocyanates**

The hazards of isocyanates are well understood. Inhalation of isocyanate vapour or particulates may cause acute irritation of the respiratory system, resulting in asthmatic symptoms, wheezing and a tightness of the chest. Some individuals can develop an allergic reaction to isocyanates, and such sensitised persons may subsequently show asthmatic symptoms when exposed to airborne concentrations of isocyanates well below the Occupational Exposure Limit. Repeated exposure may lead to permanent respiratory disability.

Isocyanates are used because they uniquely make it possible to achieve the required performance standards at low solvent levels. Because of the hazards, it is important that the risk of exposure is fully controlled. The isocyanates used in refinishing products contain very low levels of volatile monomeric isocyanate. Provided the paint mixing area is effectively ventilated, the main risk of exposure arises during
spraying, when still unreacted isocyanate in the smaller spray particles can enter the lungs. The control of particulates using an air fed respirator is thus an effective and essential means of risk control.

National regulations may require that persons exposed to products containing isocyanates, which are respiratory sensitisers, are subject to appropriate health surveillance.

### Skin and eye contact

Most solvents are able to penetrate the human skin. Skin resorption of solvents is one of the major routes of the total body burden. Repeated or prolonged contact with solvents may also lead to removal of natural fat from the skin resulting in non-allergic contact dermatitis. This defatting can also be a contributing factor in sensitisation of the skin. Skin contact with isocyanates can result in a sensitisation not only of the skin, but also of the lungs. That means that a first contact to isocyanates by skin (skin contact with a hardener) can lead to sensitisation. The next inhalation contact with isocyanates can result in skin reaction as well as allergic asthma. Skin contacts with isocyanates therefore should be avoided.

Skin contact can be easily prevented by wearing suitable rubber gloves. Skin protection with protection creams is a supplementary, but not a primary safety measure.

Splashes in the eyes may cause irritation and reversible local damage. Protective eyeshields are recommended where this is likely to occur.

### References

- **CEPE 1992:** Technology guidelines for vehicle refinishes: CEPE, 12th February 1992
- **CEPE 1994:** Solvent Emission Reduction In The Vehicle Refinishing Industry: CEPE, 24th March 1994
- **EPA 1998:** National Volatile Organic Compound Emission Standards for Automobile Refinish Coatings, 63 FR 15016 03/27/98
- **Naujokas 1985:** Naujokas, A.A., Plant Oper. Prog Vol. 4, No. 2, pp. 120-126, (1985)
- **PG6/34 1997:** Guidance Note PG6/34, DETR UK, revised March 1997
- **SCAQMD 1988:** South Coast Air Quality Management District Rule 1151: Motor vehicle and mobile equipment non-assembly line coating operations, revised June 1997
- **TAK/VdL 1987:** Autoreparaturlackierung: Konzentrationsmessungen in der Spritzkabinenluft, Farbe + Lack 11/1987, 911-914
- **VDI 1998:** VDI 3456: Emission reduction - the repair and painting of private and commercial vehicles (small and medium-sized installations), Verein Deutsche Ingenieure, 1998
Thus, in spite of the identical solvent content in the paints, the emissions only depend on the ratio of organic solvent to solids, and the water content of the coating must be discounted. All VOC values in this paper are therefore expressed ‘less water’.

APPENDIX A: EFFECT OF WATER

Diagram 1 compares three paints with the same solvent content, but different amounts of solids and water. Their composition is:

<table>
<thead>
<tr>
<th>Component</th>
<th>Water</th>
<th>Solvent</th>
<th>Solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>percent</td>
<td>20</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>60</td>
<td>20</td>
<td>20</td>
<td>6.7</td>
</tr>
<tr>
<td>73.3</td>
<td>20</td>
<td>20</td>
<td>6.7</td>
</tr>
</tbody>
</table>

Thus, in spite of the identical solvent content in the paints, the emissions only depend on the ratio of organic solvent to solids, and the water content of the coating must be discounted. All VOC values in this paper are therefore expressed ‘less water’.

Diagram 1 shows these compared at equal amounts of solids, so that the same surface area is painted with all three.

Diagram 1:

The effect of water on the calculation of VOC content
APPENDIX B: CALCULATION OF AVERAGE EMISSION REDUCTION

In order to calculate the emissions from the whole process (table B part 1), the average volume percent usage of each product type, expressed as ready-for-use paint, was estimated from CEPE statistics (column B). The VOC values in Table 2 are shown in column C, and using an average solvent specific gravity of 0.85, the corresponding mass (column D) and volume (column E) of solvent can be calculated. The solids volume (column G) is thus the difference between columns E and B.

It is assumed that there is no change in the amount of repair work carried out -- that is, that the volume of solid paint consumed is constant. The amount of solvent corresponding to the new VOC values is then calculated as follows (any water content is ignored, as explained in section 3.1).

Let m kg be the new mass of solvent emitted, at an average specific gravity of 0.85

\[ S_1 \text{ l. be the solids volume per litre of the new paint} \]
\[ P \text{ l. be the new volume of paint (less any water)} \]
\[ S \text{ l. be the volume of solids in column G} \]
\[ K \text{ g/l be the CEPE guideline VOC value in column K} \]

Since P l. paint contains S l. of solids, and \((m/0.85)\) l. of solvent

\[ (1) \quad P = S + (m/0.85) \]

But 1 l. of paint contains K g/l of solvent and S1 l. of solids, so

\[ (2) \quad 1 = (K/(0.85\times1000)) + S1 \]
and \( S1 = 1 - K/850 \)

Now the volume of solids in P litres is S, so

\[ (3) \quad S = P*S1 \]
\[ = P(1 - K/850) \]

Combining (1) and (3)

\[ (4) \quad S = (S + (m/0.85))*(1 - K/850) \]

and by rearrangement

\[ m = S*K*0.85/(850 - K) \]

The further reduction obtained by enclosed gunwash and by efficient spray equipment (e.g. HVLP) is shown in column M. This is based on a 20% paint use reduction due to efficient spray equipment. The detailed emissions model using this calculation is shown in Table B below.
### Table B part 1:

**Calculation of the baseline scenario (1992)**

<table>
<thead>
<tr>
<th>Product</th>
<th>% Usage, litres</th>
<th>VOC, g/l 1992</th>
<th>VOC, kg 1992</th>
<th>VOC, litres 1992</th>
<th>Specific gravity, 1992</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gun cleaner</td>
<td>6</td>
<td>850</td>
<td>5.10</td>
<td>6.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Precleaner</td>
<td>8</td>
<td>850</td>
<td>6.80</td>
<td>8.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Wash primer</td>
<td>5</td>
<td>780</td>
<td>3.90</td>
<td>4.59</td>
<td>1.70</td>
</tr>
<tr>
<td>Precoat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.41</td>
</tr>
<tr>
<td>1-pack primer surfacer</td>
<td>4</td>
<td>720</td>
<td>2.88</td>
<td>3.39</td>
<td>2.10</td>
</tr>
<tr>
<td>2-pack primer surfacer</td>
<td>10</td>
<td>600</td>
<td>6.00</td>
<td>7.06</td>
<td>2.30</td>
</tr>
<tr>
<td>Wet-on-wet surfacer</td>
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<td>600</td>
<td>1.80</td>
<td>2.12</td>
<td>2.10</td>
</tr>
<tr>
<td>Nitrocellulose topcoat</td>
<td>2</td>
<td>720</td>
<td>1.44</td>
<td>1.69</td>
<td>1.36</td>
</tr>
<tr>
<td>Alkyd topcoat</td>
<td>2</td>
<td>600</td>
<td>1.20</td>
<td>1.41</td>
<td>1.36</td>
</tr>
<tr>
<td>2-pack topcoat</td>
<td>22</td>
<td>600</td>
<td>13.20</td>
<td>15.53</td>
<td>1.36</td>
</tr>
<tr>
<td>Clearcoat</td>
<td>15</td>
<td>600</td>
<td>9.00</td>
<td>10.59</td>
<td>1.10</td>
</tr>
<tr>
<td>Basecoat</td>
<td>18</td>
<td>800</td>
<td>14.40</td>
<td>16.94</td>
<td>1.85</td>
</tr>
<tr>
<td>Special/plastics</td>
<td>5</td>
<td>840</td>
<td>4.20</td>
<td>4.94</td>
<td>1.36</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
<td>69.92</td>
<td></td>
<td>27.51</td>
</tr>
</tbody>
</table>

### Table B part 2:

**Calculation of the CEPE proposals**

<table>
<thead>
<tr>
<th>Product</th>
<th>CEPE Solids, litres</th>
<th>CEPE Solids, kg</th>
<th>CEPE VOC, g/l</th>
<th>CEPE VOC, kg</th>
<th>CEPE + HVLP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gun cleaner</td>
<td>0.00</td>
<td>0.00</td>
<td>850</td>
<td>1.02</td>
<td>1.02</td>
</tr>
<tr>
<td>Precleaner</td>
<td>0.00</td>
<td>0.00</td>
<td>200</td>
<td>1.60</td>
<td>1.60</td>
</tr>
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<td>Wash primer</td>
<td>0.21</td>
<td>0.35</td>
<td>780</td>
<td>1.95</td>
<td>1.56</td>
</tr>
<tr>
<td>Precoat*</td>
<td>0.21</td>
<td>0.35</td>
<td>540</td>
<td>0.30</td>
<td>0.24</td>
</tr>
<tr>
<td>1-pack primer surfacer</td>
<td>0.61</td>
<td>1.28</td>
<td>540</td>
<td>0.91</td>
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<td>4.35</td>
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<td>1.85</td>
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<td>1.05</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alkyd topcoat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-pack topcoat **</td>
<td>7.36</td>
<td>10.02</td>
<td>420</td>
<td>6.11</td>
<td>4.89</td>
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<tr>
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<td>4.41</td>
<td>4.85</td>
<td>420</td>
<td>3.66</td>
<td>2.93</td>
</tr>
<tr>
<td>Basecoat</td>
<td>1.06</td>
<td>1.96</td>
<td>420</td>
<td>0.88</td>
<td>0.70</td>
</tr>
<tr>
<td>Special/plastics</td>
<td>0.06</td>
<td>0.08</td>
<td>840</td>
<td>4.20</td>
<td>3.36</td>
</tr>
<tr>
<td>Total</td>
<td>27.51</td>
<td></td>
<td>48.87</td>
<td>49.49</td>
<td></td>
</tr>
</tbody>
</table>

Average solvent %: 48.87 49.49
Emission reduction due to paint: 62.39 62.39
Emission reduction due to HVLP: 6.77
Total: 69.16

* current usage corresponds to a part replacement of etch primer
** all obsolete technology topcoats are replaced by 2-pack
The term 'filler' is sometimes used interchangeably with 'surfacers'. For clarity in these Guidelines, the use of the term 'filler' is restricted to Body filler and Pore filler, defined below.

**Body filler** - A heavy bodied compound, designed for knife application in thick layers to fill major imperfections in panels.

**Pore filler** - This is a ragging filler for plastic mouldings - that is, it is rubbed into the surface with a rag, to fill small holes and other imperfections from the moulding process.

**Topcoat** - Topcoat 1 -coat conventional Any pigmented coating that has gloss and durability in its own right, and does not require additional coats of clear to be applied.

Topcoats 2- and 3-coat base and clear A two- or three-stage process, in which one or more pigmented basecoats are applied, which must be subsequently coated with clearcoat to provide the required appearance and durability

**Basecoat** - A pigmented coating, designed to provide the colour and any desired optical effect, but not the gloss or surface resistance of the coating system.

**Clearcoat** - A transparent coating (that may be, but is usually not coloured) that provides the final gloss and resistance properties of the coating system.

**Special Products** - In the case of a limited number of Special Products, the target VOC values cannot be achieved by current technology. These products are typically ancillaries used for special effects, and their use each has been estimated as <1% of total coatings (BCF, 1995). Typical Special Products are described in table 9 of the VDI guidelines (VDI, 1998). The different product types, and the justification for their need, are described below.
Additives: Matting, texturing and leather graining agents (typical VOC content 500-600 g/l)

These are added to compliant top coats, including clear coat, to provide special surface finishes. They are typically required for small areas of specific models of car.

At present, it is not possible to match the appearance of the original finish while retaining a VOC value under 420 g/l.

Coatings for plastic components (typical VOC content 600-780 g/l)

The following products are required specifically for coating plastic components.

a. Adhesion primers for plastics (typical VOC content 800 g/l)

Some plastics polymers, e.g. polypropylene, have a very low surface energy, which makes it difficult to achieve good adhesion. The only primers available to overcome this problem have high VOC contents, but are applied in very thin films (5 microns maximum).

b. Additives: Plasticisers for surfacers, topcoats and clearcoats for plastics (typical VOC content 700 g/l)

Plastic components are typically less rigid than metal. This means that the coating must be plasticised to provide the necessary flexibility. This is achieved by the addition of plasticising resins, but at the cost of somewhat higher VOC content.

Additives: Spot repair fade out thinner (typical VOC content 840 g/l)

Spot repair techniques, in which very small areas of damage are repaired, instead of whole panels, are in themselves an effective means of emission reduction, as well as being attractive economically. There is, however, a problem even with conventional products. During the application of the clear coat, the spray mist forms a halo of fully integrated, dust like paint film at the edge of the repaired area. Even polishing techniques are unsuccessful in removing the evidence that the area has been repaired.

The solution is to add a specially formulated thinner to the final coat only, that helps to dissolve and integrate this halo. Inevitably, this increases the VOC content of this final coat, but the much lower quantity of coating used ensures that on balance the technique leads to much lower emissions than full panel repairs.

Recycling filler (typical VOC content 400-600 g/l)

During the coating process, it is common to find small amounts of unthinned, uncatalysed paint that are surplus at the end of each job. To avoid the waste of these residues, special fillers have been developed, to which the residues can be added up to a certain percentage, without loss of properties. This is a useful waste reduction technique, as well as reducing costs. However, the fillers concerned cannot yet be offered in low VOC form.

Transparent design colours (typical VOC content 780 g/l)

These are solvent borne transparent coatings, based on solvent soluble dyes. They are applied alone or blended with solvent borne basecoat, to provide special colour effects. They are nearly always used on motorcycles, but can occasionally be used on other vehicles as special design colours. Because of their transparency, and the need to build thin even coats, they can only be supplied in low solids form.

At present, water borne products are not practicable, because of the solubility of the dyestuffs.
APPENDIX D: HOW THE DIRECTIVE WORKS

The Directive takes as its model a bodyshop that works to BAT with no regard for cost. It receives a delivery of 100 kg of products, containing 75 kg of solvent. This is pretty close to the actual 1992 situation.

In use, 25% of the solvent is fugitive, i.e. not captured in the spraybooth. The rest, the captured emissions, is assumed to be processed - e.g. by an afterburner - to eliminate 80%. This is an achievable target, but not an economically practicable one.

For every 25 kg of paint solids in this model, 30 kg of solvent are emitted to the atmosphere. (Note that water is ignored in this calculation.)

But there is an easier, and more cost effective way of achieving the same result.

If we eliminate the solvent at source - by using reduced solvent products - we can achieve the same end result, as is shown in the second picture.

This, then, becomes the objective.

With different assumptions on the initial solvent level, the amount of fugitive emissions, and the percentage abatement of captured emissions, this model is used for a large number of industrial paint sectors.

Technology guidelines for vehicle refinishes, CEPE 1999