Category		Title
NFR:	**2.D.3.d**	**Coating applications**
SNAP:	**0601** **060101** **060102** **060103** **060104** **060105** **060106** **060107** **060108** **060109**	**Paint application** **Manufacture of automobiles** **Car repairing** **Construction and buildings** **Domestic use (except 060107)** **Coil coating** **Boat building** **Wood** **Other industrial paint application** **Other non-industrial paint application**
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Contents

1 Overview

This chapter deals with the use of paints within the industrial and domestic sectors as described by the source activity titles. Traditionally, the term paint has often been used to describe pigmented coating materials only, thus excluding clear coatings such as lacquers and varnishes. However, here the term paint is taken to include all materials applied as a continuous layer to a surface with the exception of glues and adhesives which are covered by NFR source category 3.D.3 Other product use. Inks, which are coatings applied in a non continuous manner to a surface in order to form an image, are excluded by the definition given above.

Application of coatings during the manufacture of a number of other industrial products is covered by NFR source category 3.C Chemical products:

- adhesive, magnetic tapes, films and photographs manufacturing (SNAP 060311);
- textile finishing (SNAP 060312);
- leather tanning (SNAP 060313).

The use of paint is a major source of non-methane volatile organic compounds (NMVOC) emissions. The use of paints is generally not considered relevant for emissions of particulate matter, heavy metals or persistent organic pollutants (POPs). The separate NFR codes dealt with by this chapter are described below. It must be noted that the NFR and SNAP source category definitions do not match perfectly one-to-one in this source category. An attempt has been made to split the SNAPs over the NFR source category definitions in the text below.

1.1 Decorative coating application

Coating applications: construction and buildings (SNAP activity 060103)

This category refers to the use of paints for architectural application by construction enterprises and professional painters.

Coating applications: domestic use (SNAP activity 060104)

This category refers to the use of paints for architectural or furniture applications by private consumers. It is good practice not to include other domestic solvent use. However, it is sometimes difficult to distinguish between solvents used for thinning paints and solvents used for cleaning.

1.2 Industrial coating application

Coating applications: manufacture of automobiles (SNAP activity 060101)

This category refers to the coating of automobiles as part of their manufacture; it includes corrosion protection at point of manufacture; however it does not include the application of aftermarket sealants, covered in the chapter on underseal treatment of vehicles (NFR 3.D.3 Other product use, or SNAP code 060407). The application of sealants as part of the manufacturing process is covered here. Note that in some countries, only those paints manufactured for coating of high volume production vehicles (i.e. cars and light vans) are classified as automobile manufacture paints.

Coating applications: car repairing (SNAP activity 060102)

This category refers to the coating of road vehicles carried out as part of vehicle repair, conservation or decoration outside of manufacturing sites, or any use of refinishing-type coatings where this is carried out as part of an original manufacturing process. In some countries, specialist paints which are used for coating small volume vehicles such as heavy goods vehicles and buses are classified as vehicle refinishing paints.

Coating applications: coil coating (SNAP activity 060105)

This category refers to the coating of coiled steel, aluminium or copper alloy strips as a continuous process.

Coating applications: boat building (SNAP activity 060106)

This category refers to all paints for the hulls, interiors and superstructures of both new and old ships and boats. Strictly speaking this sector should include paints for both marine and river craft, although there may be differences between the classifications of coatings in different countries.

Coating applications: wood (SNAP activity 060107)

This category refers to all paints for wood and wooden products, but excludes the use of wood preservatives and creosote (see chapter for SNAP 060406).

Other industrial coating applications (SNAP activity 060108)

This category refers to all industrially applied paints for metal, plastic, paper, leather and glass substrates which are not covered by any of the other categories described here.

1.3 Other coating applications

Other non-industrial coating applications (SNAP activity 060109)

This category refers to the use of high performance protective and/or anti corrosive paints applied to structural steel, concrete and other substrates and any other non industrial coatings which are not covered by any of the other SNAP codes described here. The sector includes coatings for offshore drilling rigs, production platforms and similar structures as well as road marking paints and non-decorative floor paints.

2 Description of sources

2.1 Process description

This chapter covers the use of paints by industry, and by the commercial and domestic sectors. Most paints contain organic solvent which must be removed by evaporation after the paint has been applied to a surface in order for the paint to dry or ‘cure’. Unless captured and either recovered or destroyed, these solvents can be considered to be emitted to atmosphere. Some organic solvent may be added to coatings before application and will also be emitted. Further solvent is used for cleaning coating equipment and is also emitted.

The proportion of organic solvent in paints can vary considerably. Traditional solvent-borne paints contain approximately 50 % organic solvents and 50 % solids. In addition, more solvent may be added to dilute the paint further before application. High solids and waterborne paints both contain less organic solvent — typically less than 30 % — while powder coatings and solvent-free liquid coatings contain no solvent at all.

Paints are applied using a variety of methods:

- Spreading, e.g. by brush, roller or paint pad;
- spraying, including air-assisted and airless spraying, electrostatic spraying;
- flow coating, e.g. dipping, curtain coating, and roller coating;
- electrode position.

After application of the paint the surface is air or heat dried (stoved) to remove the volatile solvents from the coated surface.

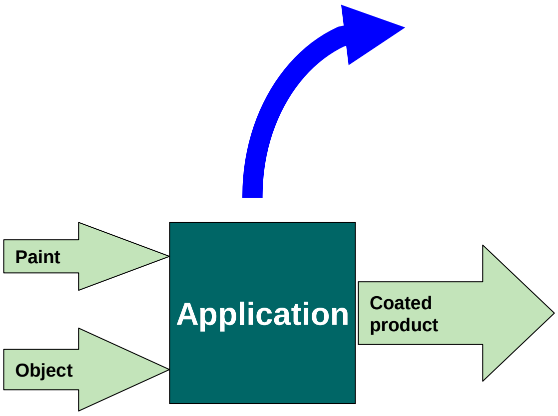

Figure 2-1 Process scheme for source category 2.D.3.d Coating applications

2.2 Techniques

2.2.1 Decorative coating application

Depending on the product requirements and the material being coated, a surface may have one or more layers of coating applied. For example, a first coat may be applied to cover surface imperfections or to assure adhesion of the subsequent coatings, intermediate coats might provide the required colour texture and a final coat can provide protection, durability and gloss. Coatings can be applied by a variety of methods such as brushing, rolling, spraying, dipping and flow coating; following application, the surface is air and/or heat dried to remove the volatile solvents from the coated surface.

2.2.1.1 Construction and buildings (SNAP activity 060103) and domestic use (SNAP activity 060104)

These two categories refer to the use of paints for the interiors and exteriors of buildings. These paints are often referred to as decorative or architectural coatings and their use is covered by two SNAP codes, 060103 (Construction of buildings) and 060104 (Domestic use). The former refers to paint supplied to professional decorators and used by painting contractors, local authorities, government departments, industrial and commercial companies, etc. and is often called trade decorative paint. The latter refers to paint sold to the general public as ‘do-it-yourself’ paint and is also known as retail decorative paint. There are only small differences in the formulations of these two types of paint and application methods are similar in both cases, although spray application may be used to a greater extent by professional decorators. Application by brush or roller is the preferred option.

It is possible to distinguish the main following applications of paints for the whole architectural sector:

- interior walls, ceilings and floors;
- exterior walls and floors;
- interior wood substrates, e.g. floors, furniture, doors, window frames;
- exterior wood substrates, e.g. fences, garden sheds, gable boards, garden furniture, wooden chalets;
- interior metallic substrates, e.g. radiators, tanks;
- exterior metallic substrates, e.g. fences, portals, garden furniture.

In addition, paints will fulfil a range of functions (e.g. undercoat or topcoat) and provide different finishes ranging from matt to gloss. The composition of the paint is very dependent upon the substrate being painted, the function and the finish required.

2.2.2 Industrial coating application

2.2.2.1 Coating applications: manufacture of automobiles (SNAP activity 060101)

Surface coating of an automobile body is a multi-step operation carried out on an assembly line conveyor system. Although finishing processes vary from plant to plant, they have some common characteristics and generally four major steps can be recognised:

- metal pre-treatments;
- application and curing of primer coatings;
- application and curing of primer surface coatings;
- application and curing of topcoats.

Various auxiliary operations such as sealant application and repair operations may also be carried out.

Pre-treatments include the removal of rust using mineral acids and oils and other surface contamination using alkalis, followed by phosphating. The purpose of this is to modify the surface of the metal car body in order to improve the subsequent adhesion of the primer coating and also to increase the corrosion resistance of the metal. No NMVOC emissions have been reported for these processes. Primers can be applied by dipping, spraying or electrode position. Virtually all primers are now applied by the latter method. Primer surfacers and topcoats (basecoat plus clearcoat) are applied by spraying, which may be manual or automatic. It is common for metallic finishes to be applied using a basecoat plus clearcoat. This process requires an extra coat of paint, which originally led to higher emission rates (however, powder, water-borne and very high solids clearcoats have been developed in order to avoid emission increases). All automotive coatings require stoving for some technologies at temperatures up to a maximum of about 180 ^{o}C.

The application and curing of the primer, primer surfacer and topcoat account for 50 to 80 % of the NMVOC emitted from assembly plants. Final topcoat repair, cleanup, and miscellaneous sources, such as the coating of small component parts and application of sealants, account for the remaining 20 % to 50 %. These figures may have changed following the introduction of the Solvents Emissions Directive, since more water-based or high solid coatings are being used.

2.2.2.2 Coating applications: car repairing (SNAP activity 060102)

Paints used for car repairs are often termed automotive or vehicle refinish paints. These products are commonly used to repair damaged bodywork, although occasionally they can be used for purely cosmetic reasons. Typically, a small area only will be repainted and spraying is always used to apply the coating. Because refinish paints are applied to a fully finished vehicle, fitted with fabric, plastic and rubber components, curing temperatures must be relatively low, a constraint which does not apply to original automotive coatings. Because of this, different technologies are used for the two types of paint.

It is good practice to note that refinish paints may be used by vehicle manufacturers to repair imperfections in original coatings and it is good practice to include these paints here.

2.2.2.3 Coating applications: coil coating (SNAP activity 060105)

Coil coating is the application of paints to continuous metal strip (generally steel, although aluminium and copper alloys are also painted) and is generally carried out on a large scale. The painted metals are used in the manufacture of kitchenware such as non-stick pans, white goods such as refrigerators, and for building cladding. Roller coating is used to apply the paint which is then cured at high temperatures.

2.2.2.4 Coating applications: boat building (SNAP activity 060106)

Paints for marine applications have some severe challenges to meet, in particular the need for excellent corrosion protection and anti-fouling properties. The formulation will depend upon the area being coated (e.g. hull or superstructure) and whether the paint is an original coating or refinish paint. Marine paints are invariably applied as systems, since all of the properties required cannot be met by a single paint. Paints are commonly applied by spraying, although brushing and rollering are also used.

2.2.2.5 Coating applications: wood (SNAP activity 060107)

Wood may be colour coated, stained or varnished. Application of paint is by roller or curtain coating (applicable only to flat stock) or spraying. Paints can be stoved or air dried, with air drying frequently being carried out as an uncontained process. Fugitive emissions are therefore significant from many wood painting processes.

2.2.2.6 Other industrial coating applications (SNAP activity 060108)

Paints supplied by industrial activities other than those already described are sometimes referred to as the general industrial sector. Products painted include agricultural, construction, and earthmoving equipment (‘ACE’), aircraft, cans and drums, caravans, domestic appliances, electrical components, freight containers, machine tools, military vehicles, motor vehicle components including engines, office equipment, paper and plastics, and toys. The scale of operation varies considerably, from large operations employing automated roller coating to small-scale manual spraying of paint. Processes may be enclosed or open air and both air-dried and stoved coatings are used.

2.2.3 Other coating application

2.2.3.1 Other non-industrial coating applications (SNAP activity 060109)

This sector consists of the application of high performance protective anti corrosive and/or fire resistant coatings to buildings and other large metallic structures, as well as coatings for concrete, road marking, etc. Most paint is applied in-situ by brushing, rolling or spraying, although a significant proportion of new-construction steelwork may be coated in shop.

2.3 Emissions

The most important pollutant released from painting activities is NMVOC. Particulate matter can also be emitted where spraying is used as an application technique; however many spraying operations are carried out in spray booths fitted with some type of particulate arrestment device. As mentioned earlier, heavy metal compounds, used as pigments, could be emitted to air; however, no emission factors are available.

NMVOC emissions result from the use of organic solvents in paints. The evaporation of the solvent is essential for the proper curing of the paint; however, it is possible to reduce the quantity of solvent needed either by substituting water or by applying the paint at a low(er) solvent content. Powder paints and solvent-free liquid paints do not contain solvent and so NMVOC emissions are avoided. In the case of powder paints, there is the potential for emissions of particulate matter.

A number of factors affect the mass of NMVOC emitted per unit of coated product. These include:

- NMVOC (solvent) content of coatings;
- volume solids content of coating;
- paint usage;
- transfer efficiency.

NMVOC (solvent) content of coatings: emissions can therefore be reduced by decreasing the organic solvent content of paint.

Volume solids content of coating: since generally a given thickness or depth of solids needs to be applied to a surface, increasing the volume solids content of a paint means that a smaller volume of paint is required per unit of coated surface.

Paint usage: paint usage will be dependent upon the film thickness and the area painted. The extent to which these can be modified is fairly limited, since they will be dictated by the design and function of the coated article. Decreases in paint usage might be possible in some cases through process improvements or improved process control.

Transfer efficiency: this is the percentage of solids in paint applied which remains on the surface of a coated article, and is thus an indication of the amount of paint wastage. Increasing the transfer efficiency means less paint wastage and therefore less needless NMVOC emission.

It is good practice to note that the first two factors are sometimes, but not always, connected, i.e. it is possible to decrease the NMVOC content of paint without increasing the solids content by substituting water for organic solvent.

Some industrial painting processes can be fully enclosed and automated. Examples include coil coating, application of automotive electrocoat primers and coating of some metal, plastic and wooden substrates. These processes are, to a large extent, enclosed and emissions can be easily captured and treated by end-of-pipe technology. Many other painting processes are carried out manually, but are still to a greater or lesser extent enclosed, usually by special 'booths'. Again, the emissions can be captured and treated by end-of-pipe technology, although the economics of doing so are generally less favourable than in the previous case. Examples of these processes include the application of some automotive paints and the painting of many metal and wooden objects. Finally, some industrial painting processes are uncontained, for example the in-situ painting of ships and immovable structures.

Solvent is emitted from the moment the paint is applied. Some paints require stoving (heating in an oven) in order to cure fully, others are air dried. Emissions of solvent from ovens can be vented to control devices, whereas air drying is often allowed to proceed in uncontained areas.

All painting activities lead to at least some fugitive emissions. The extent varies; for coil coating a figure of 5 % has been reported previously, while emissions from the in-situ painting of ships are about 95 % fugitives.

2.4 Controls

The best — and in some cases the only — way to control NMVOC emissions from paint application is to alter the process in such a way that no products containing solvent have to be used, or by reformulating the product in order to minimise the solvent content (see Table 2-1). Where for practical reasons prevention is not (yet) possible, it is good practice to use 'add-on' or 'end-of-pipe' abatement technology.

Paint technology is developing rapidly: increasingly more low-solvent coatings become available as a result of intensive research. Low-solvent and solvent-free paint can be divided into several categories. The table below gives a brief review of alternative paints with typical solvent content.

Table 2-1 Solvent content of alternative paints (source: ECE–VOC Task Force, 1990)

Category	Mean solvent content (wt-%)
Waterborne paint	< 20
Powder paint	0
High-solid paint (1 pack alkyds)	< 30
Low-solvent (1 pack radiation cure)[1]	0–3
Low-solvent (2 pack epoxy)[2]	< 10
Low-solvent (2 pack polyurethane paint)[2]	< 10
Conventional solvent paint	40–70

Notes:
1. [1] Setting of paint by IR or UV radiation.
2. [2] Setting of paint by chemical reaction between binder (base-component) and hardener.

The solvent content on application may be higher due to the use of 'thinners'. It is good practice to note that some types of alternative paint still contain a low percentage of solvents. This is the case for waterborne and high-solid coatings. However, the content of organic solvents in these coatings is less than 30 %. Powder and solvent-free liquid coatings do not contain organic solvents. When considering the effectiveness of changing to different coatings, it is important to consider the coverage efficiency, since this varies from paint to paint, as well as the solvent content.

Control options on exhaust air are the following:

- adsorption onto a solid surface;
- absorption by a liquid;
- membrane separation;
- condensation;
- incineration;
- biological treatment.

Improvements in the transfer efficiency (fraction of the solids in the total consumed coating which remains in the part) decrease the amount of coating which must be used to achieve a given film thickness, reducing emissions of NMVOC to the ambient air. With brush and roller painting the loss of paint is small; however, uneven coating may lead to higher paint consumption. With spray painting, on the other hand, only part of the paint is effectively used since a proportion of the paint is sprayed around the product. Spray losses are determined by the product's shape and the spray equipment used. Transfer efficiency for typical air-atomised spraying ranges from 50–75 % (difficult shapes, but using HVLP guns); in industrial applications this may increase to about 90 %. Electrostatic spray is most efficient for low viscosity paints. Charged paint particles are attracted to an oppositely charged surface. Spray guns, spinning discs or bell shaped atomisers can be used to atomise the paint. Typical transfer efficiencies are in the range from 80 to 95 %. High volume, low pressure (HVLP) air-atomised spray guns were introduced in the 1990s and are designed to reduce paint wastage caused by overspray. They have been reported to be cost effective compared with conventional air-atomised spray guns with paint usage reduced by 20 % (Aspinwalls/NERA, 1995).

2.4.1 Decorative coating application

The replacement of high solvent-based coatings by low solvent-based and water-based coatings has considerably reduced the emissions. These measures have been studied by the European Commission to regulate volatile organic compounds (VOC) content of the different types of coatings. The result of this is the Solvents Emissions Directive 1999/13/EC and the Product Directive 2004/42/EC (also referred to as the 'Decopaint Directive'). This regulation is implemented in two phases; phase 1 has been introduced and phase 2 will be introduced in 2010 (Expert Group on Techno-economic Issues (EGTEI), 2003).

Table 2-2 VOC content limit values for decorative paint and varnishes (in g/l ready to use)

Coating categories	Type	Phase I (g/l)* (2007)	Phase II (g/l)* (2010)
Interior matt wall and ceilings	WB	75	30
	SB	400	30
Interior glossy walls and ceilings	WB	150	100
	SB	400	100
Exterior walls of mineral substrate	WB	75	40
	SB	450	430
Interior/exterior trim and cladding paints for wood and metal	WB	150	130
	SB	400	300
Interior/exterior trim varnishes and wood stains, including opaque wood stains	WB	150	130
	SB	500	400
Interior and exterior minimal build wood stains	WB	150	130
	SB	700	700
Primers	WB	50	30
	SB	450	350
Binding primers	WB	50	30
	SB	750	750
One pack performance coatings	WB	140	140
	SB	600	500
Two-pack reactive performance coatings for specific end use, such as floors	WB	140	140
	SB	550	500
Multi-coloured coatings	WB	150	100
	SB	400	100
Decorative effects coatings	WB	300	200
	SB	500	200

2.4.2 Industrial coating application

2.4.2.1 Coating applications: manufacture of automobiles (SNAP activity 060101)

With particular reference to car-coating operations, three significant actions can be taken to reduce emissions:

1. installation of abatement equipment;

2. modification of the spraying process, the oven and air supply systems;
3. reformulation of coating.

With regard to the installation of abatement equipment, only two technologies have actually been proven on a large-scale basis in commercial installations:

- adsorption onto a solid surface;
- incineration.

The latter can be used either as the final step after adsorption or as a 'combined' collection and destruction process.

With regard to the reformulation of coating, opportunities exist for changes in coating formulations as follows:

- coating solvent content: water-borne, high solids, powder coatings;
- steel body part versus pre-coloured plastic parts.

Water-borne paints and low-solvent lines are in use in most automobile painting lines. For special parts (e.g. fuel tanks, shock-absorbers) powder paints are also in use.

2.4.2.2 Coating applications: car repairing (SNAP activity 060102)

Emissions from car repairing are regulated under the Product Directive 2004/42/EC. Following the introduction of this Directive, emissions must be controlled and it is no longer possible to use purely solvent-based coatings (for VOC limit values see Table 2-2). Waterborne and high-solid coatings are common practice nowadays in EU-27. Outside this region however, solvent-based coatings may still be used in daily practice.

2.4.2.3 Coating applications: coil coating (SNAP activity 060105)

Incineration is currently used by some coil coaters and is likely to remain the most popular choice of abatement system. Due to the enclosed nature of these processes and therefore the high capture and destruction efficiency of incineration, it is not likely that emissions from coil coating will be reduced much further. Powder coatings were seen of as an alternative, but cannot replace coil coatings due to problems with the layer thickness.

Emissions from this sector have been significantly reduced by the introduction of the European Solvents Directive 1999/13/EC.

2.4.2.4 Coating applications: boat building (SNAP activity 060106)

The use of HVLP spray guns has become common practice. Following the EU Solvents Emissions Directive, it is no longer possible to use solvent-based coatings without control options. Some reformulation of the paint has taken place and is continuing nowadays, but market demands limit the extent of this reformulation.

The Solvent Directive 1999/13/EC mentions that 'coating activities which cannot be applied under contained conditions (as shipbuilding, aircraft painting), may be exempted from emission limit values; the reduction scheme is then to be used, unless it is demonstrated that this option is not technically and economically feasible. In this case, the operator must demonstrate to the satisfaction of the competent authority that BAT (Best Available Techniques) is being used'.

2.4.2.5 Coating applications: wood (SNAP activity 060107)

This sector covers a wide range of applications and so a variety of abatement options could be adopted. Reformulation of many paint systems may be possible with waterborne, high solid, powder and radiation cured paints all being developed. Where spraying is employed, solvent emissions can be reduced by switching to HVLP spray guns.

Many wood painting operations have significant fugitive emissions. These can be reduced by good solvent management, by the use of low solvent coatings, highly efficient application techniques and by enclosing the process wherever possible so that the air can be extracted through NMVOC abatement equipment.

As concerns the types of coatings, the use of high-solid paints (e.g. UV-cured paints) is the most promising option; powder or waterborne paints are less common, as they require high polymerisation temperatures not compatible with the wooden support. Oven and spray booths can be equipped with activated carbon systems or combustion devices (both catalytic and thermal). Activated carbons must be avoided for some dangerous and reactive solvents; combustion technologies, on the other hand, are highly efficient with low air flow rates, whereas wood products industry is characterised by very high flow rates. Considerable efforts are being made towards an improvement of transfer efficiencies (common values in the 1990s were 0.15–0.5 for automatic systems and 0.1–0.2 for manual systems).

Emissions from this sector have been significantly reduced by the introduction of the European Solvents Directive 1999/13/EC.

2.4.2.6 Other industrial coating applications (SNAP activity 060108)

Emissions from this sector have been significantly reduced by the introduction of the European Solvents Directive 1999/13/EC. As with painting of wood, this sector covers a wide range of applications and a variety of control techniques are used to reduce the NMVOC emissions. These control techniques normally fall under one of three categories:

- modification in paint formula;
- process changes;
- add-on controls.

At the present time, modification in paint formula is the best means to reduce solvent emissions in industrial paints. The use of low solvent or powder coatings may reduce NMVOC emissions by 40 to 65 per cent overall. However, substitutes for products currently being used may not always be commercially available or fully developed for some applications.

Examples of process changes include:

- improvement of the application processes: electrostatic guns (where appropriate), heated paints (thus allowing higher solids content), two-component spray units which reduce wastage and minimise the use of cleaning solvents;
- reduction of the ventilation air flow rate with a better ventilation control, a recirculation system for the ventilation air from manned cabins to unmanned zones;
- the development of the use of pre-painted metal sheets provided that emissions at the point of coating can be more effectively controlled.

Add-on controls include activated carbon adsorption, thermal and catalytic incineration. These technologies may have very high technical efficiencies of 90 to more than 99 per cent, but may only apply to a portion of the emission from the entire facility. Due to the generally high flow rate of waste gases and the low solvent content, add-on controls are often not the most cost-effective abatement option and may be technically complex. They are also only cost-effective for large installations.

2.4.3 Other coating application

2.4.3.1 Other non-industrial coating applications (SNAP activity 060109)

Most coatings are applied in-situ, and the only abatement options which may be considered for these coatings are improvements in transfer efficiency and reformulation of coatings. Brush and roller application are widely used, and since these methods of application have high transfer efficiencies, little further can be done. Where spraying is used there is potential for the use of more efficient systems, such as high volume low pressure (HVLP) spraying systems. Reformulation options include high solids and waterborne coatings, and high solids technologies are now widely available. Waterborne technology has developed enormously over the last decades. Even for the higher technical specifications, waterborne alternatives have become available but are not widely used because of climatic/environmental constraints when coating large structures.

3 Methods

3.1 Choice of method

Figure 3-1 presents the procedure to select the methods for estimating emissions from coating application. This decision tree is applicable for all three source categories (decorative, industrial and other) discussed in this chapter. The basic idea is:

- if detailed information is available, use it;
- if the source category is a key category, a Tier 2 or better method must be applied and detailed input data must be collected. The decision tree directs the user in such cases to the Tier 2 method, since it is expected that it is easier to obtain the necessary input data for this approach than to collect facility level data needed for a Tier 3 estimate. However, in the case of coating applications, it may not be obvious to collect all the necessary information to apply a Tier 2 approach;
- the alternative of applying a Tier 3 method, using detailed process modelling, is not explicitly included in this decision tree. However, detailed modelling will always be done at facility level and results of such modelling could be seen as ‘facility data’ in the decision tree.

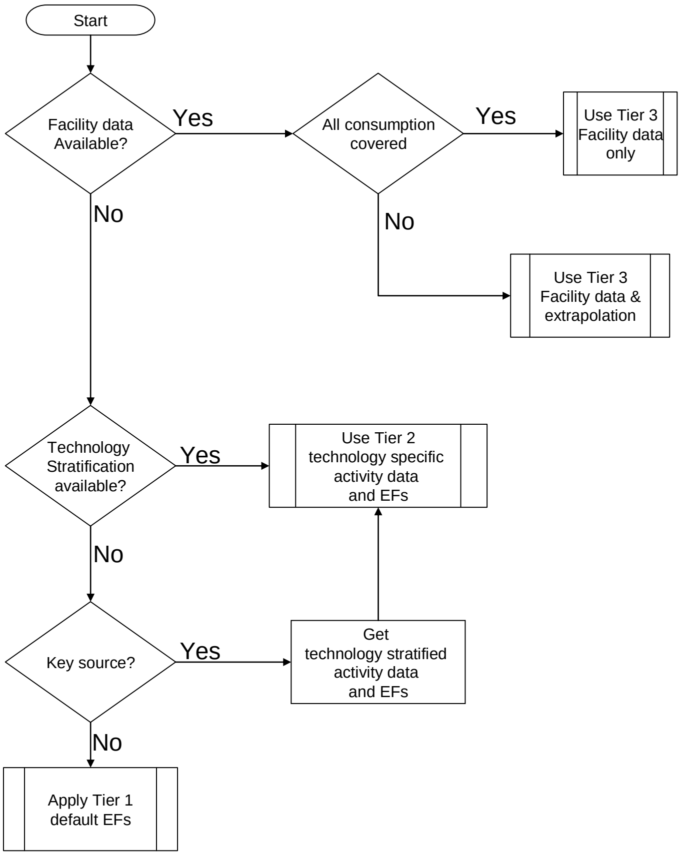

Figure 3-1 Decision tree for source category 2.D.3.d Coating applications

3.2 Tier 1 default approach

3.2.1 Algorithm

The default Tier 1 approach is to multiply the consumption of paint by an emission factor. The general equation is:

$$E_{pollutant} = AR_{production} \times EF_{pollutant} \quad (1)$$

where:

$E_{pollutant}$ = the emission of the specified pollutant,

$AR_{production}$ = the activity rate for the coating application (consumption of paint),

$EF_{pollutant}$ = the emission factor for this pollutant.

This equation is applied at the national level, using annual national total figures for the consumption of paint. Information on the consumption of paint, suitable for estimating emissions using of the simpler estimation methodology (Tier 1 and 2), is widely available from UN statistical yearbooks or national statistics.

The Tier 1 emission factors assume an averaged or typical technology and abatement implementation in the country and integrate all different sub-processes in the chemical industry between feeding the raw material into the process and the final shipment of the facilities.

In cases where specific abatement options are to be taken into account, a Tier 1 method is not applicable and a Tier 2 or Tier 3 approach must be used.

3.2.2 Default emission factors

This section includes default Tier 1 emission factors for the different subcategories from source category 2.D.3.d Coating applications as:

- Decorative coating application,
- Industrial coating application,
- Other coating application.

The Tier 1 default emission factors have been taken from the online version of the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model (International Institute for Applied Systems Analysis (IIASA), 2008). A (rounded) weighted average emission factor over all countries in the model has been derived from dividing total NMVOC emissions by total paint use. Year 2000 data have been used in order to estimate an average emission factor describing the situation, however care should be taken when applying this emission factor. Because of the EU Directive 2004/42/EC, which came into force on 1.1.2007, it is no longer allowed in the EU Member States to bring decorative or vehicle refinishing paint products to the market with a VOC content that exceeds the maximum for those product categories. For non-EU countries however, emissions may be significantly higher than the estimate provided here. This has been taken into account in the 95 % confidence intervals. These are expert judgements based on old literature values and the more specifically implied emission factors from GAINS.

Another complicating issue is that different kinds of paint are used in, for instance, Scandinavia and the Mediterranean countries, because of the different construction materials that are being used. The on-line version of the GAINS model provides country-specific emission factors, which take into account this country-specific information.

Furthermore, GAINS considers multiple years with a specific emission factor for every year considered. These time-specific emission factors can also be considered technology-specific emission factors for the technology in that specific year (and country).

For documentation of the IIASA GAINS model, please refer to the website http://gains.iiasa.ac.at/gains/, also for definitions of the source categories used in the model.

For calculating Tier 1 emission factors, the following IIASA source definitions have been used:

- Decorative coating: DECO_P (Decopaint);
- Industrial coating: IND_P_OT (Industrial paint application — general industry);
- Other coatings: For this source category no specific information was available. Therefore, all paint application sources have been considered to derive from the Tier 1 default emission factor. The large uncertainty reflects the variety of paint applications that may be included in this source category.

Table 3-1 Tier 1 emission factors for source category 2.D.3.d Decorative coating application

Tier 1 default emission factors					
	Code	Name			
NFR Source Category	2.D.3.d	Coating applications			
Fuel	NA				
Not applicable	NOx, CO, SOx, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Aldrin, Chlordane,				
Not estimated	SCCP				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NMVOC	150	g/kg paint applied	100	400	IIASA (2008)

Table 3-2 Tier 1 emission factors for source category 2.D.3.d Industrial coating application

Tier 1 default emission factors					
	Code	Name			
NFR Source Category	2.D.3.d	Coating applications			
Fuel	NA				
Not applicable	NOx, CO, SOx, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Aldrin, Chlordane,				
Not estimated	SCCP				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NMVOC	400	g/kg paint applied	100	800	IIASA (2008)

Table 3-3 Tier 1 emission factors for source category 2.D.3.d Other coating application

Tier 1 default emission factors					
	Code	Name			
NFR Source Category	2.D.3.d	Coating applications			
Fuel	NA				
Not applicable	NOx, CO, SOx, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Aldrin, Chlordane,				
Not estimated	SCCP				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NMVOC	200	g/kg paint applied	4	1000	IIASA (2008)

3.2.3 Activity data

The total quantity of paint used within each NFR source category is required for calculating the emissions. Information on the total use of paint, suitable for estimating emissions using the simpler estimation methodology (Tier 1 and 2), may be available from national statistics.

3.3 Tier 2 technology-specific approach

The Tier 2 approach can be used when different objects being painted can be distinguished, as well as the different paints that are used and the quality of these paints (VOC emission reduction measures that may be in place).

3.3.1 Algorithm

The Tier 2 approach is similar to the Tier 1 approach. To apply the Tier 2 approach, both the activity data and the emission factors need to be stratified according to the different processes that may occur in the country. These techniques may include:

- different products to be painted;

- the use of different paints (solvent borne, waterborne);
- abatement techniques to reduce the emissions.

There following approach is used to estimate emissions from the use of coatings:

Stratify the use of paint in the country to model the different process types occurring in the national paint use into the inventory by:

- defining the use of paint using each of the separate process types (together called 'technologies' in the formulae below) separately, and
- applying technology-specific emission factors for each process type:

$$E_{pollutant} = \sum_{technologies} AR_{use,technology} \times EF_{technology,pollutant} \quad (2)$$

where:

$AR_{use,technology}$ = the use of paint within the source category, using this specific technology,

$EF_{technology,pollutant}$ = the emission factor for this technology and this pollutant.

If no direct activity data are available, penetration of different technologies within the paint application could be estimated from data on capacities, number of employees or other data that reflect the relative size of each of the different technologies.

A country where only one technology is implemented is basically a special case of the above approaches. The penetration of this technology in such a case is 100 % and the algorithm in equation (2) reduces to:

$$E_{pollutant} = AR_{production} \times EF_{technology,pollutant} \quad (3)$$

This section discusses the Tier 2 algorithm based on paint used. However, for some technologies within the paint industry, technology-specific emission factors are expressed in production units rather than paint used. For instance, emission factors for truck and van coating are given in kg/vehicle rather than kg/tonne paint used. For these cases a similar algorithm is applicable, where it is good practice to replace the use of paint as activity data by the relevant activity statistics (e.g. number of vans or trucks coated).

3.3.2 Technology-specific emission factors

Tier 2 technology-specific emission factors are provided in this section. Emission factors have been extracted from the IIASA GAINS model, similar to the Tier 1 emission factors. Most of the data in the GAINS model are originally taken from the EGTEI sector background documents (EGTEI, 2003). This section presents the uncontrolled emissions for solvent-based paints. Emission factors for NMVOC include use of thinners; however, if more specific or detailed information is available, this should be used in the compilation of emission estimates.

It must be noted that country-specific emission factors are available in the IIASA GAINS model. They are also available for various years (data for 1990, 2000 and 2010 from the European Council of producers and importers of paints, printing inks and artists' colours have been used) and may be used for an emission inventory for an individual country. These country- and year-specific emission factors take into account country-specific information on implemented technologies and abatement measures and changes therein over time.

3.3.2.1 Decorative coating application (2.D.3.d)

The emission factors have been calculated using an assessment of the information presented in EGTEI sector background documents (EGTEI, 2003). The emission factors represent the ratio between the total emissions and the total use of paint in the mentioned countries, taking into account only the so-called 'reference case' (EGTEI, 2003). The reference case refers to the use of conventional solvent-based paints containing 50 wt.-% solvents). This information has also been used in the online version IIASA RAINS/GAINS model (IIASA, 2008).

Please take care when applying the emission factors in the Tier 2 tables below, because they refer to the use of conventional solvents. Subsection 3.3.3.1 of the present chapter presents the abatement efficiencies for these emission factors. Abatement is identified here as the use of paints with less solvents and the use of add-on abatements such as thermal incineration.

The emission factors are presented for an average (medium) facility size. Information for larger and smaller size facilities may be available from the EGTEI background documents.

A study carried out for the European Commission (EC DG Environment Tender 2000, available via http://ec.europa.eu/environment/air/pdf/decopaint.pdf) is available as a useful background document.

Table 3-4 Tier 2 emission factors for source category 2.D.3.d Decorative coating application, Decorative paint, Construction of buildings, Conventional solvent-based products

Tier 2 emission factors					
	Code	Name			
NFR Source Category	2.D.3.d	Coating applications			
Fuel	NA				
SNAP (if applicable)	060103	Paint application : construction and buildings			
Technologies/Practices	Use of conventional solvent-based products containing 50 wt-% solvent				
Region or regional conditions					
Abatement technologies					
Not applicable	NOx, CO, SOx, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Aldrin, Chlordane, Chlordecone, Dieldrin, Endrin, Heptachlor, Heptabromo-biphenyl, Mirex, Toxaphene, HCH, DDT, PCB, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total 4 PAHs, HCB, PCP				
Not estimated	SCCP				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NMVOC	230	g/kg paint	100	300	Assessment of data from EGTEI

Table 3-5 Tier 2 emission factors for source category 2.D.3.d Decorative coating application, Decorative paint, Domestic use of paints, Conventional solvent-based products

Tier 2 emission factors					
	Code	Name			
NFR Source Category	2.D.3.d	Coating applications			
Fuel	NA				
SNAP (if applicable)	060104	Paint application : domestic use (except 06.01.07)			
Technologies/Practices	Use of conventional solvent-based products containing 50 wt-% solvent				
Region or regional conditions					
Abatement technologies					
Not applicable	NOx, CO, SOx, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Aldrin, Chlordane, Chlordecone, Dieldrin, Endrin, Heptachlor, Heptabromo-biphenyl, Mirex, Toxaphene, HCH, DDT, PCB, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total 4 PAHs, HCB, PCP				
Not estimated	SCCP				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NMVOC	230	g/kg paint	100	300	Assessment of data from EGTEI

3.3.2.2 Industrial coating application

Tier 2 technology-specific emission factors for industrial coating application are provided in this section. Most of the emission factors are taken from the EGTEI background documents (EGTEI, 2003).

Please take care when applying the emission factors in the Tier 2 tables below. All these emission factors refer to the so-called 'reference case' (EGTEI, 2003). Subsection 3.3.3.2 of the present chapter presents the abatement efficiencies for these emission factors. Abatement is identified here as the use of paints with less solvents and the use of add-on abatements such as thermal incineration.

The emission factors are presented for an average (medium) facility size. Information for larger and smaller size facilities may be available from the EGTEI background documents.

Table 3-6 Tier 2 emission factors for source category 2.D.3.d Industrial coating application, Car coating

Tier 2 emission factors					
	Code	Name			
NFR Source Category	2.D.3.d	Coating applications			
Fuel	NA				
SNAP (if applicable)	060101	Paint application : manufacture of automobiles			
Technologies/Practices	Car coating				
Region or regional conditions					
Abatement technologies	Solvent-based primer and basecoat; no secondary measures				
Not applicable	NOx, CO, SOx, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Aldrin, Chlordane, Chlordecone, Dieldrin, Endrin, Heptachlor, Heptabromo-biphenyl, Mirex, Toxaphene, HCH, DDT, PCB, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total 4 PAHs, HCB, PCP				
Not estimated	SCCP				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NMVOC	8	kg/car	5	10	EGTEI (2003)

Table 3-7 Tier 2 emission factors for source category 2.D.3.d Industrial coating application, Vehicle refinishing

Tier 2 emission factors					
	Code	Name			
NFR Source Category	2.D.3.d	Coating applications			
Fuel	NA				
SNAP (if applicable)	060102	Paint application : car repairing			
Technologies/Practices	Vehicle refinishing				
Region or regional conditions					
Abatement technologies	Solvent-based primer and basecoat; no secondary measures				
Not applicable	NOx, CO, SOx, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Aldrin, Chlordane, Chlordecone, Dieldrin, Endrin, Heptachlor, Heptabromo-biphenyl, Mirex, Toxaphene, HCH, DDT, PCB, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total 4 PAHs, HCB, PCP				
Not estimated	SCCP				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NMVOC	720	g/kg paint	400	1000	EGTEI (2003)

Table 3-8 Tier 2 emission factors for source category 2.D.3.d Industrial coating application, Coil coating

Tier 2 emission factors					
	Code	Name			
NFR Source Category	2.D.3.d	Coating applications			
Fuel	NA				
SNAP (if applicable)	060105	Paint application : coil coating			
Technologies/Practices					
Region or regional conditions					
Abatement technologies	Solvent-based coatings; no secondary measures				
Not applicable	NOx, CO, SOx, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Aldrin, Chlordane, Chlordecone, Dieldrin, Endrin, Heptachlor, Heptabromo-biphenyl, Mirex, Toxaphene, HCH, DDT, PCB, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total 4 PAHs, HCB, PCP				
Not estimated	SCCP				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NMVOC	480	g/kg paint applied	300	700	EGTEI (2003)

The default emission factor for coil coating has been recalculated in terms of g/kg paint applied (EF in literature is given in g/m^2 coil coated) by applying the default conversion factor of 90 g paint/m^2 coil coated, as given in EGTEI (2003).

Table 3-9 Tier 2 emission factors for source category 2.D.3.d Industrial coating application, Wood coating

Tier 2 emission factors					
	Code	Name			
NFR Source Category	2.D.3.d	Coating applications			
Fuel	NA				
SNAP (if applicable)	060107	Paint application : wood			
Technologies/Practices	Wood coating				
Region or regional conditions					
Abatement technologies	Low solids system; conventional application process (45% efficiency); no secondary measures				
Not applicable	NOx, CO, SOx, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Aldrin, Chlordane, Chlordecone, Dieldrin, Endrin, Heptachlor, Heptabromo-biphenyl, Mirex, Toxaphene, HCH, DDT, PCB, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total 4 PAHs, HCB, PCP				
Not estimated	SCCP				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NMVOC	800	g/kg paint applied	600	950	EGTEI (2003)

The default emission factor for wood coating corresponds to an assumed 80 % solvent content of the paint (EGTEI, 2003). If estimates are available for the area of wood coated, then an emission factor of 345.6 g NMVOC/m^2 wood covered may be used (EGTEI, 2003).

Table 3-10 Tier 2 emission factors for source category 2.D.3.d Industrial coating application, Truck/van coating

Tier 2 emission factors					
	Code	Name			
NFR Source Category	2.D.3.d	Coating applications			
Fuel	NA				
SNAP (if applicable)	060108	Other industrial paint application			
Technologies/Practices	Truck / Van coating				
Region or regional conditions					
Abatement technologies	Solvent-based coatings; no secondary measures				
Not applicable	NOx, CO, SOx, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Aldrin, Chlordane, Chlordecone, Dieldrin, Endrin, Heptachlor, Heptabromo-biphenyl, Mirex, Toxaphene, HCH, DDT, PCB, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total 4 PAHs, HCB, PCP				
Not estimated	SCCP				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NMVOC	28	kg/vehicle	20	40	EGTEI (2003)

Table 3-11 Tier 2 emission factors for source category 2.D.3.d Industrial coating application, Truck cabin coating

Tier 2 emission factors					
	Code	Name			
NFR Source Category	2.D.3.d	Coating applications			
Fuel	NA				
SNAP (if applicable)	060108	Other industrial paint application			
Technologies/Practices	Truck cabin coating				
Region or regional conditions					
Abatement technologies	Solvent-based primer and basecoat; no secondary measures				
Not applicable	NOx, CO, SOx, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Aldrin, Chlordane, Chlordecone, Dieldrin, Endrin, Heptachlor, Heptabromo-biphenyl, Mirex, Toxaphene, HCH, DDT, PCB, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total 4 PAHs, HCB, PCP				
Not estimated	SCCP				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NMVOC	8	kg/vehicle	5	10	EGTEI (2003)

Table 3-12 Tier 2 emission factors for source category 2.D.3.d Industrial coating application, Bus coating

Tier 2 emission factors					
	Code	Name			
NFR Source Category	2.D.3.d	Coating applications			
Fuel	NA				
SNAP (if applicable)	060108	Other industrial paint application			
Technologies/Practices	Bus coating				
Region or regional conditions					
Abatement technologies	Solvent-based primer and basecoat; no secondary measures				
Not applicable	NOx, CO, SOx, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Aldrin, Chlordane, Chlordecone, Dieldrin, Endrin, Heptachlor, Heptabromo-biphenyl, Mirex, Toxaphene, HCH, DDT, PCB, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total 4 PAHs, HCB, PCP				
Not estimated	SCCP				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NMVOC	150	kg/bus	100	200	EGTEI (2003)

Note:
The original EGTEI emission factor is 145.2 kg/bus. This appears too high a level of precision for the level of uncertainty, and so a value of 150 kg/bus is recommended here.

Table 3-13 Tier 2 emission factors for source category 2.D.3.d Industrial coating application, Wire coating

Tier 2 emission factors					
	Code	Name			
NFR Source Category	2.D.3.d	Coating applications			
Fuel	NA				
SNAP (if applicable)	060108	Other industrial paint application			
Technologies/Practices	Wire coating				
Region or regional conditions					
Abatement technologies	70% solvent in enamel; 90% efficiency in oven; no secondary measures				
Not applicable	NOx, CO, SOx, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Aldrin, Chlordane, Chlordecone, Dieldrin, Endrin, Heptachlor, Heptabromo-biphenyl, Mirex, Toxaphene, HCH, DDT, PCB, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total 4 PAHs, HCB, PCP				
Not estimated	SCCP				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NMVOC	17	g/kg wire	10	20	EGTEI (2003)

Relevant abatement efficiencies when using paints with less solvent, or when using additional secondary abatement measures, can be found in subsection 3.3.3 of the present chapter.

The emission factors in the tables below are taken from the BREF document for ‘Surface Treatment using Organic Solvents’ (European Commission, 2007). However, an emission factor of 1 kg/kg coating is reported in EGTEI (2003), indicating that the emission factor could also be significantly higher.

Table 3-14 Tier 2 emission factors for source category 2.D.3.d Industrial coating application, Leather finishing

Tier 2 emission factors					
	Code	Name			
NFR Source Category	2.D.3.d	Coating applications			
Fuel	NA				
SNAP (if applicable)					
Technologies/Practices	Leather finishing				
Region or regional conditions					
Abatement technologies					
Not applicable	NOx, CO, SOx, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Aldrin, Chlordane, Chlordecone, Dieldrin, Endrin, Heptachlor, Heptabromo-biphenyl, Mirex, Toxaphene, HCH, DDT, PCB, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total 4 PAHs, HCB, PCP				
Not estimated	SCCP				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NMVOC	200	g/kg leather	100	300	European Commission (2007)

Table 3-15 Tier 2 emission factors for source category 2.D.3.d Industrial coating application, Boat building

Tier 2 emission factors					
	Code	Name			
NFR Source Category	2.D.3.d	Coating applications			
Fuel	NA				
SNAP (if applicable)					
Technologies/Practices	Boat building				
Region or regional conditions					
Abatement technologies					
Not applicable	NOx, CO, SOx, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Aldrin, Chlordane, Chlordecone, Dieldrin, Endrin, Heptachlor, Heptabromo-biphenyl, Mirex, Toxaphene, HCH, DDT, PCB, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total 4 PAHs, HCB, PCP				
Not estimated	SCCP				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NMVOC	125	g/m2	100	150	European Commission (2007)

3.3.2.3 Other coating application

A Tier 2 technology-specific emission factor for other coating application is shown below. This factor is taken from an earlier version of the EMEP Corinair Guidebook (EMEP/EEA 2006) and is applicable only to uncontrolled emissions and represents the ‘conventional’ situation before the Solvents Emissions Directive came into force.

Table 3-16 Tier 2 emission factors for source category 2.D.3.d Other coating application

Tier 2 emission factors					
	Code	Name			
NFR Source Category	2.D.3.d	Coating applications			
Fuel	NA				
SNAP (if applicable)	060109	Other non industrial paint application			
Technologies/Practices					
Region or regional conditions					
Abatement technologies	All types of paint; no secondary measures				
Not applicable	NOx, CO, SOx, NH3, TSP, PM10, PM2.5, Pb, Cd, Hg, As, Cr, Cu, Ni, Se, Zn, Aldrin, Chlordane, Chlordecone, Dieldrin, Endrin, Heptachlor, Heptabromo-biphenyl, Mirex, Toxaphene, HCH, DDT, PCB, PCDD/F, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, Total 4 PAHs, HCB, PCP				
Not estimated	SCCP				
Pollutant	Value	Unit	95% confidence interval		Reference
			Lower	Upper	
NMVOC	740	g/kg paint	400	1000	Guidebook (2006)

For this source category, abatement options (as presented in the following section) are not provided. If emissions are reported in the ‘Other’ source category are lower than the uncontrolled emission factor given here, the abatement efficiencies for decorative or industrial coating application may be used.

3.3.3 Abatement

A number of technologies exist that are aimed at reducing the emissions of specific pollutants. In this chapter, this not only includes add-on abatement techniques (e.g. thermal incineration), but also the use of paints with less solvents. The resulting emission can be calculated by replacing the technology-specific emission factor with an abated emission factor as given in the formula:

$$EF_{technology,abated} = (1 - \eta_{abatement}) \times EF_{technology,unabated} \quad (4)$$

When more than one abatement technique is applied (e.g. better paints and add-on techniques), it is good practice to subsequently apply these efficiencies to the applicable Tier 2 emission factor presented in subsection 3.3.2 of the present chapter to derive the emission factor for the specific situation.

This section presents default abatement efficiencies for a number of abatement options applicable in this sector. These are all related to the reference cases in the previous section (Tier 2 technology-specific emission factors).

3.3.3.1 Decorative coating application

Efficiencies presented in Table 3-17 relate to the reference emission factor in Table 3-4 and Table 3-5 (applicable to both technologies). It is good practice to apply these reduction efficiencies when using paints with less solvent.

Table 3-17 Abatement efficiencies ($\eta_{abatement}$) for source category 2.D.3.d Decorative coating application

Tier 2 Abatement efficiencies					
	Code	Name			
NFR Source Category	2.D.3.d	Decorative coating application			
Fuel	NA	not applicable			
SNAP (if applicable)	060103 060104	Construction of buildings Domestic use			
Abatement technology	**Pollutant**	**Efficiency**	**95% confidence interval**		**Reference**
		Default Value	**Lower**	**Upper**	
Substitution with dispersion/emulsion (2-3 wt-% solvent)	NMVOC	39%	15%	63%	EGTEI (2003)
Substitution with water-based paints (efficiency 80%)	NMVOC	26%	0%	56%	EGTEI (2003)
Substitution with high solids paints (efficiency 40-60%)	NMVOC	4%	0%	43%	EGTEI (2003)
Substitution with dispersion/emulsion and water-based paints	NMVOC	65%	51%	79%	EGTEI (2003)
Substitution with dispersion/emulsion and high solids paints	NMVOC	43%	21%	66%	EGTEI (2003)
Substitution with dispersion/emulsion, water-based and high solids paints	NMVOC	70%	57%	82%	EGTEI (2003)

3.3.3.2 Industrial coating application

This section provides reduction efficiencies for industrial coating application sectors when using paint types with less solvent and/or add-on abatement techniques. When both less solvent coatings and add-on abatement equipment are applied, it is good practice to apply both the efficiencies in succession.

Table 3-18 Abatement efficiencies ($\eta_{abatement}$) for source category 2.D.3.d Industrial coating application, Car coating

Tier 2 Abatement efficiencies					
	Code	Name			
NFR Source Category	2.D.3.d	Industrial coating application			
Fuel	NA	not applicable			
SNAP (if applicable)	060101	Manufacture of automobiles			
Technologies/Practices	Car coating				
Abatement technology	**Pollutant**	**Efficiency**	**95% confidence interval**		**Reference**
		Default Value	**Lower**	**Upper**	
Water-based primer; solvent-based basecoat	NMVOC	10%	6%	14%	EGTEI (2003)
Solvent-based primer; water-based basecoat	NMVOC	40%	20%	50%	EGTEI (2003)
Water-based primer and basecoat	NMVOC	50%	30%	70%	EGTEI (2003)
Add on: incinerator on drying oven	NMVOC	10%	7%	20%	EGTEI (2003)
Add on: Incinerator on drying oven; activated carbon adsorption on spray booth & thermal incineration	NMVOC	40%	20%	60%	EGTEI (2003)

Table 3-19 Abatement efficiencies ($\eta_{abatement}$) for source category 2.D.3.d Industrial coating application, Vehicle refinishing

Tier 2 Abatement efficiencies					
	Code	Name			
NFR Source Category	2.D.3.d	Industrial coating application			
Fuel	NA	not applicable			
SNAP (if applicable)	060102	Car repairing			
Technologies/Practices	Vehicle refinishing				
Abatement technology	**Pollutant**	**Efficiency**	**95% confidence interval**		**Reference**
		Default Value	**Lower**	**Upper**	
Conventional primer; high solid surfacer; conventional topcoat(s); basic cleaning agent	NMVOC	8%	5%	10%	EGTEI (2003)
Conventional primer; high solid surfacer; improved topcoat(s); better cleaning agent(1)	NMVOC	60%	40%	90%	EGTEI (2003)
Conventional primer; very high solid surfacer; improved topcoat(s); better cleaning agent(2)	NMVOC	70%	40%	100%	EGTEI (2003)

Table 3-20 Abatement efficiencies ($\eta_{abatement}$) for source category 2.D.3.d Industrial coating application, Coil coating

Tier 2 Abatement efficiencies					
	Code	Name			
NFR Source Category	2.D.3.d	Industrial coating application			
Fuel	NA	not applicable			
SNAP (if applicable)	060105	Coil coating			
Technologies/Practices					
Abatement technology	**Pollutant**	**Efficiency**	**95% confidence interval**		**Reference**
		Default Value	**Lower**	**Upper**	
Coil coating line with water-based coatings (10 wt-% solvent content)	NMVOC	75%	50%	100%	EGTEI (2003)
Coil coating line with powder coating systems (solvent free)	NMVOC	100%	100%	100%	EGTEI (2003)
Add on: Thermal oxidation	NMVOC	90%	50%	100%	EGTEI (2003)

Table 3-21 Abatement efficiencies ($\eta_{abatement}$) for source category 2.D.3.d Industrial coating application, Wood coating

Tier 2 Abatement efficiencies					
	Code	Name			
NFR Source Category	2.D.3.d	Industrial coating application			
Fuel	NA	not applicable			
SNAP (if applicable)	060107	Wood			
Technologies/Practices	Wood coating				
Abatement technology	**Pollutant**	**Efficiency**	**95% confidence interval**		**Reference**
		Default Value	**Lower**	**Upper**	
Medium solids system (55% solvent content)	NMVOC	31%	20%	50%	EGTEI (2003)
High solids system (20% solvent content)	NMVOC	75%	40%	100%	EGTEI (2003)
Very high solids system (5% solvent content)	NMVOC	94%	60%	100%	EGTEI (2003)
Add-on: Thermal oxidation	NMVOC	76%	50%	100%	EGTEI (2003)

Table 3-22 Abatement efficiencies ($\eta_{abatement}$) for source category 2.D.3.d Industrial coating application, Truck/van coating

Tier 2 Abatement efficiencies					
	Code	Name			
NFR Source Category	2.D.3.d	Industrial coating application			
Fuel	NA	not applicable			
SNAP (if applicable)	060108	Other industrial paint application			
Technologies/Practices	Truck / Van coating				
Abatement technology	**Pollutant**	**Efficiency**	**95% confidence**		**Reference**
		Default Value	**Lower**	**Upper**	
50% two layer - 50% one layer; waterborne primer, high solid basecoat, clear coat and solid coat; improvement of cleaning stages; incineration on electrophoresis oven applied; improved solvent recovery/consumption reduction; incineration on primer and enamel	NMVOC	34%	20%	50%	EGTEI (2003)
50% two layer - 50% one layer; waterborne primer, high solid basecoat, clear coat and solid coat; improvement of cleaning stages; incineration on electrophoresis oven applied; improved solvent recovery/consumption reduction; incineration on primer and enamel; partial VOC abatement in the enamel spray booths	NMVOC	37%	20%	50%	EGTEI (2003)
80% two layer - 20% one layer; waterborne primer and basecoat, high solid clear coat, waterborne solid coat; improvement of cleaning stages; incineration on electrophoresis oven applied; improved solvent recovery/consumption reduction; incineration on primer and enamel	NMVOC	54%	30%	80%	EGTEI (2003)

Table 3-23 Abatement efficiencies ($\eta_{abatement}$) for source category 2.D.3.d Industrial coating application, Truck cabin coating

Tier 2 Abatement efficiencies						
	Code	Name				
NFR Source Category	2.D.3.d	Industrial coating application				
Fuel	NA	not applicable				
SNAP (if applicable)	060108	Other industrial paint application				
Technologies/Practices	Truck Cabin coating					
Abatement technology	**Pollutant**	**Efficiency**	**95% confidence**		**Reference**
		Default Value	**Lower**	**Upper**	
50% two layer - 50% one layer; waterborne primer, high solid basecoat, clear coat and solid coat; improvement of cleaning stages; incineration on electrophoresis oven applied; improved solvent recovery/consumption reduction; incineration on primer and enamel	NMVOC	40%	20%	60%	EGTEI (2003)
50% two layer - 50% one layer; waterborne primer, high solid basecoat, clear coat and solid coat; improvement of cleaning stages; incineration on electrophoresis oven applied; improved solvent recovery/consumption reduction; incineration on primer and enamel; partial VOC abatement in the enamel spray booths	NMVOC	45%	30%	60%	EGTEI (2003)
80% two layer - 20% one layer; waterborne primer and basecoat, high solid clear coat, waterborne solid coat; improvement of cleaning stages; incineration on electrophoresis oven applied; improved solvent recovery/consumption reduction; incineration on primer and enamel	NMVOC	60%	40%	80%	EGTEI (2003)

Table 3-24 Abatement efficiencies ($\eta_{abatement}$) for source category 2.D.3.d Industrial coating application, Bus coating

Tier 2 Abatement efficiencies					
	Code	Name			
NFR Source Category	2.D.3.d	Industrial coating application			
Fuel	NA	not applicable			
SNAP (if applicable)	060108	Other industrial paint application			
Technologies/Practices	Bus coating				
Abatement technology	**Pollutant**	**Efficiency**	**95% confidence**		**Reference**
		Default Value	**Lower**	**Upper**	
50% two layer - 50% one layer; waterborne primer, high solid basecoat, clear coat and solid coat; improvement of cleaning stages; improved solvent recovery/consumption reduction; incineration on electrophoresis oven, primer and enamel	NMVOC	48%	30%	80%	EGTEI (2003)
80% two layer - 20% one layer; waterborne primer and basecoat, high solid clear coat, waterborne solid coat; improvement of cleaning stages; improved solvent recovery/consumption reduction; incineration on electrophoresis oven, primer and enamel	NMVOC	62%	40%	90%	EGTEI (2003)

Table 3-25 Abatement efficiencies ($\eta_{abatement}$) for source category 2.D.3.d Industrial coating application, Wire coating

Tier 2 Abatement efficiencies						
	Code	Name				
NFR Source Category	2.D.3.d	Industrial coating application				
Fuel	NA	not applicable				
SNAP (if applicable)	060108	Other industrial paint application				
Technologies/Practices	Wire coating					
Abatement technology	**Pollutant**	**Efficiency**	**95% confidence**		**Reference**	
		Default Value	**Lower**	**Upper**		
62% solvent content in enamel; reduced emissions from wax application; reduced fugitive emissions; 97% abatement efficiency in oven	NMVOC	76%	50%	100%	EGTEI (2003)	

Table 3-26 Abatement efficiencies ($\eta_{abatement}$) for source category 2.D.3.d Industrial coating application, Leather coating

Tier 2 Abatement efficiencies					
	Code	Name			
NFR Source Category	2.D.3.d	Industrial coating application			
Fuel	NA	not applicable			
SNAP (if applicable)	060108	Other industrial paint application			
Technologies/Practices	Leather coating				
Abatement technology	**Pollutant**	**Efficiency**	**95% confidence**		**Reference**
		Default Value	**Lower**	**Upper**	
Use of water based products (30 wt-% solvent content)	NMVOC	65%	40%	90%	EGTEI (2003)
Add on: Thermal oxidation	NMVOC	81%	50%	100%	EGTEI (2003)
Add on: Biofiltration	NMVOC	81%	50%	100%	EGTEI (2003)

3.3.4 Activity data

The Tier 2 methodology requires different activity statistics per sector. The number of painted buses, cars or trucks is known to calculate the emissions for vehicle coatings. The emission factors calculated per car assume an average area painted of:

- for car coating: a typical car is 80 m^2;
- for truck/van coating: a typical truck or van is 200 m^2;
- for truck cabin coating: a typical truck cabin is 60 m^2;
- for bus coating: a typical bus is 380 m^2.

Using these figures, the emission factors may be recalculated in terms of mass per area painted.

For wire coating, the mass of wire coated is the relevant activity statistics, while for all other sources the activity data is the use of paint.

3.4 Tier 3 emission modelling and use of facility data

Tier 3 is not available.

4 Data quality

4.1 Completeness

Trade balance (import-export) and production statistics of a country may be compared to total emissions from solvent use. Per-capita emission factors can also be used to verify emission estimates.

Frequently, trade balance figures can provide a good overall figure than the use of surrogate statistics, although the level of detail is less.

4.2 Avoiding double counting with other sectors

There is a considerable possibility for double counting here, because of the use of cleaning and thinning solvents. In general, thinning solvents are not covered elsewhere and need to be included in the total for this sector. It is good practice not to include cleaning solvents for metals (specifically those used in metal degreasing) in sectors covering paint application.

4.3 Verification

4.3.1 Best Available Technique emission factors

The BAT (Best Available Techniques) reference document (BREF) entitled 'Surface Treatment Using Organic Solvents (STS)' (European Commission, 2007) reflects an information exchange carried out under Article 16(2) of Council Directive 96/61/EC (IPPC Directive). The BREF document summarises the key BAT conclusions relating to the most relevant environmental issues. Although the industry is complex in size and range of activities, the same generic BAT may be considered for all.

4.3.1.1 Decorative coating application

BAT is only applicable to decorative products applied in a factory (installation). The majority of the decorative paint application, however, is going into professional use (painters) and do-it-yourself painting. For this group (~ 75 % of the paint), there is no accepted BAT.

4.3.1.2 Industrial coating application

Agricultural and construction equipment

For coating of agricultural and construction equipment, BAT is to:

- reduce solvent consumptions and emissions, maximise efficiency of the coating application and minimise energy usage by a combination of paint, drier and waste-gas treatment techniques. The associated emission values are either:
    - emissions of 20–50 mg C/m³ in waste gas and 10–20 % for fugitive emissions, or
    - overall emissions of 0.2 to 0.33 kg VOC/kg solids input;
- reduce material consumptions, solvent emissions and the amount of airflow to be treated by using dipping techniques for the coating of components prior to assembly ;
- use other paint systems to replace paints based on halogenated solvents.

Paint application: manufacture of automobiles (SNAP activity 060101)

For coating of cars, BAT is to minimise the energy consumption in the selection and operation of painting, drying/curing and associated waste gas abatement systems

A whole coating system needs to be considered, as individual steps may be incompatible. The associated emission values are 10–35 g/m^2 (e-coat area) (or 0.3 kg/body + 8 g/m^2 to 1.0 kg/body + 26 g/m^2 equivalent). Lower values have been achieved in two exceptional circumstances that are reported.

Paint application: coil coating (SNAP activity 060105)

For coil coating, BAT is to:

- reduce energy consumption using a selection of techniques. Associated consumption values are:

Table 4-1 Coil coating: energy consumption for aluminium and steel substrates

Energy consumption per 1 000 m^2 of substrate	Minimum	Maximum
Electricity used as kWh/1 000 m^2 for aluminium	270	375
Electricity used as kWh/1 000 m^2 for steel	250	440
Fossil fuels used as MJ/1 000 m^2 for aluminium	4 000	9 800
Fossil fuels used as MJ/1 000 m^2 for steel	3 000	10 200

- reduce solvent emissions using a combination of techniques described. Associated emission values are:
  - for new plants: 0.73–0.84 g/m^2 for waste gases and 3–5 % for fugitive emissions,
  - for existing plants: 0.73–0.84 g/m^2 for waste gases and 3–10 % for fugitive emissions. Existing plants will only achieve the lower values of the range when they are significantly upgraded;
- recycle the aluminium and steel from residual substrates.

Paint application: wood (SNAP activity 060107)

For coating of furniture and wood, BAT is to:

- reduce solvent consumptions and emissions, maximise efficiency of coating application and minimise energy usage by a combination of paint, drier and waste-gas treatment techniques. The associated emission values are either 0.25 kg VOC or less per kg solids input, or as in the table below:

Table 4-2 Wood coating: VOC emissions for various paint systems and with primary emission reduction measures

Paint system organic solvent content	Solvent content (wt-%)	Emission reduction measures	VOC emission (g/m^2)
High	65	High efficiency application techniques and good housekeeping	40-60
Medium	20		10-20
Low	5		2-5

- reduce particulate emissions to air (see generic BAT, above). This industry recorded a split view: the associated emission value is 10 mg/m^3 or less for both new and existing installations. The rationale is: this value is economically and technically feasible in the industry.

Other industrial paint application (SNAP activity 060108)

For coating of other metal surfaces, BAT is to:

- reduce solvent consumptions and emissions, maximise efficiency of the coating application and minimise energy usage by a combination of paint, drier and waste-gas treatment techniques. The associated emission values are 0.1 to 0.33 kg VOC/kg solids input. However, this does not apply to installations where the emissions are included in the mass emission calculations for the serial coatings of vehicles;
- reduce material consumptions by using high efficiency application techniques;
- use other paint systems to replace paints based on halogenated solvents.

For coating of plastic work pieces, BAT is to:

- reduce solvent consumptions and emissions, maximise efficiency of coating application and minimise energy usage by one or a combination of paint, drier and waste-gas treatment techniques. The associated emission values are 0.25 to 0.35 kg VOC/kg solids input.

  However, this does not apply to installations where the emissions are included in the mass emission calculations for the serial coatings of vehicles;
- reduce material consumption by using high efficiency application techniques;
- give priority to water-based techniques for new and upgraded systems;
- degrease simple polypropylene areas by hand with solvent impregnated wipes.

4.4 Developing a consistent time series and recalculation

No specific issues.

4.5 Uncertainty assessment

Estimating emissions from surface coating operations is very site-specific because of the wide range of coating formulations and the variety of coating techniques in use.

4.5.1 Emission factor uncertainties

Due to the wide range of paint applications and the even larger number of paint formulations which are available, there must be considerable scope for uncertainty in emission factors. Due to developments in paint formulation, the emission factors may be valid for only a short period. Improved emission factors are therefore required especially for controlled processes.

Another aspect is the variation of paint types. This requires good activity data, which may not be present, particularly with the increasing use of alternatives to high solvent paints.

4.5.2 Activity data uncertainties

No specific issues.

4.6 Inventory quality assurance/quality control QA/QC

No specific issues.

4.7 Gridding

No specific issues.

4.8 Reporting and documentation

No specific issues.

5 Glossary

Paint	Traditionally a material containing pigment which is applied to a surface in order to form a film with protective, decorative and/or particular technical properties. Stains, which contain transparent pigments, are strictly speaking paints. In this chapter, the term paint should be understood to include unpigmented (clear) coatings, such as lacquers and varnishes as well.
Varnish	Correctly speaking an unpigmented material which forms a hard glossy clear film and which cures by means of a chemical reaction as well as evaporation of the solvent. In practice, the term is often used interchangeable with lacquer.
Lacquer	Correctly speaking an unpigmented material which forms a hard glossy clear film and which dries by evaporation of solvent alone, i.e. where no chemical reactions occur. In practice, the term is often used interchangeable with varnish.
Electrocoating	A process in which resins are electrolytically deposited on a substrate. The substrate is immersed in a water-borne resin system. A current is applied, with the substrate acting as either anode or cathode depending upon the resin system used. Resin in the vicinity of the substrate is destabilised and deposited.

6 References

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7 Point of enquiry

Enquiries concerning this chapter should be directed to the relevant leader(s) of the Task Force on Emission Inventories and Projection's expert panel on combustion and industry. Please refer to the TFEIP website (www.tfeip-secretariat.org/) for the contact details of the current expert panel leaders.