

Federal Environmental Agency (Umweltbundesamt)

Air quality management programs

Report no. 500 44 301

**Implementation guide for the  
German Solvent Ordinance  
(31. BImSchV)**

Ute Hackmack  
Birgit Mahrwald

Federal Environmental Agency, Berlin office (Umweltbundesamt Berlin)

February 2002

The following official documents are mentioned in the present report:

*Federal Immission Control Act* (Bundes-Immissionsschutzgesetz)

*TA Luft* (First general administrative regulation to the Federal Immission Control Act (Technical Instructions for Air Quality Control) – Erste Allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz (Technische Anleitung zur Reinhaltung der Luft – TA Luft))

## Contents

Abstract	
1 Preface.....	7
2 Introduction.....	8
2.1 The ozone dilemma.....	8
2.2 International Conventions and EU Directives.....	8
2.3 The Solvent Ordinance .....	9
2.3.1 Status of the Ordinance in German law .....	10
2.3.2 Structure of the Ordinance .....	11
3 Types of installations that fall within the scope of the Ordinance .....	13
3.1 Threshold values .....	14
3.2 Reporting requirements .....	15
3.3 General requirements.....	17
3.4 Specific requirements .....	19
3.5 Transitional regulations .....	19
3.6 Initial proof .....	20
3.7 Requirements and applicability flowcharts for selected installation types.....	22
4 The reduction scheme .....	31
4.1 Operator-defined reduction scheme.....	32
4.2 Specific reduction scheme .....	32
4.2.1 Determination of coating solids content .....	34
4.2.2 Reference-emission calculation .....	35
4.2.3 Target-emission calculation .....	36
4.3 Simplified reduction scheme .....	37
5 The solvent management plan .....	40
5.1 Definition of input and output .....	41
5.1.1 Input (solvent use).....	43
5.1.2 Output (solvent output).....	45
5.2 Determination of solvent consumption (C) .....	48
5.3 Demonstration of compliance with limit values.....	49
5.3.1 Determination of fugitive emissions (F).....	49
5.3.2 Determination of total emissions .....	51
5.4 Compliance with a specific reduction scheme .....	54
5.5 Note on the determination of substance flows .....	55

5.5.1 Application of the indirect fugitive-emissions calculation method.....	55
5.5.2 Determination of qualitative substance flow .....	56
5.5.3 Relevance of substance flows for the solvent management plan 59	
5.5.4 Summary .....	63
5.6 Inventorying and computing data .....	63
5.6.1 Input .....	66
5.6.2 Output.....	68
5.6.3 Solvent and solids content .....	74
6 Practical examples .....	75
6.1 Heatset web offset printing (activity 1.1) .....	75
6.2 Other printing activities apart from rotogravure (activity 1.3).....	78
6.3 Surface cleaning (activity 2.1) .....	85
6.4 Dry cleaning (activity 3.1) .....	87
6.5 Other coating activities (activity 8.1) .....	90
6.5.1 Agricultural machinery .....	90
6.5.2 General machine construction .....	93
6.6 Coating of wood or wood materials (activity no. 9).....	97
6.6.1 Window manufacturer .....	97
6.6.2 Furniture manufacturer (solvent consumption 5-15 t/year).....	99
6.6.3 Coating of wood or wood materials (solvent consumption > 15 t/year) .....	101
6.7 Footwear manufacturing (activity no. 15) .....	103
7 Existing guidelines and relevant computer applications .....	104
7.1 Studies and guidelines .....	104
7.1.1 Studies regarding emission reduction potential .....	104
7.1.2 Guidelines .....	104
7.2 Computer applications/internet.....	107
7.2.1 Federal Environmental Agency (Umweltbundesamt) <i>Wissensspeicher</i> (knowledge base) and internet portal .....	107
7.2.2 Implementation support for the printing industry.....	107
7.2.3 Applications referred to in the present report .....	108
8 References.....	110
9 Figures.....	114

10Tables.....	117
---------------	-----

## **Abstract**

During the process of implementing the EU solvent directive (1999/13/EC) in national law, it was found that all stakeholders urgently require information in regard to the Directive.

After a brief survey of the legal and technical background of the Solvent Ordinance (31. BImSchV), the application domain of the Ordinance is discussed for specific installations with regard to the relevant threshold values. New environmental control mechanisms – the reduction scheme and solvent management plan – are then described.

The definition of solvent outputs and the various output pathways from an installation are then discussed. Compiling and calculating substance flow data, as well as the calculation of fugitive emissions, total emissions, and solvent consumption are then explained using various practical examples that apply to emission-generating activities in Germany. Practical examples are also provided for the reduction scheme.

The document provides compliance support in the form of tables and forms that were elaborated with the assistance of the competent authorities from a number of German states, as well as other stakeholders.

The report concludes by describing guidelines and other publications pertaining to the elaboration of solvent management plans and reduction schemes, as well as published software or software that is preparation.

## 1 Preface

On Aug. 25, 2001 *Ordinance regarding the reduction of VOC emissions resulting from the use of organic solvents in specific installations – 31<sup>st</sup> BImSchV* (German designation: 31. BImSchV) went into effect as Article 1 of the Federal Immission Control Act. This statute, which is also referred to as the Solvent Ordinance, serves to implement the corresponding EU Directive EC/13/99 in German law and for the most part adopts the approach taken by the Directive.

The Solvent Ordinance specifies regulations for 19 different areas of activity and is mainly aimed at installation operators. The process of implementing the Ordinance has clearly shown that implementation of the Ordinance necessitates a great deal of information for all stakeholders, i.e. installation operators, implementing agencies, and installation suppliers.

A plethora of small installations that are not subject to authorization fall within the scope of the Ordinance, which for the first time requires these installation to submit reports to the competent authority in the form of annual solvent management plans and, where applicable, reduction schemes. Solvent management plans and reduction schemes are completely new mechanisms in German immission control legislation. However, the information that operators and the competent authorities need in order to comply with the Ordinance is lacking in whole or in part, or is extremely inaccurate, and above all there is a yawning information gap in regard to the application modalities for these new mechanisms. Hence the in some cases highly complex issues faced by both operators and the competent authorities in elaborating solvent management plans and reduction schemes are addressed in the present report, which will hopefully help set the stage for optimally across-the-board compliance with the Ordinance.

## 2 Introduction

### 2.1 The ozone dilemma

Ozone plays a dual role in the earth's atmosphere. In the stratosphere (approximately 10 km above the earth's surface), it absorbs ultraviolet radiation that would otherwise cause severe damage to living organisms. In the troposphere (the lowest region of the atmosphere), if present in higher concentrations, ozone has the following harmful properties:

- ☐ It is a health hazard for humans
- ☐ It damages plants
- ☐ It contributes to the greenhouse effect
- ☐ As one of the most potent oxidants, ozone oxidizes numerous metals at room temperature and can also destroy a host of organic compounds, and hence the products in which they occur such as rubber, textiles, leather and paint.

The confluence of ozone, human activity and strong sunlight produces the precursor substances nitrogen dioxide (mainly generated by automobile exhaust) and volatile organic compounds (VOC; primarily the result of solvent use).

VOCs and nitrogen dioxide drive air pollution beyond the threshold of safety. In addition to causing pollution where they are generated, these substances also spread over a wide area and cause pollution in neighboring countries. Thus, solving the ozone problem is necessarily both a domestic and an international undertaking.

### 2.2 International Conventions and EU Directives

In December 1999 the UN-ECE Protocol [1] was signed by 30 ECE (Economic Commission for Europe) members. The Protocol calls for measures to reduce acidification, eutrophication and ground-level ozone immissions, and its main mechanism consists of emissions ceilings for each country. Germany has committed itself to a 69% reduction in VOC emissions by 2010 relative to 1990 levels.



In mid-1999, the European Commission proposed the Directive on national emission limits<sup>1</sup> which is analogous to the UN-ECE Protocol. This Directive was based on the assumption that the precursor substances VOC and nitrogen dioxide must be reduced by 70 to 80% relative to 1990 levels throughout central Europe in order for the region to remain permanently within WHO's recommended safety limit for human health (120 µg/m<sup>3</sup>, 8 hour mean).

The EU Solvent Directive (1999/13/EC) [2] represents an important step toward emission reduction of the precursor substance VOC, 50% of which is attributable to solvent use. The EU began considering this Directive in 1990. Unlike the UN-ECE Protocol and the NEC (National Emissions Ceilings) Directive, both of which approach the ozone problem from the standpoint of impact and hence define emissions limits for precursor substances, the EU Solvent Directive specifies quantitative requirements for specific types of industrial installations that use solvent. The Directive aims to reduce human health risk by reducing VOC emissions from industrial installations with a view to achieving a 50% reduction in these emissions by 2010 relative to 1990 levels throughout Europe.

## 2.3 The Solvent Ordinance

In Germany, the EU Solvent Directive was implemented by means of the Ordinance for implementation of Directive 1999/13/EC regarding the reduction of VOC emissions (Verordnung zur Umsetzung der Richtlinie 1999/13/EG über die Begrenzung von Emissionen flüchtiger organischer Verbindungen) [3]. The Ordinance went into effect on Aug. 25, 2001 and is available (in German) from [www.bmu.de](http://www.bmu.de).

The Ordinance consists of five articles. Article 1, which consists of *Ordinance regarding the reduction of VOC emissions resulting from the use of organic solvents in specific installations – 31<sup>st</sup> BImSchV* (available in English) [4], governs industrial activities that fall within the scope of the EU Solvent Directive including printing, surface finishing, dry cleaning, painting and varnishing, paint, varnish, adhesive and pharmaceutical manufacturing, and rubber conversion and extraction. Any installation that exceeds the mandated threshold values for any of these activities mandatorily and automatically falls within the scope of the Ordinance,

---

<sup>1</sup> The NEC directive specifies national emission ceilings for SO<sub>2</sub>, NO<sub>x</sub>, VOC and NH<sub>3</sub> that must be met by 2010.

which means that the installation operator is required to reduce VOC emissions. The Ordinance defines two ways in which this can be done:

Compliance either with emission limit values for waste gases and fugitive emissions or with total emission limit values

- ☐ Through implementation of and compliance with a reduction scheme

The reduction scheme option aims to promote the implementation of primary reduction measures such as the use of low-solvent or solvent-free substances.

The Ordinance lays down more stringent measures for the release of the following VOCs, which are particularly hazardous to human health and have the following properties:

- ☐ They are carcinogenic, mutagenic, or toxic to reproduction
- ☐ They are suspected of inducing irreversible disorders such as cancer
- ☐ They are Class I no. 3.1.7 substances pursuant to *TA Luft 1986* [5]

Article 2 consists of the revised Ordinance on the restriction of emissions of highly volatile halogenated hydrocarbons - 2.BImSchV, which implements EU requirements pertaining to the installations regulated by the Solvent Ordinance.<sup>2</sup>

Articles 1 and 2 aim to reduce VOC emissions resulting from the industrial use of solvents by an additional 20% by 2010.

The present report confines itself to a discussion of Article 1 of the *Ordinance regarding the reduction of VOC emissions resulting from the use of organic solvents in specific installations – 31<sup>st</sup> BImSchV*, which counts as the actual Solvent Ordinance and is available in English.

### 2.3.1 Status of the Ordinance in German law

The Solvent Ordinance pertains to the Federal Immission Control Act (Bundes-Immissionsschutzgesetz; BImSchG). It applies to operators of installations that are subject to authorization as well as those that are not subject to authorization, the latter being subject under the Ordinance for the first time to a reporting requirement. Inasmuch as the Solvent Ordinance only governs VOC requirements, installations subject to authorization pursuant to *Ordinance on the restriction of emissions of highly volatile halogenated hydrocarbons - 4. BImSchV* are subject to the requirements of *TA Luft* in addition to those of the Solvent Ordinance.

---

<sup>2</sup> Surface cleaning, dry cleaning and extraction installations that use halogenated VOC solvents

### 2.3.2 Structure of the Ordinance

The Solvent Ordinance consists of general provisions and various Annexes (see Table 1). In addition to the general provisions, which consist of five sections, the six Annexes constitute a crucial component of the Ordinance. Annex I lists the types of installations in which the activities defined in Annex II are realized, and also lists the threshold values for the various areas of activities (see Table 2). Annex III describes the requirements for the types of installations listed in Annex I in terms of emission limit values and in some cases additional parameters. Annex IV and V describe the new reduction scheme and solvent management plan, as well as the requirements and regulations pertaining to their use. Annex VI describes the requirements pertaining to the implementation of monitoring mechanisms.

	<b>Title</b>	<b>Article designations</b>	
Part 1	Scope and definitions	§1 §2	Scope Definitions
Part 2	Emission limit values	§3 §4	General requirements Special provisions
Part 3	Measurement and monitoring	§5 §6	Installations not subject to authorization Installations subject to authorization
Part 4	General regulations	§7 §8 §9 §10 §11 §12	Conditions governing the discharge of waste gases Reporting to the European Commission Public information Supplementary or more extensive requirements Exemptions Administrative breaches
Part 5	Final provisions	§13	Transitional regulations
Annexes	Annex I Annex II Annex III Annex IV	List of installations List of activities Specific requirements Reduction scheme	

	Annex V Annex VI	Solvent management plan Requirements pertaining to the implementation of monitoring mechanisms
--	---------------------	---

Table 1: Contents of the Solvent Ordinance

### 3 Types of installations that fall within the scope of the Ordinance

The Solvent Ordinance governs the construction and operation of the following types of installations that realize one or more of the following activities listed in Annex II of the Ordinance:

Installation type and activity	Solvent consumption threshold value (t/year)
<b>1. Printing</b>	
1.1 Heatset web offset printing installations	15
1.2 Publication rotogravure installations	25
1.3 Installations that realize other printing activities	15
<b>2. Surface cleaning</b>	
2.1 Surface cleaning installations	1
<b>3. Dry cleaning</b>	
3.1 Dry cleaning installations	0
<b>4. Coating of road vehicles, driving cabs, commercial vehicles, and rail vehicles</b>	
4.1 Motor vehicle coating installations	0
4.2 Truck cabin coating installations	0
4.3 Commercial vehicle coating installations	0
4.4 Bus coating installations	0
4.5 Rail vehicle coating installations	5
<b>5. Vehicle refinishing</b>	
5.1 Vehicle refinishing installations	0
<b>6. Coil coating</b>	
6.1 Coil coating installations	10
<b>7. Coating of winding-wire</b>	
7.1 Installations that coat winding wire using coatings containing phenol, cresol or xylene	0
7.2 Installations that coat winding wire using other coatings	5
<b>8. Coating of other metallic or plastic surfaces</b>	
8.1 Installations that coat other metallic or plastic surfaces	5
<b>9. Coating of wood or wood materials</b>	
9.1 Installations that coat wood or wood materials and consume up to 15 tons of solvent annually	5
9.2 Installations that coat wood or wood materials and consume more than 15 tons of solvent annually	15
<b>10. Coating of textile, fabric, film and paper surfaces</b>	
10.1 Installations that coat textiles or fabric	5
10.2 Installations that coat film or paper surfaces	5
<b>11. Leather coating</b>	
11.1 Installations that coat leather	10

Installation type and activity	Solvent consumption threshold value (t/year)
<b>12. Wood impregnation</b>	
12.1 Installations that impregnate wood using preservation products that contain solvent	10
12.2 Wood impregnation using creosote	0
<b>13. Wood and plastic lamination</b>	
13.1 Wood/plastic lamination installations	5
<b>14. Adhesive coating</b>	
14.1 Adhesive coating installations	5
<b>15. Footwear manufacture</b>	
15.1 Footwear manufacturing installations	5
<b>16. Manufacture of coatings preparations, varnishes, wood or building preservation products, adhesives, inks</b>	
16.1 Installations that manufacture paints or other coatings	100
16.2 Installations that manufacture wood or building preservation products	100
16.3 Adhesive manufacturing installations	100
16.4 Ink manufacturing installations	100
<b>17. Rubber conversion</b>	
17.1 Rubber conversion installations	10
<b>18. Vegetable oil and animal fat extraction and vegetable oil refining activities</b>	
18.1 Vegetable oil and animal fat extraction and vegetable oil refining installations	10
<b>19. Manufacture of pharmaceutical products</b>	
19.1 Installations that manufacture pharmaceutical products	50

Table 2: Installations and activities that fall within the scope of the Solvent Ordinance

### 3.1 Threshold values

Whether or not an installation falls within the scope of the Ordinance depends on the type of activity involved and the installation's annual solvent consumption. The activities that fall within the scope of the Ordinance, as well as the threshold values for annual solvent consumption in the various types of installations, are listed in Table 2.

Practical example: The activities realized in a coating installation at a carpentry workshop (installation type 9: installations that coat wood or wood materials) fall within the scope of the Ordinance. Annual solvent consumption as defined in the initial solvent management plan yields the following values:

- ☐ The threshold value of equal to or greater than 5 t/y is not reached, which means that the installation does not fall within the scope of the Ordinance.
- ☐ Solvent consumption ranges from 5 to 15 t/y, which means that the installation falls within the scope of no. 9.1 in Annex 1.

- Solvent consumption exceeds 15 t/y, which means that the installation falls within the scope of no. 9.2 in Annex 1.

Installations that coat wood or wood materials (no. 9) that have less than 20 employees and do not realize series production and/or subcontracting do not fall within the scope of the Ordinance and thus are not subject to a reporting requirement pursuant to the Ordinance.

To realize an approximate estimate of solvent input, the computed quantity of coating is multiplied by a factor of 0.7 and is compared with the threshold value. The multiplication factor is based on the mean solvent content of the coating systems in use (in this case 65%) and the proportion of solvent cleaner used.

Annual solvent consumption is to be calculated cumulatively. This means that all solvent consumption for installations that realize a single specific activity in more than one sub-installation, process step or auxiliary installation is to be totaled. The applicable solvent consumption level for an installation consists of the **cumulative sum of each individual use of solvent in that installation.**<sup>3</sup>

For some types of installations (e.g. all coating installations) that fall within the scope of the Solvent Ordinance (31<sup>st</sup> BImSchV), the threshold values for solvent consumption are considerably lower than for installations that are subject to *Ordinance on the restriction of emissions of highly volatile halogenated hydrocarbons - 4. BImSchV*. Consequently, the Solvent Ordinance applies to installations that are subject to authorization, as well as to those that are not subject to authorization.

The VOC emission limits of installations that are subject to authorization fall within the scope of the Solvent Ordinance, whereas other requirements such as limits on particulate matter are regulated by *TA Luft*.

### 3.2 Reporting requirements

Installations that are not subject to authorization that fall within the scope of the Ordinance are subject to a reporting requirement. Existing installations that are subject to authorization are not subject to a reporting requirement since they have either received authorization or have applied for it.

The period within which the operator of an installation is required to submit a report to the competent authority differs for existing and new installations, as follows:

---

<sup>3</sup> Article 1(1) sentence 2, 31. BImSchV

- ☐ Operators of new installations are required to submit a report before the installation is put into operation
- ☐ Operators of existing installations were to have submitted a report by Aug. 25, 2003
- ☐ Operators of existing installations that was not exceeding any applicable threshold value when the Ordinance went into effect are required to submit a report within six months of the first instance of exceeding any such threshold
- ☐ Operators of an installation that has been substantially changed are to notify the competent authority prior to realization of such change, or are to apply for authorization to realize such change

The following criteria determine what counts as a substantial change in an installation pursuant to the Ordinance:<sup>4</sup>

For installations subject to authorization pursuant to article 16 paragraph(1) of the Solvent Ordinance (BimSchG) and for installations not subject to authorization, the presence of a substantial change is determined by whether or not

- ☐ pursuant to the assessment of the competent authority, any change may have significant adverse effects on human health or the environment
- ☐ any change in nominal capacity for specific installations<sup>5</sup> has resulted in more than a 25% increase in VOC emissions or
- ☐ any change in nominal capacity for the remaining types of installations has resulted in more than a 10% increase in VOC emissions.

The aforementioned operator's report is to contain the relevant data for the installation (as determined in consultation with the competent authority), e.g. number of the installation type and activity number pursuant to Annexes I and II, substances used and their solvent content, quantity of solvent used, data regarding production capacity and the operator.

---

<sup>4</sup> See definition of "substantial change" in article 2(28), German Solvent Ordinance (31. BImSchV)

<sup>5</sup> Pertains to type 1.1, 1.3, 9.2 and 11.1 installations whose solvent consumption is up to 25 t/year, type 4.1-4.5, 8.1, 9.1, 10.1, 10.2, 12.1 and 14.1 installations whose solvent consumption is up to 15 t/year, and type 16.1-16.4 installations whose solvent is up to 500 t/year.



### 3.3 General requirements

The general requirements of the Solvent Ordinance<sup>6</sup> apply to all installations that fall within its scope. Following is a partial description of these requirements:

- ☐ The Ordinance requires that any VOC that is classified by Germany's hazardous substances law (Chemikalienrecht) as carcinogenic, mutagenic, or toxic to reproduction be replaced by another substance. Pursuant to the Chemicals Act (Chemikaliengesetz), wherever possible any substance or preparation that is listed with R phrases R45, R46, R49, R60 or R61 is to be replaced as expeditiously as possible<sup>7</sup>. In realizing these measures, the operator is required to take into consideration the suitability of the substitute substance as well as the cost benefit ratio obtained by substituting a less harmful substance. VOC emissions that are listed with any of the aforementioned R phrases are not to exceed a mass flow of 2.5 g/h or a mass concentration of 1 mg/m<sup>3</sup>, including in terms of their cumulative total emissions.
- ☐ Any VOC that is listed with R40 is not to exceed a mass flow of 100 g/h or mass waste-gas emission of 20 mg/m<sup>3</sup>. This applies as well to any VOC that falls within the scope of no. 3.1.7 class I of *TA Luft 1986*.
- ☐ Installation operators are to take all measures necessary to ensure that emissions are minimized during start-up and shut-down operations.

A decision chart is used to determine which (if any) emission limits apply to a particular installation.

If no substitute is available for any of the aforementioned VOCs that are of particular concern (i.e. an extreme health hazard), the emission limits specified in section 3 hereunder apply, including in the event a reduction scheme is implemented.

---

<sup>6</sup> See Article 3, German Solvent Ordinance (31. BImSchV)

<sup>7</sup> R45: may cause cancer; R46: may cause heritable genetic damage; R49: may cause cancer by inhalation; R60: may impair fertility; R61: may cause harm to the unborn child

<sup>8</sup> R40: limited evidence of a carcinogenic effect.

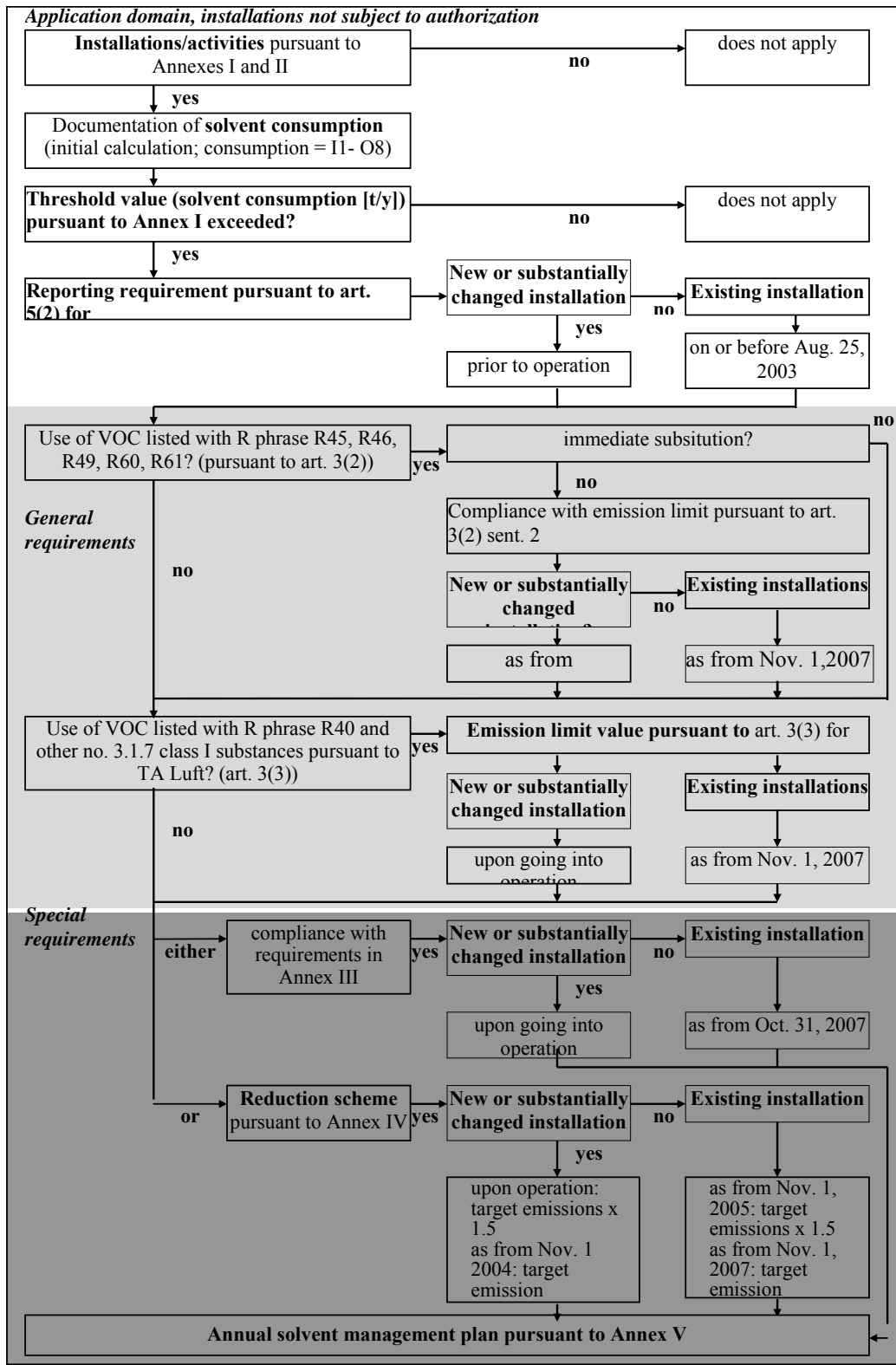


Figure 1: Decision chart for installations not subject to authorization

### 3.4 Specific requirements

Article 4<sup>9</sup> requires operators to construct and operate installations in such a way as to comply with the emission limit values specified in Annex III of the Ordinance as well as with any other applicable requirements. Emission limit values fall into three categories: values for contained waste gases, fugitive emissions, and total emissions. These parameters apply to new installations and substantially changed installations upon being put into operation, and for existing installations as from Nov. 1, 2007. Thereafter, installations subject to authorization will be required to comply with requirements that heretofore were not included in the authorization notification or that are more stringent than the limit values specified in the authorization notification.

For detailed information regarding specific requirements in this regard, see Annex III of the Solvent Ordinance.<sup>2</sup>

Article 4 of the Solvent Ordinance also allows the operator to realize a reduction scheme pursuant to Annex IV. Operators that realize a reduction scheme are exempt from the emission limits specified in Annex III.

### 3.5 Transitional regulations

Existing installations are to comply with the requirements in Annex III or IV of the Ordinance by the end of the applicable transitional period. Existing waste gas cleaning plants are subject to specific transitional regulations. Under certain conditions (see Table 3), existing waste gas cleaning plants are allowed higher waste gas emission values after 2007 than those specified in Annex III. These transitional rules are intended to give the operator the opportunity to comply with the Ordinance in a cost efficient manner.

---

<sup>9</sup> Pursuant to Article 4 sentence 1 in conjunction with Annex III, German Solvent Ordinance (31. BImSchV)

<sup>2</sup> Annex III of the Solvent Ordinance specifies the following exception for type 2.1 (surface cleaning) installations that bears mention here: Waste gas and fugitive emission requirements are waived for this type of installation if a solvent cleaner containing less than 20% solvent is used (e.g. for vehicle depreservation); all other requirements apply in such cases however.

Requirements for existing installations	Compliance deadline
Compliance with emission limit values and limit values for fugitive emissions pursuant to Annex III	as from Nov. 1, 2007
Compliance with a reduction scheme <sup>a</sup> pursuant to Annex IV: - 1.5 times higher than the target emission  - Target emission	as from Nov. 1, 2005 as from Nov. 1, 2007
Emission limit values for abatement equipment, <sup>b</sup> subject to the following requirements:	
a) 50 mg C/m <sup>3</sup> for post-combustion systems	on or before Dec. 31, 2013
b) 100 mg C/m <sup>3</sup> for abatement equipment other than that in installations subject to authorization as per a)	on or before Dec. 31, 2013
b) 150 mg C/m <sup>3</sup> for abatement equipment other than that in installations not subject to authorization as per b)	on or before Dec. 31, 2013

<sup>a</sup>The operator is required to demonstrate to the competent authority by Oct. 31, 2004 that the reduction scheme has been implemented

<sup>b</sup>Applies solely when total emissions E for the installation do not exceed the mandated limit value

Table 3: Transitional rules and compliance deadlines for existing installations

### 3.6 Initial proof

New installations are required to submit proof of compliance with waste gas concentration limit values no later than six months after going into operation, whereas existing installations have until Dec. 31, 2009 to submit such proof. In both cases compliance is to be established by means of measurements,<sup>10</sup> except “insofar as deployment of the best available techniques obviates the need for abatement equipment for purposes of compliance with such limit values.”<sup>2</sup>

Initial proof of compliance with **fugitive emission** limit values, and as a rule **total emission limits** as well, is to be submitted no later than Nov. 1, 2007, even if the Ordinance does not explicitly and unambiguously specify

<sup>10</sup> Article 5(4) sentence 1(1a) in conjunction with Article 13, German Solvent Ordinance (31. BImSchV)

<sup>2</sup> Article 5(4) last sentence, German Solvent Ordinance (31. BImSchV)

this deadline.<sup>3</sup> At a minimum, the operator is to have realized estimates by the aforementioned dates that will then be fleshed out in order to comply with the required solvent management plan over a twelve-month period, i.e. no later than Nov. 1, 2008.

The operator is to demonstrate compliance with the reduction scheme pursuant to Annex IV(B) in two phases. Operators of existing installations are to submit proof by Nov. 1, 2005 that they have complied with the first emission reduction phase. In other words, these operators are to prove that their installation does not exceed the maximum allowable emissions (target emission) by more than 150%. Operators are to prove by Nov. 1, 2007 that maximum allowable total emissions limits are no longer being exceeded (second phase of emission reduction).<sup>11</sup> These dates are legally enforceable even if the Ordinance does not explicitly specify them. Moreover, in order to allow the competent authority sufficient time to verify the feasibility of envisaged reduction measures, operators are required to submit a description of planned technical measures and the consequent emission reduction measures well in advance of the compliance deadlines for the first and second emission reduction phases. The fact that the required reduction measures are to be realized by the aforesaid deadlines gives the operator the opportunity to submit substantiation of such measures. The table below provides an overview of the various deadlines and timeframes:

<b>Requirements</b>	<b>Initial proof for new installations</b>	<b>Initial proof for existing installations</b>
Waste gas concentration values	3-6 months after going into operation	by Dec. 31, 2009
Fugitive emissions or total emission limit values pursuant to Annex III	12 months after going into operation	by Nov. 1, 2007
Reduction scheme pursuant to Annex IV B: <input type="checkbox"/> 1.5 higher than the target emission	immediately upon going into operation	by Nov. 1, 2005

---

<sup>3</sup> Article 5(6) sentence 1(1)(2) in conjunction with Article 13, German Solvent Ordinance (31. BImSchV)

<sup>11</sup> Article 5(6)(3) in conjunction with Annex IV(B(1) and Article 13, German Solvent Ordinance (31. BImSchV)

<input type="checkbox"/> Target emission	as from Nov. 1, 2004	by Nov. 1, 2007
Maximum allowable solvent content in substances used pursuant to Annex IV(C)	immediately upon going into operation	by Nov. 1, 2005

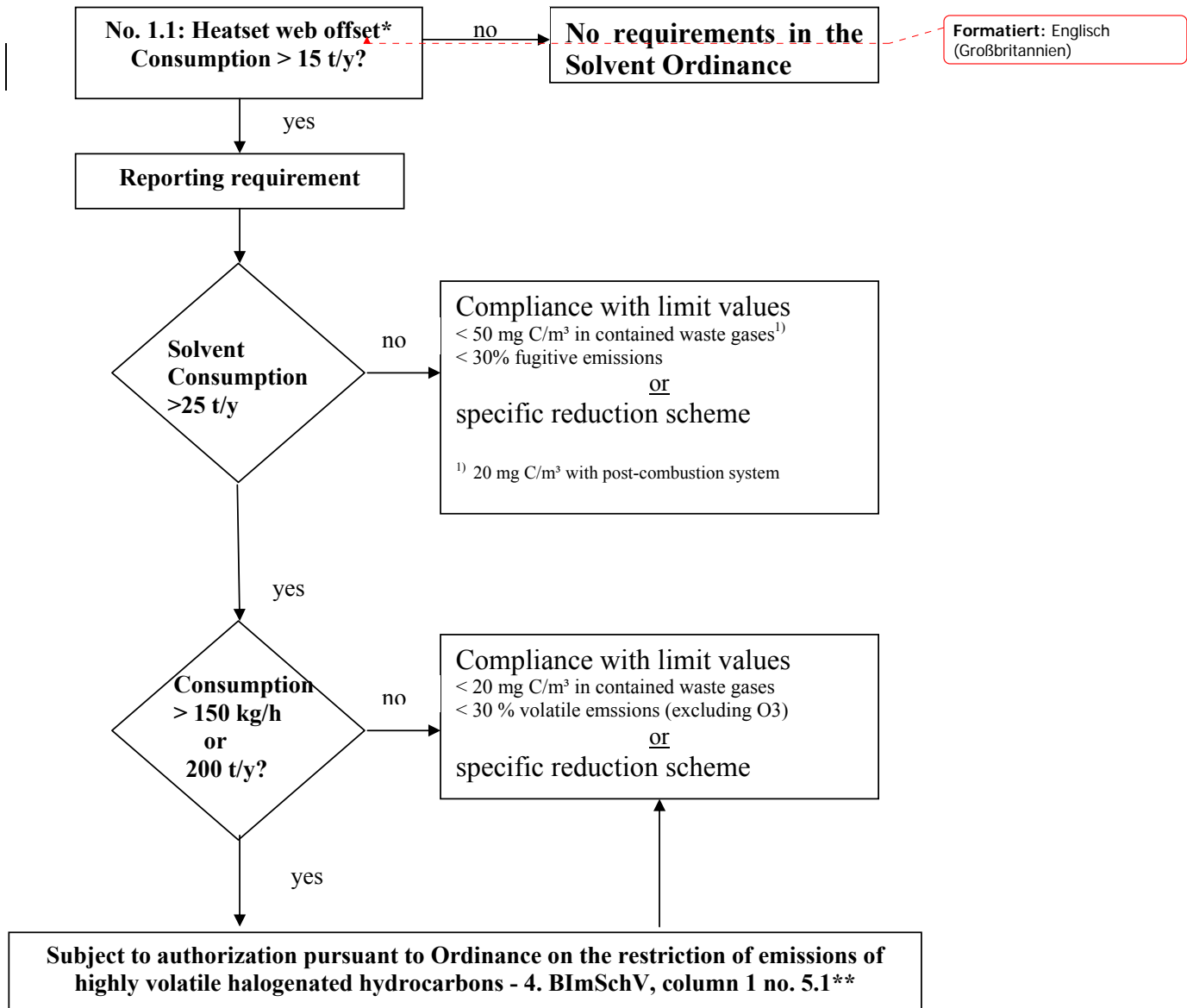
Table 4: Deadlines for initial proof of compliance with the Solvent Ordinance

As from Nov. 1, 2007, operators of installations that coat wood or wood materials and whose solvent consumption is 5-15 t/year (Annex I(9.1)) are to calculate solvent consumption and demonstrate compliance with the applicable requirements using a solvent management plan every three years.

### **3.7 Requirements and applicability flowcharts for selected installation types**

The requirements and applicability flowcharts below can be used to determine whether certain installations and activities fall within the scope of the Ordinance, and if so, to which special requirements in Annex III the installation is subject in addition to the general requirements specified in the Solvent Ordinance (31st BImSchV).

Special requirements in Annex III are indicated by footnotes in the flowcharts.



\*All installations that fall within the scope of the Ordinance are also subject to the following special requirement in Annex III(1.1.3): isopropanol content in damping solution is not to exceed 8%

\*\*In addition to the requirements of the Solvent Ordinance, installations subject to authorization are also subject to the requirements of *TA Luft* excluding the requirements therein pertaining to VOC limits.

Figure 2: Requirements and applicability flowchart for heatset web offset installations

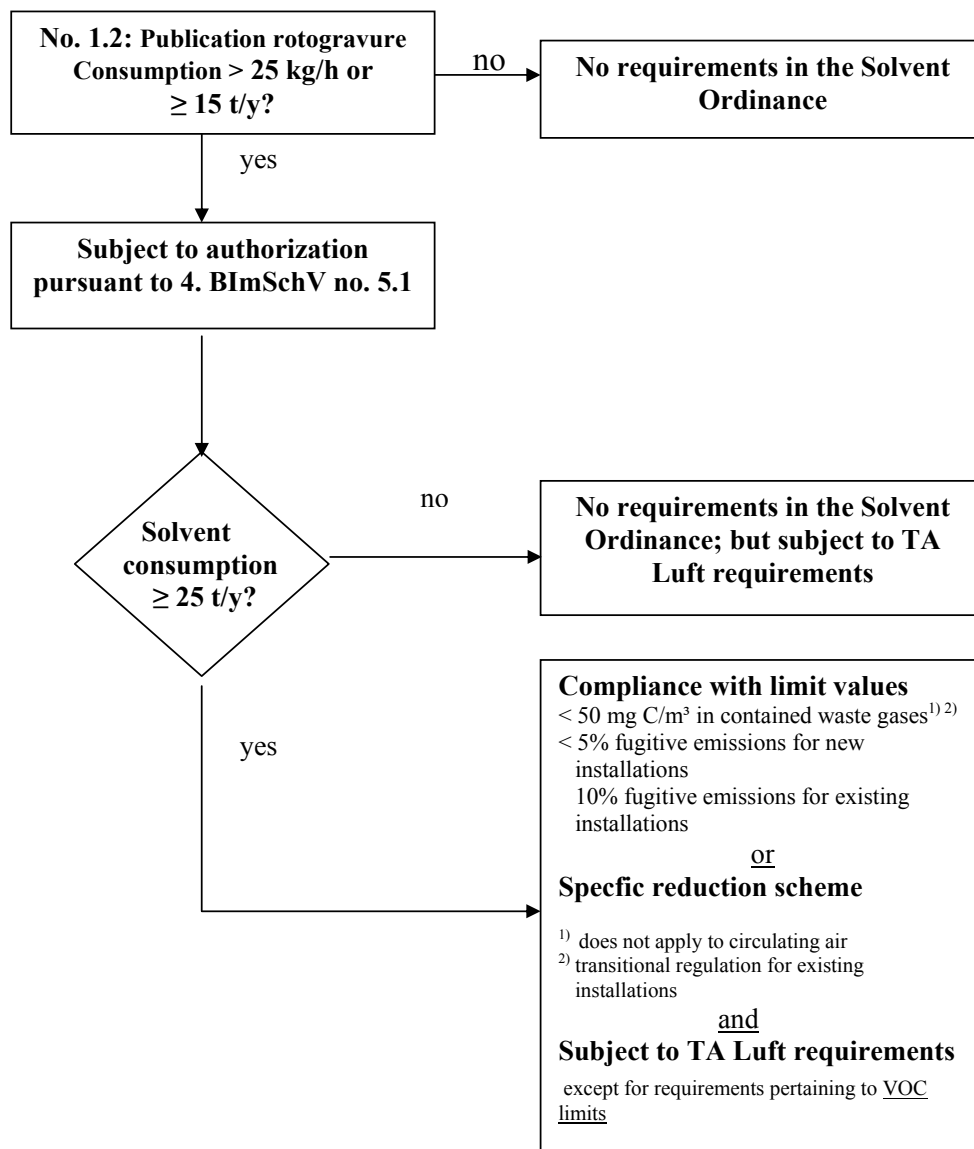
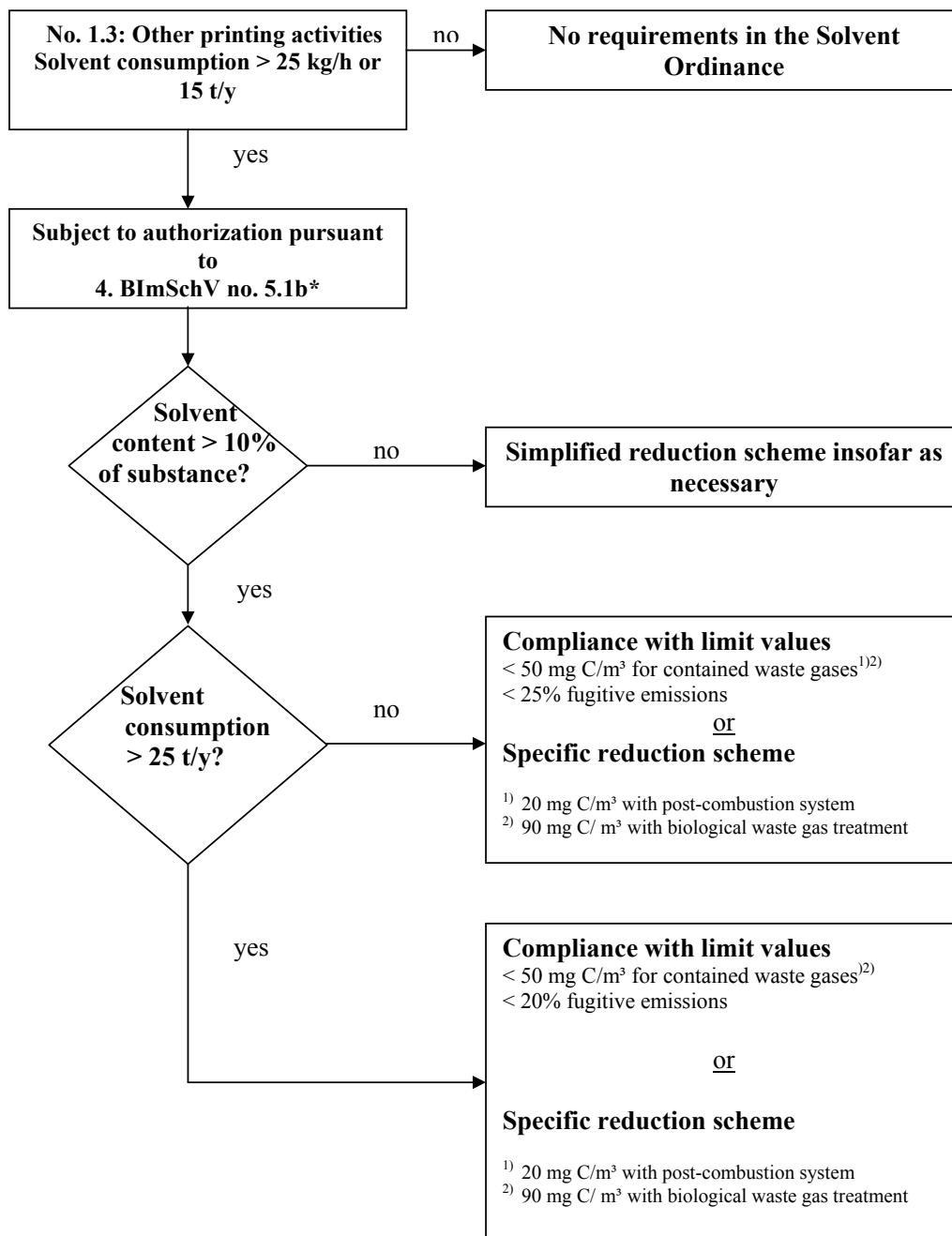


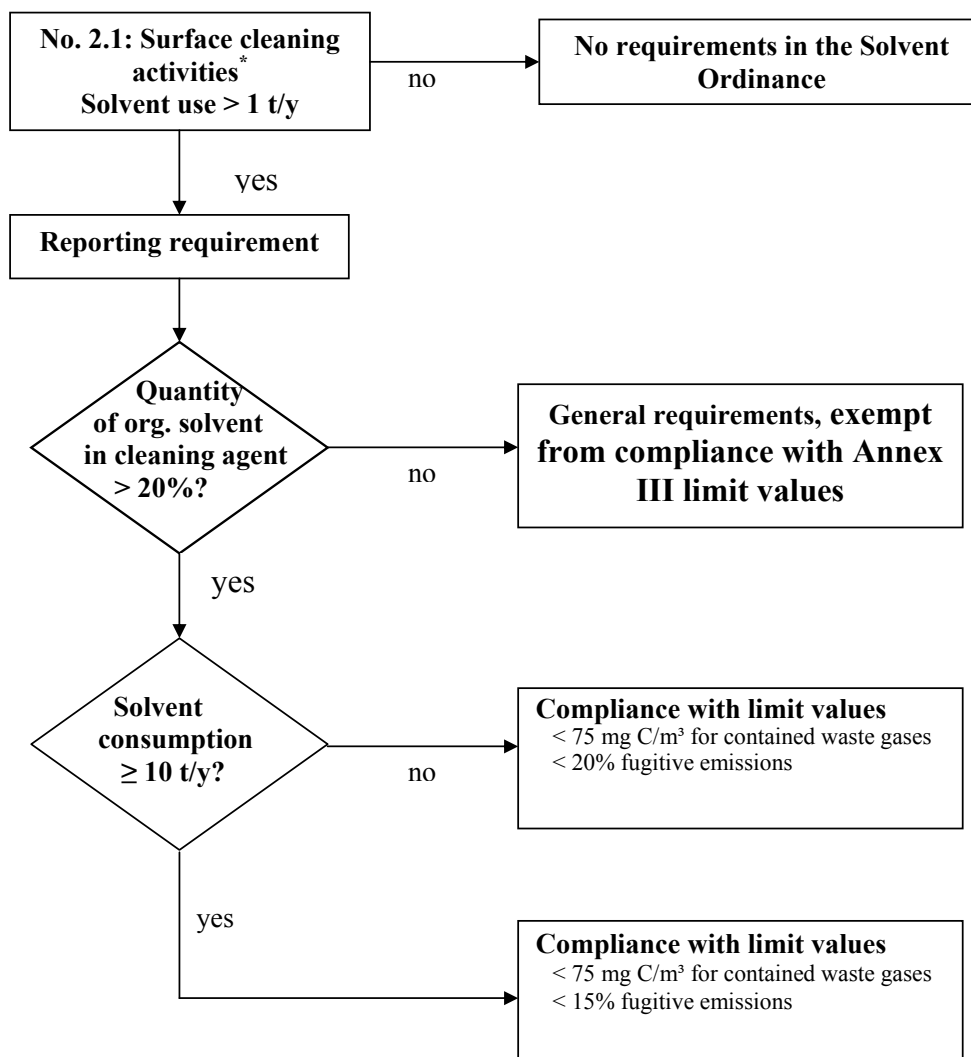
Figure 3: Requirements and applicability flowchart for publication rotogravure installations





\*\*In addition to the requirements of the Solvent Ordinance, installations subject to authorization are also subject to the requirements of *TA Luft*, excluding the requirements therein pertaining to VOC limits.

Figure 4: Requirements and applicability flowchart for other printing installations



\*) All installations that fall within the scope of the Ordinance are also subject to the following special requirement in Annex III(2.1.3): cleaning is to be realized using the best available techniques in installations that are as enclosed as possible

Figure 5: Requirements and applicability flowchart for surface cleaning installations

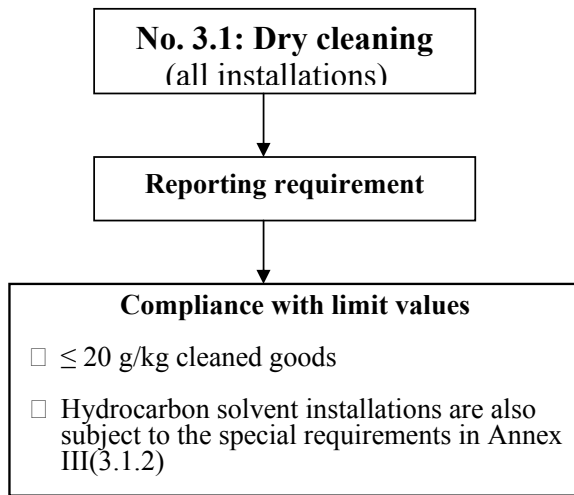
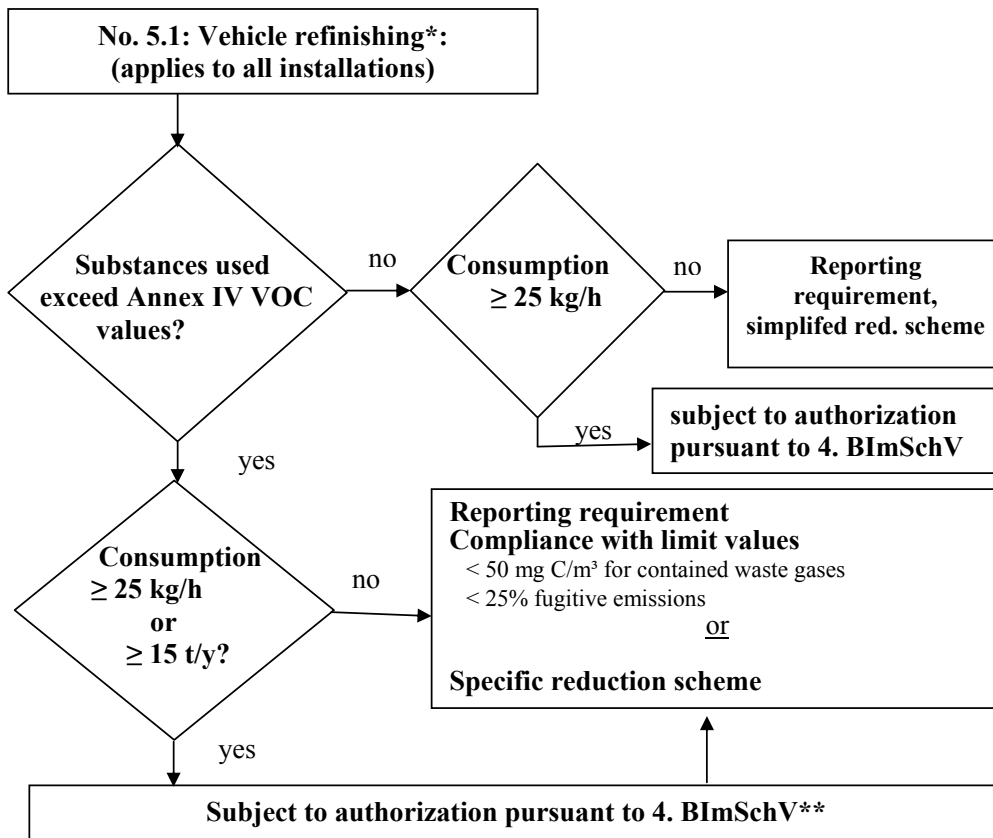


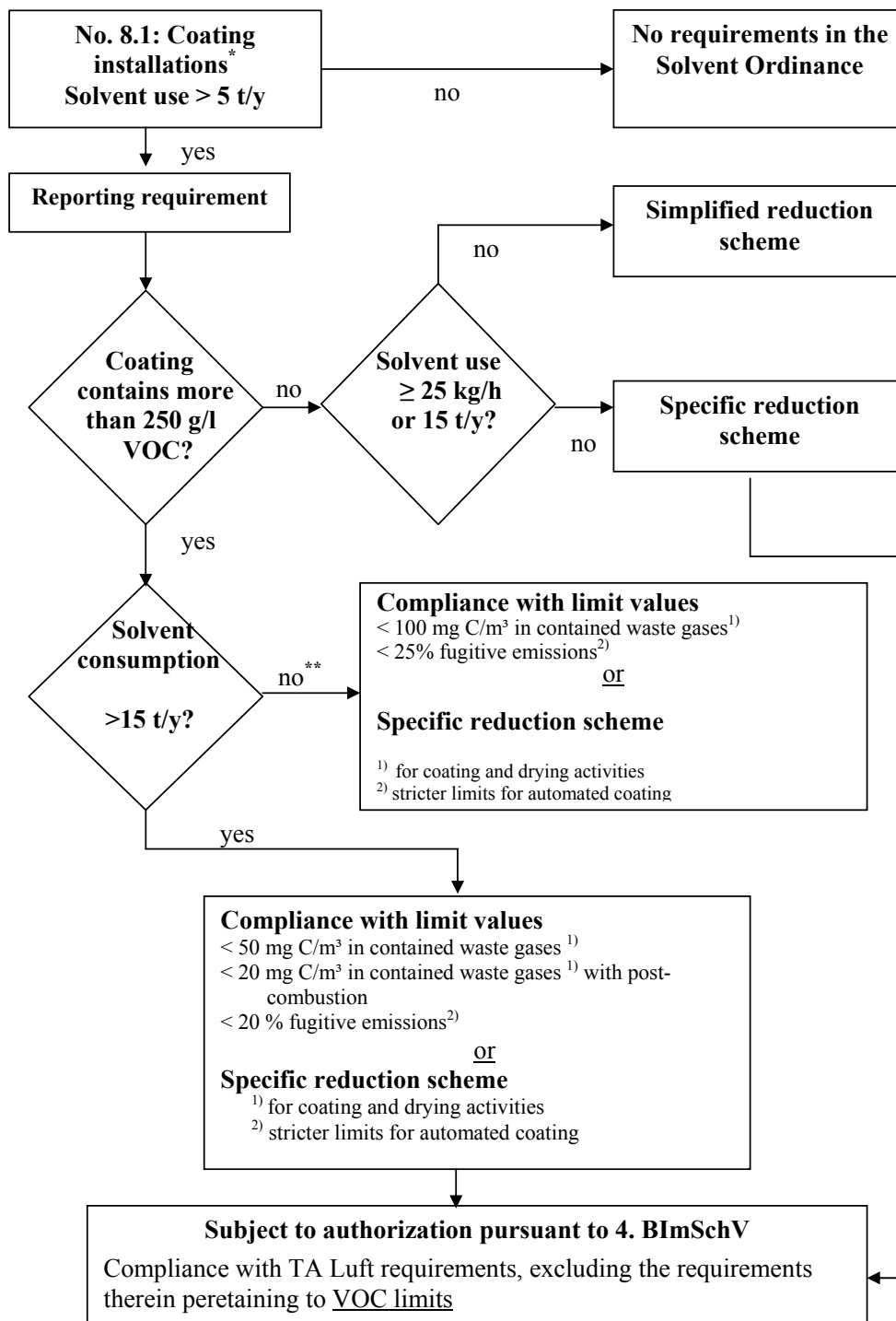
Figure 6: Requirements and applicability flowchart for dry cleaning installations



\*The flowchart reflects industry standards, which the Ordinance contradicts for this type of installation

\*\*subject to authorization . \*In addition to the requirements of the Solvent Ordinance, all installations are also subject to the requirements of TA Luft, excluding the requirements therein pertaining to VOC limits.

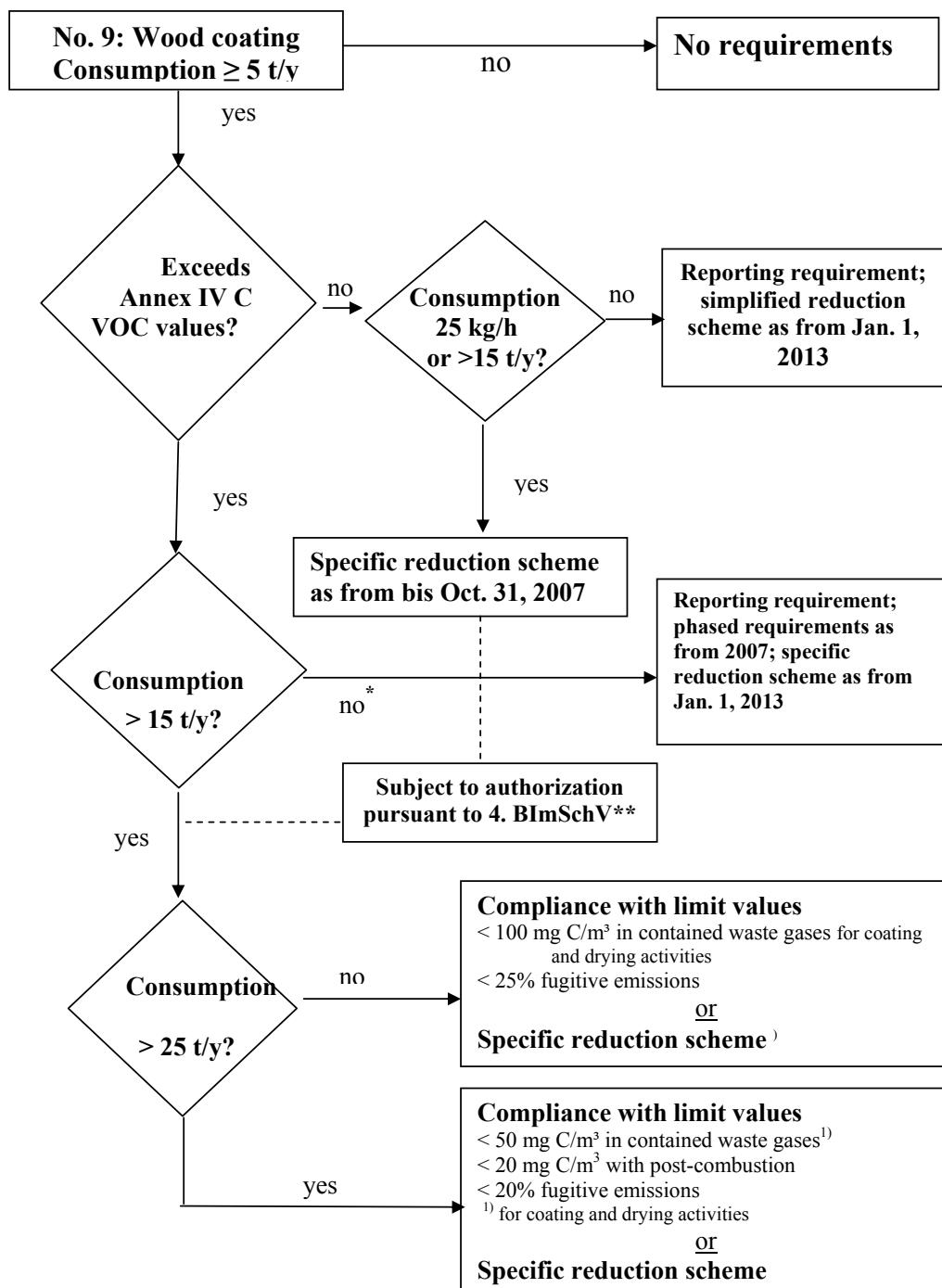
Figure 7: Requirements and applicability flowchart for vehicle refinishing installations



\*The special requirements in Annex III(8.3.1) can be applied to bulky goods such as ships or aircraft in lieu of the limit values indicated here.

\*\*In exceptional cases, installations that consume between 5-15 t/year may be subject to authorization if their consumption capacity exceeds 25 kg/h

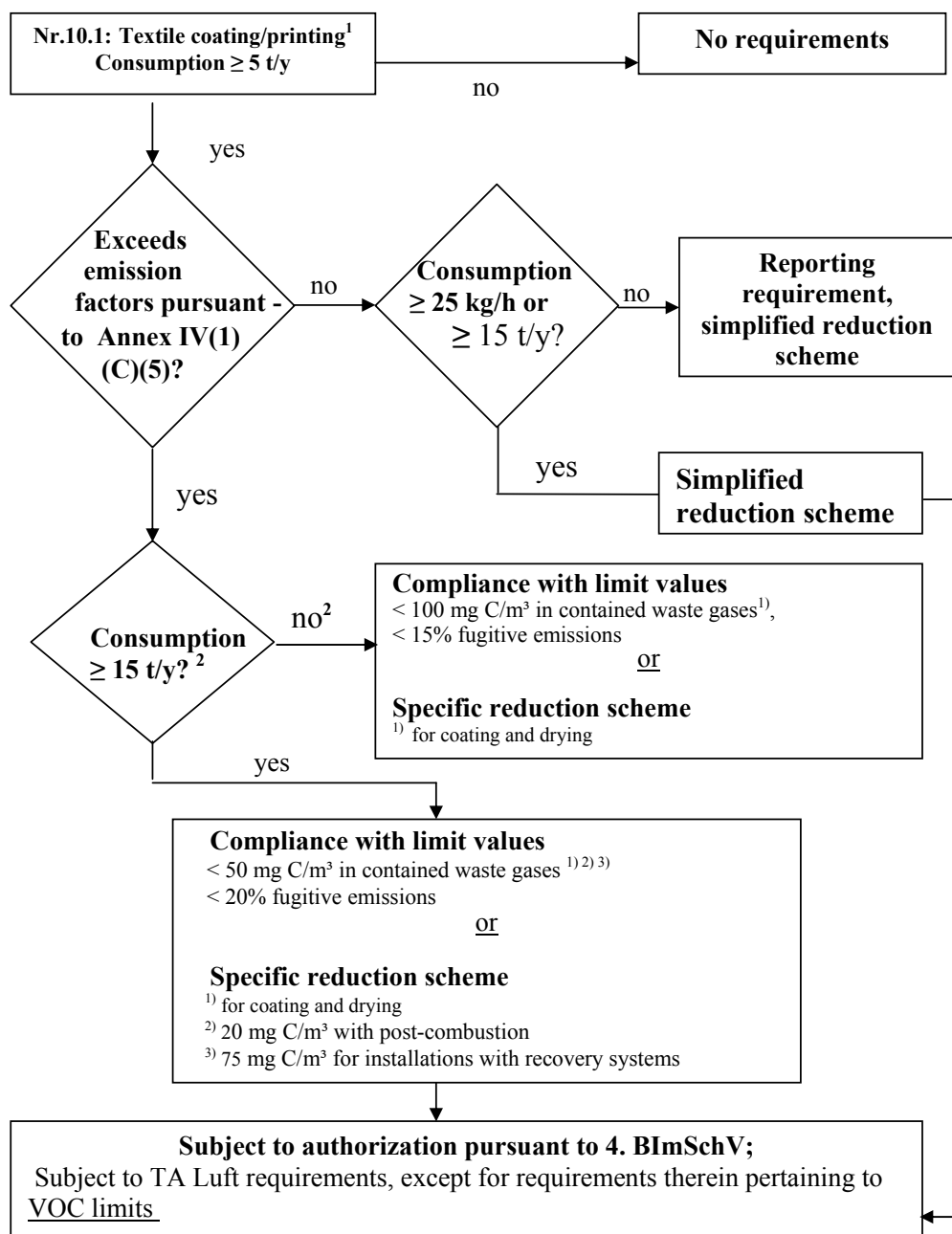
Figure 8: Requirements and applicability flowchart for installations that coat metallic or plastic surfaces



\*In exceptional cases, installations that consume between 5-15 t/year may be subject to authorization if their consumption capacity exceeds 25 kg/h

\*\*In addition to the requirements of the Solvent Ordinance, installations subject to authorization are also subject to the requirements of *TA Luft* excluding the requirements therein pertaining to VOC limits.

Figure 9: Requirements and applicability flowchart for installations that coat wood or wood materials



<sup>1)</sup> The chart only applies to coating installations that would be subject to the requirements of no. 5.1 of 4.BImSchV if their solvent consumption exceeded 25 kg/h or 15 t/y.

<sup>2)</sup> In exceptional cases, installations that consume between 5-15 t/year may be subject to authorization if their consumption capacity exceeds 25 kg/h

Figure 10: Requirements and applicability flowchart for textile coating and printing installations

## 4 The reduction scheme

The Solvent Ordinance permits installation operators to elaborate what is known as a reduction scheme in lieu of compliance with Annex III limit values. However, the reduction scheme is required to reduce emissions by the same amount as they would be reduced if the installation complied with Annex III limit values.<sup>12</sup> The reduction scheme (described in Annex IV of the Ordinance) stipulates in detail the procedure for various types of installations, and in particular for all coating installations.

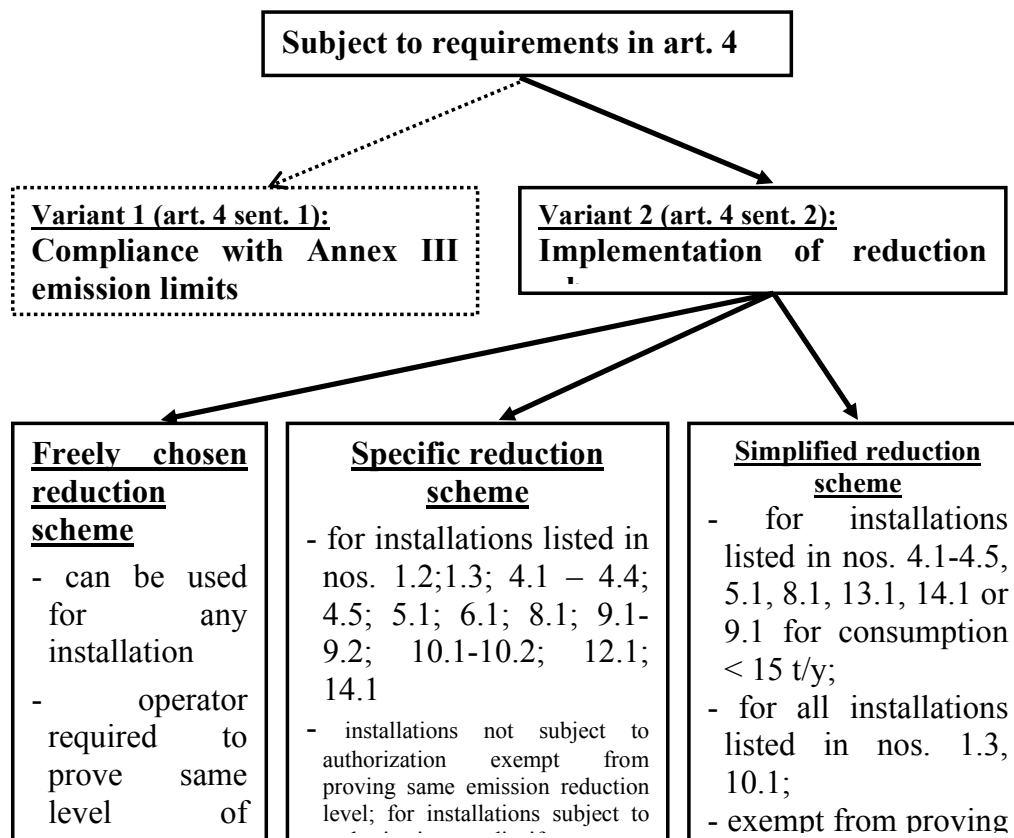


Figure 11: Reduction scheme variants

The reduction scheme is a new mechanism in German air pollution legislation that aims to promote emission reductions by enabling operators

<sup>12</sup> Cf. Article 4(2), German Solvent Ordinance (31. BImSchV)

to devise an Ordinance compliance solution that is tailored to the requirements of a specific installation and that can be readily integrated into operational processes. The reduction scheme also provides smaller installations that are currently not subject to authorization with an ecological alternative to downstream waste gas treatment.

There are three types of reduction schemes: operator-defined, specific and simplified (Figure 11). See section 6 for a description of a specimen reduction scheme.

#### **4.1 Operator-defined reduction scheme**

An operator-defined reduction scheme can be used by any operator providing that the emissions reduction realized by the installation are equivalent to Annex III emission limits.

Any method can be used that results in an emissions reduction that is at least equivalent to the reduction that would be achieved through compliance with the applicable emission limit values. The operator is required to provide plausible evidence of such equivalence.

#### **4.2 Specific reduction scheme**

The specific reduction scheme can only be used by the types of installations specified in Table 6. These are mainly installations that coat surfaces with coating substances, varnishes, adhesives or inks.

The specific reduction scheme revolves around a criterion known as the target emission, which is the maximum allowable emission load. This value must not exceed the emission level that would be achieved if the installation complied with Annex III requirements. The Ordinance provides for two-phase compliance with the target emission. In the first phase, total emissions cannot exceed the target emission by more than 150%, and in the second phase, the installation must comply with the target emission.

In addition, compliance with the target emission for existing, new, and substantially changed installations is to be achieved in accordance with specific deadlines and timeframes, which are summarized in the following table.



Maximum allowable total emissions per year	Deadline for compliance with the target emission	
	New or substantially changed installations	Existing installations
150% * target emission	Immediately upon going into operation	as at Jan. 1, 2005
Target emission	as at Nov. 1, 2004	as at Nov. 1, 2007

Table 5: Deadlines and timeframes for compliance with target emissions

The target emission is determined according to a specific formula<sup>13</sup> and on the basis of defined variables. These variables are defined in such a way that compliance with the target emission on the basis of these variables results in an emission reduction that is equivalent to compliance with Annex III requirements. Operators of installations not subject to authorization are exempt from the requirement to prove (as is required for operator-defined reduction schemes) that equivalence with Annex III requirements has been achieved. Inasmuch as operators of installations subject to authorization are required to use the best available techniques, more stringent emission reduction regulations may apply in some cases.<sup>14</sup>

The following parameters are to be applied to the calculation of the target emission:

- ☐ The volume of coating solids that was used during the period covered by the solvent management plan.
- ☐ The annual reference-emission multiplication factor
- ☐ The percentage or an equivalent reduction factor that is used for the target-emission calculation

Table 6 (below) lists the calculation factors for the various types of installations in relation to solvent consumption.

Installation type	Consumption [t/year]	Multiplication factor	Applicable percentage	Reduction factor
1.2 Publication rotogravure	> 25	4	(10+5)	0,15
1.3 Other printing activities (apart from publication rotogravure)	> 15-25	2,5	(25+5)	0,3
	> 25	2,5	(20+5)	0,25
Rotary screen printing	> 15-25	1,5	(25+5)	0,3
	> 25	1,5	(20+5)	0,25
4.1 – 4.4 Vehicle coating	< 15	2,5	(25+15)	0,4
4.5 Coating of rail vehicles	> 5 -15	1,5	(25+15)	0,4
	> 15		(20+5)	0,25

<sup>13</sup> Annex IV(B), German Solvent Ordinance (31. BImSchV)

<sup>14</sup> Article 4 sentence 3, German Solvent Ordinance (31. BImSchV)

Installation type	Consumption [t/year]	Multiplication factor	Applicable percentage	Reduction factor
5.1 Vehicle refinishing		2,5	(25+15)	0,4
6.1 Coil coating	> 10	2,5	(3 + 5)	0,08
8.1 Coating of other metallic or plastic surfaces				
<input type="checkbox"/> Other types of coating	> 5 -15 > 15	1,5 1,5	(25+15) (20+5)	0,4 0,25
<input type="checkbox"/> Coating of sheeting materials	> 5 -15 > 15	1,5 1,5	(15+15) (10+5)	0,3 0,15
9.1- 9.2 Coating of wood or wood materials	> 5 -15 > 15 -25 > 25	4 3* 3*	(25+15) (25+15) (20+5)	0,4 0,4 0,25
10.1/10.2 Coating of textile, fabric, film and paper surfaces	> 5 -15 > 15	4	(15+15) (10+5)	0,3 0,15
12.1 Wood impregnation	> 10	1,5	(45+5)	0,5
14.1 Adhesive coating				
<input type="checkbox"/> Other installations	> 5 -15 > 15	3 3	(25+5) (20+5)	0,3 0,25
<input type="checkbox"/> Coating of sheeting materials	> 5 -15 > 15	3 3	(15+5) (10+5)	0,2 0,15
Food contact coatings	see nos. 8.1, 10.1, 10.2 or 14.1	2,33	see nos. 8.1, 10.1, 10.2 or 14.1	
Aerospace or shipping coatings		2,33		

\*A multiplier of 4 can be used for processes (e.g. roller application) whose efficiency exceeds 85%.

Table 6: Calculation factors for the elaboration of specific reduction schemes

In the following, the procedure for the elaboration of specific reduction schemes is described in detail.

#### 4.2.1 Determination of coating solids content

Coating solids are defined as any solid that remains in a paint, varnish, ink, adhesive, or any other coating substance following the evaporation of surface water or VOC. Solids include (but are not limited to) binders, pigments, and fillers.<sup>15</sup>

Solids and solvent content are to be calculated along with the solvent content of the input substance. The data needed for this calculation can be obtained either (a) from the applicable DIN safety sheets (b) by requesting it from the relevant manufacturer or (c) through the use of the relevant materials management software. The calculation is to include the baseline and final warehouse inventories for the period covered by the solvent management plan.

<sup>15</sup> Pursuant to Annex IV(B)(2), German Solvent Ordinance (31. BImSchV)

#### 4.2.2 Reference-emission calculation

The reference emission is a mathematical value that constitutes the hypothetical total emission that would be released if conventional solvent coatings were used in an installation in the absence of emission reduction measures of any kind.

The reference emission calculation is based on the assumption that a conventional coating installation uses coatings containing a mean solvent and solids concentration that is characteristic for a specific industry. In this calculation, solids constitute the only relative constant value in the coating process since the solid is the only substance that is needed in order to obtain the desired coating. The calculation is also based on the assumption that a specific amount of VOC is released per volume of solids used and that this VOC emission will not be reduced by any downstream emission reduction measures. The emission volume is constituted by the underlying reference emission specified by the reduction scheme and is calculated as follows:

$\text{Reference emission} = \text{solids volume} * \text{multiplication factor}$
---

The multiplication factor in this formula indicates the mean amount of solvent released per amount of coating solids applied using industry-standard techniques, as calculated for a specific industry. The various industries and their multiplication factors are listed in Table 1 column 3.

The multiplication factors are calculated on the basis of an assumed mean amount of solids and organic solvent content in a coating substance for a specific industry. For example, it is assumed that coatings used in the wood industry contain an average of 35% solids and 65% organic solvent. It is also assumed that 100% of the solvent contained in such coatings is emitted. In addition to these coating-substance emissions, any emission from thinners (roughly 20-30% of coating solvent volume) and any emission resulting from the use of cleaning agents (an estimated 20% of coating solvent volume) are also to be counted. The sum total of all of the aforementioned quantities constitutes the total amount of solvent emitted when the relevant amount of solids is applied to a surface. Dividing solvent volume by solids volume yields a value ranging from 2.6 to 2.8.

Consequently, in implementing the EU solvent directive in Germany, the multiplication factor for the reference-emission calculation was reduced from 4 to 3 for the wood industry.

### 4.2.3 Target-emission calculation

The calculated reference emission is the starting point for calculation of the target emission, which is the maximum allowable total emission limit. This value is not to exceed the emission levels that would be achieved if the installation complied with Annex III requirements.

The target-emission calculation is based on the assumption that contained emissions will largely be eliminated by the downstream abatement equipment that will be used to comply with Annex III requirements. This means that the only emissions from the installation will be constituted by fugitive emissions and the non-precipitated solvent in scrubbed gas. Hence the target emission is calculated using a percentage that is constituted by the sum total of the following:

- ☐ The applicable aforementioned fugitive emission limit value and
- ☐ a defined value<sup>16</sup> for the proportion of contained but non-precipitated VOC emissions

The applicable percentages for specific industries are listed in Annex IV of the Solvent Ordinance and in column 4 of Table 1. Column 5 of this table also shows the reduction factors for a simplified target-emission calculation.

The target emission is calculated using the following equation:

$$\text{Target emission} = \text{reference emission} * \text{percentage}$$

or

$$\text{Target emission} = \text{reference emission} * \text{reduction factor}$$

The target and reference emission can be calculated in a single step if the amount of solids is first multiplied by the appropriate multiplication factor and is then included in the following equation:

---

<sup>16</sup> This is the effectiveness value for “best-technique” abatement equipment according to EU standards. The required effectiveness for abatement equipment in smaller coating installations is 85% and in larger installations 95%, resulting in scrubbed gas values of 15% or 5% (respectively) of solvent input.

$\text{Target emission} = \text{solids} * \text{multiplication factor} * \text{reduction factor}$
---

### 4.3 Simplified reduction scheme

The simplified reduction scheme constitutes a simplified form of proof of compliance with the target emission for a specific reduction scheme. This procedure is “simplified” in that it dispenses with the labor-intensive process of elaborating a solvent management plan. The simplified procedure can only be applied (a) in installations that use substances with a very low and defined solvent content and (b) for specific installations, mainly those that are not subject to authorization. Table 7 lists the installations that are permitted to use a simplified reduction scheme.

The VOC values listed in column 3 of Table 7 apply **solely** to (a) ready to use coatings and (b) **individual** coatings or substances, and are **not** to be interpreted as composite parameters for all substances used.

All VOC values are to be calculated using the calculation formula specified in the Ordinance.<sup>17</sup> As a rule, this calculation is realized by the coating manufacturer on the basis of DIN ISO 11890 1 and 2 standards.

---

<sup>17</sup> Annex VI(4), German Solvent Ordinance (31. BImSchV)

Installations specified in Annex II no.	Consumption threshold	Data that the operator is required to report to the competent authority, pursuant to the Ordinance
1.3	n/a	Solely the use of inks, varnishes, adhesives and/or inactive substances whose solvent content is < 10%
4.1 - 4.5, 8.1	5-15 t/y	Solely the use of coatings whose VOC value is 250 g/l, as well as cleaning agents whose solvent content is < 20%
9.1	5-15 t/y	<input type="checkbox"/> Solely the use of coatings with a maximum VOC of 250 g/l for the coating of even and flat surfaces <input type="checkbox"/> Solely the use of coatings with a maximum VOC of 450 g/l for the coating of surfaces other than even or flat surfaces <input type="checkbox"/> Solely the use of aqueous mordants with a maximum VOC value of 300 g/l
5.1	n/a	Solely the use of substances with the VOC values listed in Annex IV(C)(4).
10.1	n/a	Compliance with the following emission factors: <input type="checkbox"/> 0.8 g C/kg of textile for coating or printing processes <input type="checkbox"/> 0.4 g C/kg of textile for preparation residue or carryover
13.1, 14.1	5-15 t/y	Solely the use of adhesives and primers whose solvent content is < 5%

Table 7: Installations that are permitted to apply a simplified reduction scheme

Operators that apply a simplified reduction scheme are required to submit to the competent authority a legally binding declaration indicating that they are using solvent-free or low-solvent substances.

In contrast to specific reduction schemes, compliance with simplified reduction schemes and substantiation thereof is not subject to deadlines and timeframes. Hence, operators that wish to use this simplified substantiation method should begin using the appropriate low-solvent substances during the initial emission reduction phase of the reduction scheme (i.e. the [transitional] period during which the installation is to emit no more than 150% of the target emission). This will ensure that the installation is in compliance with the EU solvent directive, which does not provide for a simplified substantiation method. Operators who use the simplified method are to submit a legally binding declaration of compliance by Oct. 31, 2005 for existing installations and immediately upon going into operation for new installations.

If this procedure is not followed, the operator is required to implement a specific reduction scheme and the consequent initial reduction phase pursuant to the EU solvent directive.

Small installations that coat wood or wood materials (no. 9.1) that are also subject to the requirements of the Ordinance are to submit a legally binding declaration on or before Dec. 31, 2012.

The content and format of the declaration is to be determined by the competent Federal State (individual German state) authority. Following is an example of the possible content and format of such a declaration for installations listed under item 9.1.

<b>DECLARATION REGARDING VOC VALUES FOR COATINGS USED</b>			
Company name:			
Street address:			
Postal code:			
Contact person:			
Phone:			
Fax:			
Installation address:			
as above			
Industry:			
The following applies to the aforementioned installation:			
<input type="checkbox"/> Only coatings with a maximum VOC of 250 g/l are used to coat even and flat surfaces			
<input type="checkbox"/> Only coatings with a maximum VOC of 450 g/l are used to coat all other surfaces			
<input type="checkbox"/> Only aqueous mordants with a maximum VOC value of 300 g/l are used			
Documentation for the coatings used has been compiled and is available for submission to the competent authority upon request.			
Date:		Signature:	

Figure 12: Possible content and format for a legally binding declaration of compliance with a reduction scheme for the installations listed in no. 9.1

## 5 The solvent management plan

The solvent management plan is a new planning and compliance substantiation mechanism under German immision control legislation that is codified in the German solvent ordinance.

The purpose of the solvent management plan is to provide the installation operator with precise information regarding the amount of solvent used in the installation (input) and the amount of solvent that leaves the installation in various ways (output). The plan then serves as a basis for the elaboration of optimal emission reduction measures.

The solvent management plan also serves to demonstrate that solvent consumption has been determined and that the requirements of the Ordinance have been implemented.

Operators of installations that are subject to authorization and a reporting obligation are required to realize a solvent management plan (or have such a plan realized by a third party) every 12 months that demonstrates compliance with total emission and fugitive emission limit values, or that demonstrates compliance with the target emission specified in the reduction scheme.<sup>18</sup>

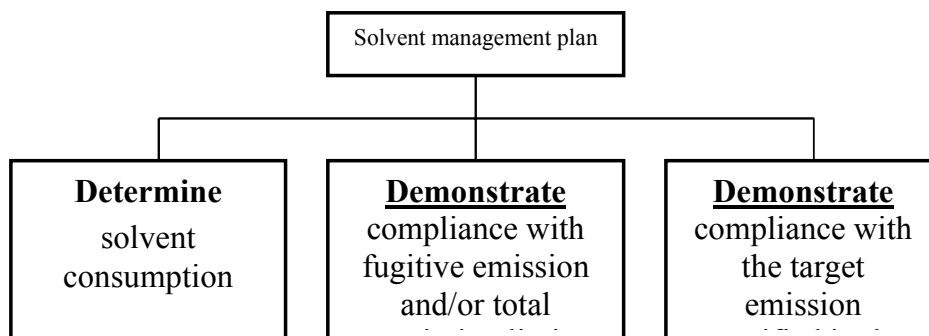


Figure 13: Application domain of the solvent management plan

Annex V of the Ordinance contains background information about the solvent management plan and explains how it works. The solvent management plan has a relatively wide scope, encompassing as it does possible solvent input and output for all types of installations that fall within the purview of the Ordinance. However, each type of input and output does not necessarily have to be present and counted for each type of installation.

---

<sup>18</sup> Pursuant to Article 5(6) Article 6(1), German Solvent Ordinance (31. BImSchV)

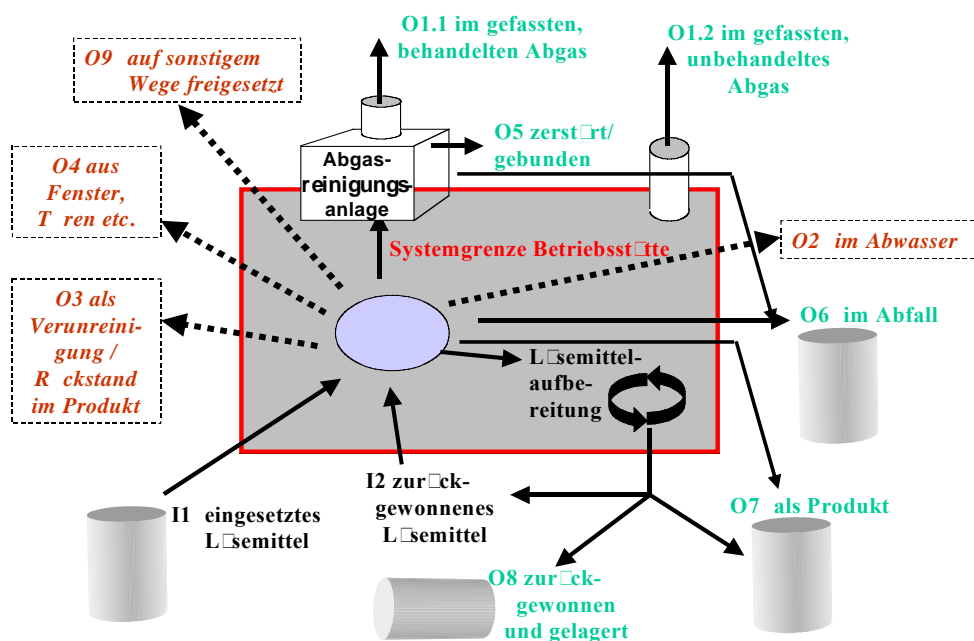


The various input and output flows are described below for purposes of clarification. The scope of substance flows is also described and instructions are provided as to how these flows can be calculated. Section 6 provides illustrative examples of this procedure.

## 5.1 Definition of input and output

During the process of implementing the EU solvent directive in national law, it was found that a clear and unambiguous definition of input and output is needed for the solvent management plan<sup>19</sup>.

The possible solvent input and output (substance) flows for an installation are illustrated in Figure 14. Fugitive emissions (F)<sup>20</sup> are represented by the outputs that are designated with dotted arrows and in italics. VOC emissions of contained, untreated waste gases (O1.2) from installations that realize specific activities are also counted as fugitive emissions (see section 5.1.2).



<sup>19</sup> Definitions of input and output pursuant to Annex V, German Solvent Ordinance (31. BImSchV)

<sup>20</sup> Definition pursuant to Article 2(6) in conjunction with Annex V(2.2.2), German Solvent Ordinance (31. BImSchV)

Figure 12<sup>21</sup>: input and output flows [6]

The table below summarizes the definitions and designations of the various input and output flows.

<b>Substance flow</b>	<b>Definition</b>	<b>Code designation</b>
<b>I1</b>	Amount of organic solvent or amount in purchased preparations	<b>purchased and used</b>
<b>I2</b>	The quantity of organic solvents or quantity thereof in preparations recovered and reused internally as solvent.	<b>recovered, used in the same process</b>
<b>O.1</b>	VOC emissions in contained waste gases	<b>in contained waste gases</b>
<b>O1.1</b>	VOC emissions in treated and contained waste gases	<b>captured treated in scrubbed gas</b>
<b>O1.2</b>	VOC emissions in untreated and contained waste gases	<b>in untreated and contained waste gases</b>
<b>O<sub>2</sub></b>	The quantity of organic solvents in wastewater, if appropriate taking into account wastewater treatment when calculating O5.	<b>in wastewater</b>
<b>O3</b>	The quantity of organic solvent that remains in an end product as residue or contaminant.	<b>residue in product</b>
<b>O4</b>	Fugitive emissions (pursuant to article 1(2)(6)) <u>in air</u> : all VOC emissions in non-contained waste gases in an installation that are released into the environment through doors, ventilation shafts or similar openings.	<b>fugitive emissions in air</b>
<b>O5</b>	Any quantity of organic solvent or compound that is captured or eliminated using a chemical or physical reaction, e.g. through the combustion or treatment of waste gases or wastewater, insofar as such solvent or	<b>eliminated/bound</b>

<sup>21</sup> **Translation of illustration (both of them):** O1.1 In contained treated waste gases / O1.2 In contained untreated waste gases / O2 In wastewater / O7 As an end product / O8 Recovered and stored / I2 Recovered solvent / I1 Input / O3 As product contaminant or residue / O4 Through windows, doors etc. / O9 Miscellaneous/ Abatement equipment / Physical limit of installation/ Solvent treatment / O5 Extirpated/bound/ O6 In waste

	compound does not fall within the scope of O6, O7 or O8.	
<b>O6</b>	Any quantity of organic solvent that is a constituent of collected waste.	<b>in waste</b>
<b>O7</b>	Organic solvents or organic solvents contained in preparations that are sold or are intended for sale as a commercially valuable product of a manufacturing process (e.g. paint, varnish, and adhesive).	<b>as a commercial product</b>
<b>O8</b>	Any organic solvent that is recovered for purposes of reuse or that is contained in a preparation that was recovered for reuse, excluding any substance that falls within the scope of I2 or O7.	<b>recovered, stored</b>
<b>O9</b>	Any organic solvent that is released in any other fashion such as accident or drip loss	<b>other outputs</b>

Table 8: Definitions and code designations for input and output

The solvent management plan can apply to any twelve month period and is to take into account only those factors that fall within the scope of the operations encompassed by the solvent management plan. In other words, only those solvents that are brought into the installation, are emitted from it, or are recovered within it fall within the scope of the solvent management plan.

### 5.1.1 Input (solvent use)

A distinction is made between two types of input in an installation: input I1 and I2.

#### Input I1 (purchased and used)

This is the quantity of purchased organic solvent and/or preparations that is used in an installation.

This quantity consists of the **sum total** of the solvent purchased **and** used during a given 12 month period. This means that in addition to solvents such as cleaners and thinners, **all** solvent substances are also to be counted, including coatings such as varnishes, paints, fillers, wax and so on. However, only the solvent constituents of preparations are to be included in solvent management plan calculations. Quantities that are indicated in kilograms are to be converted to liters and adjusted for density.

In the case of closed surface cleaning and dry cleaning installations (e.g. vacuuming), in addition to inactive substances only solvent that was added to existing quantities of solvent over the past 12 months is to be counted (as I1). Solvent in solvent reservoirs at the facility of interest is not to be counted at any time, including when the reservoirs are initially filled.

### Input I2 (recovered, used in the same process)

This is the quantity of organic solvents, or their quantity in preparations, that is recovered and reused as input into the process. The recycled solvent is counted as I2 every time it is used to carry out the activity.

Input I2 is measured for purposes of determining total solvent input (I). The total quantity is needed for the calculation of fugitive emissions (F) (see section 5.3.1).

Solvent that is recycled by processing waste solvent outside the installation is to be counted as purchased and used solvent (I1) rather than as I2 (recovered and used in the same process).

However, all quantities of solvents or preparation recovered within the installation (e.g. via adsorption or distillation) do not necessarily count as I2.

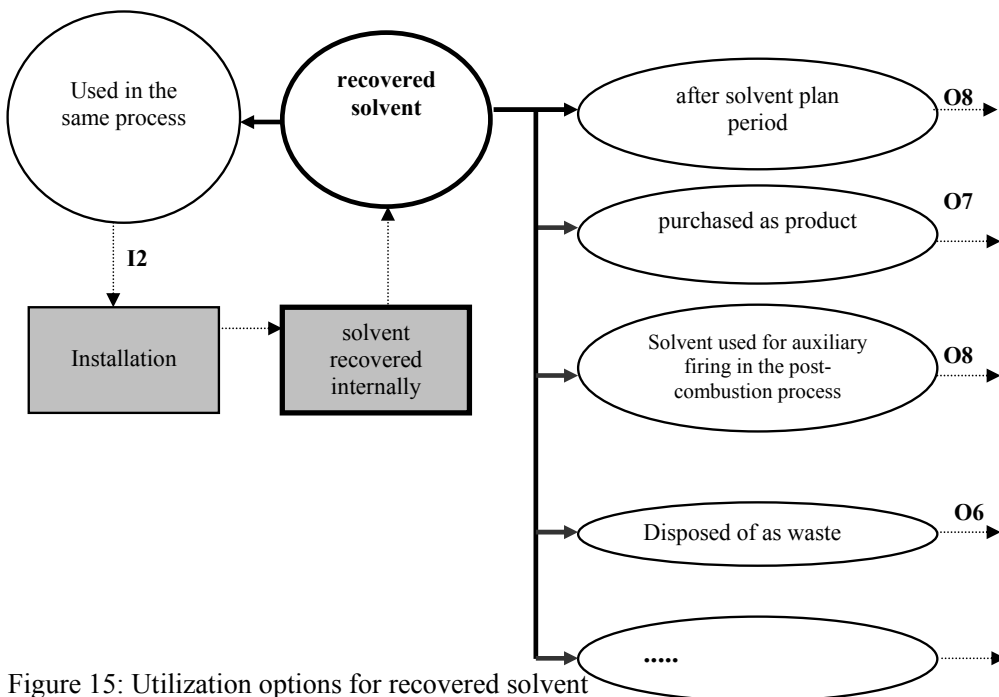


Figure 15: Utilization options for recovered solvent

Figure 15 illustrates the utilization options for recovered solvent. The solvent is counted in the solvent management plan as follows, depending on the application involved:

- ☐ Treated solvent or constituents thereof in preparations are used in the same installation or process. Only at this point (e.g. upon being reused as a thinner or cleaner) does the recovered solvent count as **I2** in the solvent management plan
- ☐ The sale of recovered solvent, e.g. as adsorptively recovered toluene in printing installations, is counted as output **O7** (as a product).
- ☐ Recovered solvent that is not used during the solvent management plan period and is stored beyond the solvent management plan period is counted as output **O8**.
- ☐ Solvent used for auxiliary firing in the postcombustion process
- ☐ Solvent is recovered from installation waste gases by an adsorption process and is realized as a auxiliary firing process (post-combustion process. Solvent that is recovered and used in this process counts as O8 output rather than as I2 input since it is used in the same process.
- ☐ Recovered solvent that is disposed of outside the installation counts as **O6** irrespective of the disposal method used (energetic recycling or reprocessing).

### 5.1.2 Output (solvent output)

Output O encompasses all output of organic solvent from an installation. This output is subdivided into outputs O1 through O9, whereby outputs O2, O3, O4 and O9 are designated as fugitive emissions<sup>22</sup>.

#### **Output O1 (in contained waste gases)**

This encompasses all contained waste gases that are discharged from an installation and which generally consist of outputs O1.1 and O1.2. In some installations, particularly ones that realize coating activities, O1.2 generally counts as a fugitive emission.

O1.1 (in scrubbed gas) means VOC emissions in treated contained waste gases. These are waste gases (including room air) that are conducted out of an encapsulated machine or the operational component of abatement equipment for purposes of treatment (see Figure 16 nos. 6 and 7).

O1.2 (in untreated gas) means VOC emissions in untreated contained waste gases. These are waste gases (including room air) that are fed out of an

---

<sup>22</sup> Article 2(6) in conjunction with Annex V(2.2.2), German Solvent Ordinance (31. BImSchV)

encapsulated machine or the operational component of abatement equipment and are not treated (see Figure 16 nos. 4 and 5).

### Output 2 (in wastewater)

This is the quantity of organic solvent that is discharged from an installation along with wastewater. This output is counted as fugitive emissions.

If wastewater containing solvent is treated within the installation, the quantity of solvent from such wastewater that is eliminated or that is bound to an adsorption substance is counted in the solvent management plan as output O5 (see output O5).

In some installations, wastewater containing solvent is disposed of as waste. In such cases, substance flow O2 is not applied and the relevant quantity of solvent is counted in the solvent management plan as output O6.

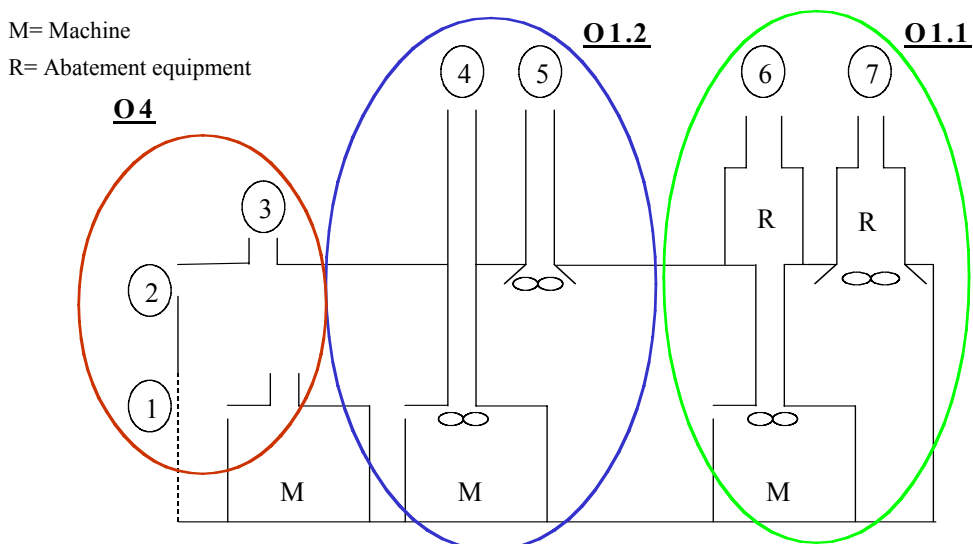


Figure 1: Contained waste gases and fugitive emissions in ambient air

### Output 3 (residue in end product)

This is the quantity of organic solvent remaining in an end product in the form of a contaminant or residue, e.g. in printed products, coatings or adhesives. This output is counted as fugitive emissions, except in the case

of output O3 for heatset web offset printing installations.<sup>23</sup> The Ordinance stipulates that solvent residues in end products (O3) do not count as fugitive emissions (F). This is the high-boiling petroleum component of the ink that is absorbed by the paper, is not expelled during the drying process and under normal conditions is not a fugitive emission.

#### **Output 4 (fugitive emissions in air)**

This is the uncaptured component of fugitive emissions that is discharged into the air (see Figure 16 nos. 1, 2, 3).

#### **Output 5 (bound/eliminated)**

This is the quantity of organic solvent and volatile organic compound that is eliminated or bound by means of a physical or chemical reaction, e.g. via combustion or waste gas or wastewater treatment.

These processes usually entail the irreversible extirpation of the solvent by means of a chemical reaction such as combustion. Output O5 generally counts as an intermediate stage for solvents that are bound through a physical reaction rather than being extirpated by waste gas or wastewater treatment, since the bound quantities of solvent generally find their way into other outputs, usually O6, but also O2 as well.

Following is a practical example of this cycle: The solvent in waste gases is adsorbed by activated carbon. The bound quantity of solvent is designated as O5 output. Upon disposal of the activated carbon with a solvent load, the O5 value is carried over to the quantity of solvent in waste (O6). The same holds true when bound solvent O5 is recovered through desorption at the installation and is sold as a product O7 (e.g. a cleaning agent) or remains in storage as O8 at the end of the solvent management plan period. In such cases, O5 is regarded as an intermediate stage and is not counted in the solvent management plan.

In other words, in order for output to be included in the solvent management plan as O5, it cannot have previously been classified under O6 (in waste), O7 (in end product) or O8 (recovered).

#### **Output 6 (in waste)**

This is the quantity of organic solvent contained in waste such as contaminated solvent, paint and distillation sludge, old paint and varnish, cleaning rags, loaded activated carbon and similar materials.

---

<sup>23</sup> See Annex III(1.1.2): heatset web offset installations

### **Output 7 (in end product)**

This is organic solvent that has been or is to be sold as a component of a products or preparation, including in particular solvents in products such as paint, varnish, and adhesive. O7 also includes any solvent recovered within the installation that is sold as a product.

### **Output 8 (recovered, stored)**

This is the quantity of organic solvent that is recovered for reuse or is contained in a preparation that is recovered for reuse and that the installation uses during the solvent management plan period for a different process, i.e. not in the same process.<sup>24</sup>

Following is a practical example of this cycle: Organic solvent is recovered during the solvent management plan period but some of this solvent is used as I2 in the same process, while the remainder is stored at the installation following the end of the solvent management plan period. This residual quantity is counted as O8 in the plan for the current year, and in the plan for the succeeding year it is counted as I1 input for purposes of calculating solvent consumption.

### **Output 9 (miscellaneous)**

This is organic solvent that is released into the atmosphere in any manner other than those covered by the output categories described above.

O9 is a “catchall” category in that all emissions pathways not described elsewhere fall within the scope of O9, including solvent that is discharged into the ground or that is lost adventitiously or due to dripping.

## **5.2 Determination of solvent consumption (C)**

Solvent consumption is determined in accordance with the solvent management plan<sup>25</sup> on the basis of the quantity of solvent purchased and used (input I1) during any 12 month period. The quantity of solvent recovered for reuse (category O8) is subtracted from the aforementioned quantity if such solvent is not sold as a product (O7) or is not used in the same process (I2).

$$C = I1 - O8$$

---

<sup>24</sup> In this case, the solvent would be counted in the solvent management plan as I2 input.

<sup>25</sup> Annex V(2.1.1), German Solvent Ordinance (31. BImSchV)



Initially, solvent consumption can be determined on the basis of total input (quantity of solvent used) without regard for specific solvent content. If the amount calculated is below the threshold value, no further calculation is required, since this definitely means that the installation and its activities do not fall within the application domain of the Ordinance.

If the calculation of solvent consumption is based on average historic industry data and if the solvent consumption calculated by the operator is just under the prescribed threshold value, the operator is required to realize an additional calculation using more precise data so as to obtain definitive figures.

### 5.3 Demonstration of compliance with limit values

Operators of installations that are subject to reporting requirements and authorization are required to monitor their total and fugitive emissions on an ongoing basis so as to ensure that the installation is in compliance with the applicable requirements, particularly total emission and fugitive emissions limit values.<sup>26</sup>

#### 5.3.1 Determination of fugitive emissions (F)

Fugitive emissions (F) can be determined in one of two ways: the **direct** or the **indirect method**.<sup>27</sup>

In realizing this calculation, untreated contained waste gases (O1.2) are to be taken into account as follows: If the O1.2 output

- ☐ is **not** counted as fugitive emissions (F), equation a is to be applied
- ☐ **is** counted as fugitive emissions (F), equation b is to be applied.

In the direct method, emitted solvent in wastewater (O2), in the end product (O3), and uncaptured air emissions (O4) are added to fugitive emissions (F).

Equation I a

$$F = O2 + O3 + O4 + O9$$

applies to the following types of installations:<sup>28</sup>

---

<sup>26</sup> Cf. Article 5(6) in conjunction with Annexes III and IV, German Solvent Ordinance (31. BImSchV)

<sup>27</sup> Definition pursuant to Annex V(2.2), German Solvent Ordinance (31. BImSchV)

- 1.2 Publication rotogravure installations
- 2.1 Surface cleaning installations
- 3.1 Dry cleaning installations
- 4.1-4.5 Coating of road vehicles, driving cabs, commercial vehicles, and rail vehicles (solvent consumption 15 t/year or greater)
- 7.1 Installations that coat winding wire using coatings containing phenol, cresol or xyleneol
- 7.2 Installations that coat winding wire using other coatings
- 10.1 Installations that coat or print textiles or fabric
- 11.1 Installations that coat leather
- 12.1 Installations that impregnate wood using preservation products that contain solvent
- 12.2 Installations that impregnate wood using creosote
- 13.1 Wood and plastic lamination installations
- 15.1 Footwear manufacture installations
- 16.1-16.4 Installations that manufacture adhesives, ink, paint or other coatings, or wood or building preservation products.
- 17.1 Rubber conversion installations
- 18.1 Vegetable oil and animal fat extraction and vegetable oil refining installations
- 19.1 Installations that manufacture pharmaceutical products

Equation I b

$$F = O1.2 + O2 + O3 + O4 + O9$$

applies to the following types of installations:

- 1.1 Heatset web offset printing installations
- 1.3 Installations that realize other printing activities
- 5.1 Vehicle refinishing installations
- 4.1-4.5 Coating of road vehicles, driving cabs, commercial vehicles, and rail vehicles (solvent consumption =15 t/year)
- 6.1 Coil coating installations
- 8.1 Installations that coat other metallic or plastic surfaces
- 9.1-9.2 Installations that coat wood or wood materials
- 10.2 Installations that coat film or paper surfaces
- 14.1 Adhesive coating installations

In the **indirect method**, fugitive emissions are calculated as follows: The quantity of solvent removed from contained waste gases (O1) and from waste (O6) and end products (O7) in the installation, as well as the quantity of extirpated or bound solvent (O5) and the quantity of solvent recovered for reuse (O8) using abatement equipment, are subtracted from the total quantity of purchased and input solvent (I1).

---

<sup>28</sup> Pursuant to Annex I, German Solvent Ordinance (31. BImSchV)

**Equation II a:**

$$F = I1 - O1 - O5 - O6 - O7 - O8$$

applies to installations that fall within the scope of equation I a.

**Equation II b:**

$$F = I1 - O1.1 - O5 - O6 - O7 - O8$$

applies to installations that fall within the scope of equation I b.

Compliance with the fugitive emission limit value is verified on the basis of the ratio between fugitive emissions (F) and total solvent consumption (I1 + I2), as calculated using the following equation:

$$x [\%] = \frac{F}{(I1 + I2)} * 100$$

Compliance is achieved if x is equal to or smaller than the fugitive emission limit value for the activity of interest.

### 5.3.2 Determination of total emissions

Total emissions are the sum of all fugitive emissions (F) and emissions in contained waste gases (O1 or O1.1).<sup>29</sup>

Compliance with the total emission limit value or target emission of a reduction plan is verified using the following equation, in accordance with the fugitive emission classification of emissions in untreated waste gases (O1.2).<sup>30</sup>

**Equation III a**

$$E = F + O1$$

equation I a.

applies to installations that fall within the scope of

**Equation III b:**

$$E = F + O1.1$$

applies to installations that fall within the scope of I b.

---

<sup>29</sup> Definition pursuant to Article 2(14), German Solvent Ordinance (31. BImSchV)

<sup>30</sup> Pursuant to Annex V(2.1.2), German Solvent Ordinance (31. BImSchV)

Depending on Annex III requirements, total emissions (E) are either divided by the appropriate product parameter or are expressed as a proportion of solvent consumption (I1 + I2). The value obtained is then compared with the required total emission limit value.

The types of installations that are subject to total emission limit values or to which emission limit values can be applied are listed in the following table.

No.	Activity	Unit of measure for total emission limit value
3.1	Dry cleaning installations	g/kg of goods cleaned
4.1 – 4.5	Coating of road vehicles, driving cabs, commercial vehicles, and rail vehicles (solvent consumption =15 t/year)	g/m <sup>2</sup>
7.1 –7.2	Installations that coat winding wire	g/kg of wire
11.1	Installations that coat leather	g / m <sup>2</sup>
12.1 – 12.2	Wood impregnation installations	kg/m <sup>3</sup> of impregnated wood
13.1	Installations that laminate wood and wood materials	g/m <sup>2</sup>
15.1	Footwear manufacture installations	g/pair of completed footwear produced
16.1 – 16.4	Installations that manufacture adhesives, ink, paint or other coatings, or wood or building preservation products.	percentage of solvent input (sum of I1 + I2); applied as an <i>alternative</i> to the emission limit value
17.1	Rubber conversion installations	
18.1	Vegetable oil and animal fat extraction and vegetable oil refining activities	kg/ton of material
19.1	Installations that manufacture pharmaceutical products	percentage of solvent input; applied as an <i>alternative</i> to the emission limit value

Table 9: Total emission limit values for certain types of installations

### **Simplified calculation of total emissions**

Total emissions (E) are determined by adding the value obtained for fugitive emissions (F) to the value obtained for outputs O1 or O1.1. However, to simplify the calculation procedure somewhat, the following formula can be used instead:

Equation IV:

$$E = I1 - O5 - O6 - O7 - O8$$

Here, the quantity of solvent removed from waste (O6) and end products (O7), as well as the quantity of extirpated or bound solvent (O5) and the quantity of solvent recovered for reuse and stored (O8), are subtracted from the total quantity of purchased and input solvent (I1).

Equation IV can be calculated in stages. In stage 1, E equals input I1 ( $E = I1$ ). If the resulting total emission limit value exceeds the mandated threshold value, a second calculation is realized in which a significant quantity of the substance flow (in most cases the quantity of solvent disposed of as waste (O6)) is subtracted from input I1 ( $E = I1 - O6$ ). If the value obtained from this calculation still exceeds the mandated threshold value, an additional quantity is subtracted from the substance flow (e.g.  $E = I1 - O6 - O7$ ) and this procedure is repeated until the entire equation has been calculated.

Phase	Emission calculation (E)	Verification of compliance with total emission limit value	
1	$E = I1$	$X = \text{threshold value}$ $\Rightarrow$ Equal to or less than threshold value	If X exceeds threshold value, perform phase 2
2	$E = I1 - O6$		If X exceeds threshold value, perform phase 3
3	$E = I1 - O6 - O7$		If X exceeds threshold value, perform phase 4
4	$E = I1 - O6 - O7 - O5$		If X exceeds threshold value, perform phase 5
5	$E = I1 - O6 - O7 - O5 - O8$		If X exceeds threshold, threshold is exceeded

Table 10: Steps in the calculation of total emission

A number of types of installations that are subject to the Ordinance such as dry cleaning, automobile repair and wood coating installations are generally exempt from steps 3-5 since the attendant output flows (O7, O5 and O8) rarely occur in such installations.

## 5.4 Compliance with a specific reduction scheme

If a specific reduction scheme<sup>31</sup> is implemented in lieu of compliance with Annex III emission limit values, the operator is required to verify that the installation is in compliance with the target emission.

As previously stated, target emission means the maximum total emissions that an installation is allowed.

In verifying this compliance, the operator is to use the solvent management plan to determine whether the installation's actual emissions fall short of the threshold specified by the target emission. This procedure will now be described.

**Verification of compliance with a specific reduction scheme:** The target emission for coating, painting, and printing installations is calculated on the basis of the quantity of solids in the coatings used.

In order to determine whether an installation is in compliance with past or envisaged emission reduction measures, actual total emissions E for the 12 month period of interest are calculated.

The target emission is determined for the same period using the equation specified in section 4.2 so as to determine whether compliance with the actual total emission of this target emission has been achieved.

The table below summarizes the data and calculation steps that make up the compliance verification procedure.

Calculation step		Results
1	Quantity of paint purchased/quantity of cleaning agent/thinner etc.	Quantity of solvent substances
2	Determination of solvent content (percentage) for each type of paint on the basis of EU safety sheets or comparable documentation The various solvent amounts that have been determined are added together.	Solvent content  Input I1
3	Determination of the quantity of solids in purchased and input paint/hardener	Solids content
4	Determination of total solids content	Amount of solids
5	Determination of organic solvent output: <input type="checkbox"/> Elimination via chemical reaction	O5 (generally of minor

---

<sup>31</sup> Article 4(2) sentence 2 in conjunction with Annex IV, German Solvent Ordinance (31. BImSchV)

Calculation step		Results
	<input type="checkbox"/> Solvent in waste or solvent waste <input type="checkbox"/> Solvent sold  <input type="checkbox"/> Solvent recovered Quantity in storage Quantity used in other processes	importance when a reduction scheme is applied) O6 O7 (generally not applicable to coating installations) O8
6	Determination of total emissions	$E = I1 - O5 - O6 - O7 - O8$
7	Determination of target emission (TE)	$TE = \text{Amount}_{\text{solids}} \times \text{factor } 1^1 \times \text{factor } 2^2$
8	Compliance with the reduction scheme is achieved when	$E < TE$

<sup>1</sup>multiplication factor    <sup>2</sup>percentage or reduction factor

Table 11: Procedure for verifying compliance with a reduction plan

All types of organic solvent that are brought into and used in the installation are to be counted, including coatings, thinners, hardeners, and cleaners. If a specific reduction scheme is used, O5 is of negligible importance since the relevant installations generally do not realize waste-gas scrubbing. Sold solvent substances (O7) are likewise of minor importance since they generally do not occur in coating installations.

## 5.5 Note on the determination of substance flows

In the interest of keeping the work involved in realizing a solvent management plan within reasonable bounds and simplifying the process of calculating solvent input and output, the operator should determine which specific substance flows are needed in order to calculate fugitive emissions, which substance flows actually occur in the installation, and which substance flows are relevant or can be disregarded for the reduction scheme.

### 5.5.1 Application of the indirect fugitive-emissions calculation method

As mentioned above, fugitive emissions can be calculated using either a direct method or an indirect method.

**The direct method is more useful for obtaining a general overview of the fugitive emissions** than for the actual calculation thereof since the consequent substance flows are difficult to calculate in an operational setting. For example, measurement and calculation of fugitive emissions

emanating from windows, doors and similar opening is an extremely complex process using the direct method.

Hence the indirect method is used instead, since it allows for a simpler substance flow measurement, calculation and determination process, particularly for installations in which substance flow data is available. In order to use the indirect method the following input and output data must be available: I1, I2, O1.1, O1.2, O5, O6, O7, and O8. Substance flows O2, O3, O4 and O9 do not apply to this calculation and can therefore be disregarded. Accordingly, substance flows O2, O3, O4 and O9 do not have to be determined for total emissions (E) or solvent consumption (SC).

The substance flows that are required for emissions calculations and the solvent management plan are listed in Table 12. Hence, data need be calculated and gathered for these substance flows only.

<b>Substance flow that applies to the indirect method</b>	<b>Required for</b>
I1	<ul style="list-style-type: none"> <li>- Determination of solvent consumption (SC)</li> <li>- Determination of fugitive emissions (F)</li> <li>- Verification of compliance with the fugitive emissions limit value</li> </ul>
I2	<ul style="list-style-type: none"> <li>- Verification of compliance with the fugitive emissions limit value</li> </ul>
O1.1	<ul style="list-style-type: none"> <li>- Determination of fugitive emissions F</li> <li>- Determination of total emissions E</li> </ul>
O1.2	<ul style="list-style-type: none"> <li>- Determination of fugitive emissions F</li> <li>- Determination of total emissions E</li> </ul>
O5	<ul style="list-style-type: none"> <li>- Determination of fugitive emissions F</li> </ul>
O6	<ul style="list-style-type: none"> <li>- Determination of fugitive emissions F</li> </ul>
O7	<ul style="list-style-type: none"> <li>- Determination of fugitive emissions F</li> </ul>
O8	<ul style="list-style-type: none"> <li>- Determination of fugitive emissions F and of solvent consumption</li> </ul>
Solids content	<ul style="list-style-type: none"> <li>- Determination of reference emissions and target emission</li> </ul>

Table 12: Substance flows to be applied for the indirect method

### 5.5.2 Determination of qualitative substance flow

A precise determination of actual inputs and outputs can help to reduce the large amount of data that the operator is required to gather.

The Ordinance stipulates that the substance flows constituted by purchased and input solvent (I1) and as a rule fugitive emissions in air (O4) are to be



measured for all types of installations that fall within the scope of the Ordinance. Other substance flows are to be measured in accordance with the type of activity and installation involved.

For example, substance flows I1 and O4 apply to painting/varnishing installations. Whether or not solvent is discharged into wastewater (substance flow O2) depends on the technology deployed, whether a wet process or dry filter is used to remove the solvent particles, and whether abatement equipment is in use. Waste gases that are discharged through a roof stack by means of a ventilation or blower system without the use of downstream abatement equipment fall into category O1.2 (untreated contained waste gases). If abatement equipment is in use, solvent content in contained waste gases (O1.1) and in eliminated or bound solvent (O5) is to be determined. End product solvent load (O3) is generally negligible and should be estimated accordingly. Substance flow O6 (waste such as cleaning cloths, paint/varnish sludge, old paint and varnish) that occurs in installations is also to be included in the qualitative substance flow calculation. The criterion for the presence of substance flows I2 and O8 is that solvent is recovered within the installation. Substance flow O7 (as a product) does not apply to painting/varnishing installations.

Qualitative substance flows can be determined using the kind of simple table shown below. However, this table encompasses only the most prevalent painting and varnishing scenarios that apply to specific industries, coating techniques, solvents and preparations, and should be fleshed out as needed to reflect actual applications in a specific installation.

Stoffstrom Substance flow	Code designation	Scenario	Substance flow present?
I1	purchased and used	purchased and used	in every instance
I2	recovered, used in the same process	internal solvent processing	
		internal paint/varnish recycling	
O1.1	in scrubbed gas	abatement equipment	
O1.2	in untreated contained waste gases	ventilation systems; contained discharge with no downstream abatement equipment	
O2	in wastewater	particles removed using a wet process	
O3	residue in product	quantity of organic solvent that remains in an end product as residue or contaminant and is thus only discharged upon leaving the installation. upon discharge from the	

Stoffstrom Substance flow	Code designation	Scenario	Substance flow present?
		installation	
O4	fugitive emissions in air	through doors, windows, vents etc.	in every instance
O5	eliminated/bound	abatement equipment	
		wastewater treatment systems	
O6	in waste	non-evaporated solvent; non-hardened paint, varnish or other coatings	
O7	as an end product	sale or distribution of solvent alone or in preparations	
O8	recovered, stored	internal solvent processing or varnish/paint recycling; storage following the conclusion of the current solvent management plan period	
O9	miscellaneous	in exceptional cases	

Table 13: Table for determination of qualitative substance flows in painting/varnishing installations

The results of a study of qualitative substance flows in a number of SME wood coating installations are summarized in Table 14. The study gathered data from spray coating installations that realize (to one degree or another) wet removal processes, waste gas discharge through roof stacks, coating via immersion coating, coating via robots, paint/varnish recycling and/or roller application. Substance flows O1.1, O5, O7, O8 and O9 were excluded from the calculations for all of the installations studied since these installations are not required to gather or calculate data for these types of outputs.

Installation	I1	I2	O1.1	O1.2	O2	O3	O4	O5	O6	O7	O8	O9
Installations A and B	x	-	-	x	-	-	x	-	-	-	-	-
Installation C	x	-	-	x	-	-	x	-	x	-	-	-
Installation D	x	x	-	x	-	-	x	-	x	-	-	-
Installation E	x	-	-	x	x	-	x	-	x	-	-	-
Installation F	x	x	-	x	x	-	x	-	x	-	-	-
Installation G	x	-	-	x	-	x	x	-	x	-	-	-

Table 14: Substance flows in wood coating installations

The table provides some indication as to the substance flow types that are found in SME wood coating installations. However, this data does not necessarily apply to all such installations since it cannot be stated with certainty that specific activities are generally associated with certain

substance flows. For example, Table 14 clearly shows that the substance flows in the installations investigated studied may differ according to the type of painting/varnishing system, coating application method and abatement equipment used. These parameters could also differ depending on the type of product being manufactured and the size of the operation. Consequently, qualitative substance should be determined for each individual installation.

### **5.5.3 Relevance of substance flows for the solvent management plan**

As previously mentioned, elaboration of a solvent management plan can be simplified by estimating the relevance of individual inputs and outputs for various activities, while substance flows that are of minor relevance to the solvent management plan can be disregarded. A table elaborated on the basis of the results of an Austrian study [7] shows the activities that fall within the scope of the solvent ordinance and the substance flows that are associated with these activities. This table shows that there are such wide differences within individual areas of activity that any attempt to formulate generalizations regarding the relevance of substance flows would simply be misleading. Hence, substance flows must be assessed on a case by case basis for each installation.

This constraint notwithstanding, an attempt will be made here to gauge the relevance of substance flows for the solvent management plan since rules of thumb can be useful for the realization of overall estimates or for assessing data plausibility.

In the analysis that follows, relevance was assessed primarily on the basis of (a) the percentage of solvent relative to solvent input and (b) average prevalence of a particular substance flow in and for a specific installation and activity, i.e. whether the substance flow occurs with average or below average frequency. Substance flows whose solvent content is less than 2% of input (I1) were disregarded. However, these disregarded flows are **not** to be excluded from the solvent management plan and **are** to be counted as fugitive emissions in air (O4).

#### **Hypothetical case study of a wood coating installation:**

This wood coating installation uses a wet process to remove coating solids from waste gases. The resulting process water is fed into a treatment system in which the coating solids are precipitated out and sedimented. Circulation within the system induces the release of volatile organic compounds via the surface of the water, and only the soluble organic

substance (e.g. glycol) remains in the wastewater. An analysis of the water in the system showed that wastewater solvent content was generally in the per thousand range, and only reached a 2% (at a maximum) in isolated cases [8]. If the approximately 5 m<sup>3</sup> of process water is replaced annually, in the worst case scenario output O2 amounts to 100 liters of solvent per year, which works out to about 1% with annual solvent input of 10 tons. Under normal conditions, less than 50 liters of solvent are discharged annually via the process water. Hence O2 can be omitted from the solvent management plan in this case.

In operational settings, it frequently occurs that waste such as old paint and varnish, empty containers with solvent residues, or cleaning cloths are left in the open for so long that the substances in or on them hardens and the solvent volatilizes. Since such waste contains only negligible amounts of solvent, output O6 can be omitted from the solvent management plan. However, in the interest of achieving emission reduction, such items should be kept in closed containers whenever possible.

A study of the wood coating sector revealed that substance flows O1.1, O5, O7 and O8 generally do not occur in this sector (see Table 14) and that therefore data need only be gathered for substance flows I1, I2, O1.2 and O6. Moreover, since output O1.2 is counted as fugitive emissions in air (O4)<sup>32</sup>, only substance flows I1, I2 and O6 remain to be measured. A study of small installations showed that in some cases waste that contains solvent (O6) is stored in the open, with the result that most of the solvent volatilizes and the residual quantity is too small to be included in the solvent management plan. It was also found that relatively few installations recover solvent, which means that input I2 can generally be disregarded, leaving only substance flow I1 to be calculated. It is safe to assume that 100% of the solvent input at such installations is discharged as fugitive emissions, which means that the scope of solvent input and output measurement and calculation in such instances is greatly reduced. The process of determining fugitive emissions (F) is greatly simplified in such cases since the quantity of input and output is essentially the same.

### **Case study from the vehicle refinishing sector**

The substance flows in an installation can be inventoried using a table such as the one shown below (Table 15), which illustrates how the relevance of the substance flows in an installation can be assessed. The higher the

---

<sup>32</sup> Cf. footnote in no. 9.2.2 Annex III, German Solvent Ordinance (31. BImSchV)

estimated level of fugitive emissions (F) generated by a substance flow, the more relevant the flow is for the solvent management plan.

Subst ance flow	Code designation	Scenario	Presen t?	Rele vant ?	Included in the solvent management plan?
I1	purchased and used	Purchase of the following products containing organic solvent: coatings and auxiliary materials; fillers; cleaning and process substances; silicone and tar removers; hardeners; spray nozzles; finishing and other polishes; paint cleaner; rim cleaners	in every instanc e	+++	no
I2	recovered, used in the same process	organic solvent recovered via internal distillation of cleaning agents		++	
O1.1	in scrubbed gas	abatement equipment		+ <sup>1)</sup>	
O1.2	in untreated contained waste gases	untreated contained waste gases count as fugitive emissions	in every instanc e	+++	yes (under O4)
O2	in wastewater	wet-process removal; applicator cleaning using wet cleaning agents		+	
O3	residue in product	varnish or paint residues,		+	
O4	fugitive emissions in air	uncaptured emissions from doors, windows etc.	in every instanc e	+++	no
O5	eliminated/bound	abatement equipment or wastewater treatment systems		+ <sup>1)</sup>	
O6	in waste	The following types of waste: residual paint, paint/varnish sludge, coagulated paint/varnish, containers whose products contain solvent, polish residues, distillation sludge, solvent contaminated by implement cleaning, cleaning cloths		++	

Subst ance flow	Code designation	Scenario	Presen t?	Rele vant ?	Included in the solvent management plan?
O7	as an end product	the following products that are sold and contain solvent: mixed paint in cans for individual customers, various retail sprays and cleaning agents		+	
O8	recovered, stored	internal distillation of paints and cleaners, activated charcoal regeneration		++	
O9	miscellaneous	accidents		+ <sup>2)</sup>	

+ = minor relevance, ++ = moderately relevant, +++ = extremely relevant

<sup>1)</sup> in isolated cases only <sup>2)</sup> in exceptional cases only

Table 15: Substance flows for vehicle refinishing installations

As a rule, substance flows (e.g. I1, O1.2, and O4) are deemed to be highly relevant (++++) when they are present in an installation and play a substantial role in the solvent management plan (output O1.2 is included under fugitive emissions for vehicle refinishing activities and does not have to listed separately).<sup>33</sup>

Substance flows are deemed to be moderately relevant (++) when they are present but do not occur in sufficiently large quantities to have a major impact on the approximate calculation of fugitive emissions (F). I2, O6 and O8 mainly come into play in this regard.

Substance flows are deemed to be of minor relevance either when they occur in such low amounts that they account for less than 2% of solvent input, or when the substance flows of interest rarely occur in most installations that realize the type of activity of interest.

If the approximate fugitive or total emission calculation yields a value that is roughly the same as the applicable threshold value, the less relevant substance flows are then applied so as to obtain a more accurate calculation.

Outputs O2, O3 and O7 are of minor relevance for vehicle refinishing installations since they account for less than 2% of solvent input. Outputs

<sup>33</sup> Cf. Annex III(5.1.2), German Solvent Ordinance (31. BImSchV)

O1.1 and O5 only occur in the presence of abatement equipment, which is only found in vehicle refinishing installations where such equipment is required in order to counteract odor problems. Hence, these outputs are of minor relevance. Output O9 is likewise of minor relevance and is only to be inventoried if solvent is released via a miscellaneous pathway (e.g. adventitious release).

When only extremely relevant (+++) substance flows are counted for a vehicle refinishing installation, total emissions and solvent input are to be regarded as reciprocally equivalent.

Only output O9 can be disregarded for all types of activities since this type of output only occurs in rare cases (e.g. in case of adventitious release).

#### **5.5.4 Summary**

The information presented in the foregoing sections (5.51-5.53) shows that for reasons of plausibility, inventorying of certain substance flows can be dispensed with when the solvent management plan is elaborated.

For example, if the indirect fugitive emission (F) auditing method is used, substance flows O2, O3, O4 and O9 can be disregarded. Table 12 shows the required substance flows for inventorying fugitive or total emissions using the indirect method.

If a qualitative substance flow assessment subsequently reveals that any input or output listed in Table 12 is absent from the installation, the attendant substance flows are exempt from measurement. If the remaining inputs and outputs are factored into the solvent management plan, the number of substance flows can be reduced anew, until only input I1 remains, at which point the calculated values for total emissions and solvent input should be the same.

### **5.6 Inventorying and computing data**

Insofar as possible, the solvent management plan should be based on existing data that is both plausible and transparent. However, historical data or mean values can be used to calculate input and output (e.g. mean emissions generated by surface cleaning realized on washing tables using a type A III cleaner [9]; efficiency of abatement equipment and wastewater treatment systems; distillation sludge solvent content). Where data pertains to a value range (e.g. 10-40% solvent content in distillation sludge), the numerical concentration is always to be applied that would constitute the

worst-case scenario, i.e. that would yield the highest possible total or fugitive emissions. This is generally the lowest numerical value.<sup>34</sup>

*Practical example 1: The solvent is discharged from the internal solvent recovery system as waste, along with the distillation sludge (substance flow O6). The solvent content of the distillation sludge ranges from 10-40%. The concentration is to be applied to the solvent management plan that would result in the lowest amount of solvent in waste and the largest amount of solvent in waste gases (in this case 10%).*

*Practical example 2: Abatement equipment efficiency is estimated to range from 80-90%. Here too, the arithmetic concentration is to be applied that would yield the highest level of fugitive or total emissions.*

Data is to be gathered regarding solvent input and output in preparations, as well as solids content in coatings.

The data can then be entered in a table or in an Excel or other spreadsheet program for purposes of calculation. The advantage of the spreadsheet program is that the various items can be tabulated, the quantity of solvent in each preparation can be determined, liters can be converted to kilograms, and fugitive/total emissions can be calculated quickly and accurately.

The spreadsheet program also allows for the evaluation of various scenarios, such as the following: What impact does the use of water-based rather than solvent-based stain, or the use of a coating containing 50% rather than 75% solvent, have on solvent input?

The table below summarizes the data computation options for inventorying input, output and solids.

---

<sup>34</sup> Any operator that does not wish to base their solvent management plan on the worst-case scenario is required to tabulate the applicable data for their installation and submit evidence supporting the plausibility of this data.



Subst ance flow	Code designation	Basis for inventorying and computation
I1	purchased and used	Invoice; delivery note; DIN safety sheet (concentration and solvent content data); supplier list showing annual quantities purchased; solvent content; list showing baseline and final warehouse inventory during the solvent management plan period; manufacturers' product information
I2	recovered, used in the same process	Company documentation of quantities of recovered solvent; flowmeter data; in some cases estimated values with explanatory annotations
O.1	in contained waste gases	Computation ( $O1 = O1.1 + O1.2$ , depending on which Annex III requirements apply)
O1.1	in scrubbed gas	Measurement protocol
O1.2	in untreated contained waste gases	Measurement protocol
O2	in wastewater	Wastewater assays pursuant to VGS (law on discharge of hazardous substances), calculation, wastewater fee statement (Abwassergebührenbescheid)
O3	residue in product	Measurement readings from product; calculations
O4	fugitive emissions in air	Reference data (workstation assessments, hazard assessments etc.)
O5	eliminated/bound	Measurements of raw and scrubbed gas, calculations regarding efficiency of abatement equipment and wastewater treatment system for worst case scenario
O6	in waste	Certificate of disposal (Entsorgungsnachweisscheine), certificate of transfer (Übernahmescheine), waste disposal fee statement (Abfallgebührenbescheide), invoices, hazardous waste compliance audits (Deklarationsanalysen), plausible estimates, calculations, weight calculations, historical or estimated operational data with explanatory annotations
O7	in end product	Solvent content in each product, formulas, operational records/documentation, production lists, quantity tabulations/computations based on invoices issued
O8	recovered, stored	Baseline and final inventory lists, operational records, throughput measurements
O9	miscellaneous	Audits and calculations
	solids content	DIN safety sheet; list of suppliers; technical data sheets; data from manufacturers; data from internet; <i>Wissensspeicher lösemittelarme Produkte</i> [10]

Table 16: Allowable sources of input, output and solids content data

### 5.6.1 Input

Input data can generally be computed on the basis of invoices, delivery notes, materials management software, DIN safety sheets, and, if solvent is recovered for reuse, the relevant documentation.

Experience has shown that upon request, many vendors will willingly provide operators with the data they need regarding the quantities of coating purchased during a specific solvent management plan period as well as solvent and solids content. Many manufacturers and suppliers are coming to regard this service as part of customer service and as an effective customer loyalty tool.

Invoices and delivery notes contain information regarding the quantities of solvent or solvent preparation the operator has purchased. These quantities are expressed either in liters or in kilograms. If the quantities are given in liters, they are to be converted to kilograms or tons.

If materials management software is used, input (quantity of solvent plus solvent in preparations) is to be determined for the baseline and final inventories of these products during the relevant solvent management plan period.

Recent safety data sheets are excellent sources of information regarding product formulas, density and solids content, as well as other information. Some manufacturers make their safety data sheets available for download on their websites as PDF files. If the manufacturer does not provide solvent and solids content information, the operator is required to request this information from the manufacturer.

The tables below show how input data can be inventoried and computed. In Table 17 (an Excel worksheet) the gray fields are write-protected so as to prevent any adventitious changes from being made. This table was elaborated and piloted mainly for wood and wood materials coating installations, but it can also be applied in other settings such as installations that coat metal or plastic surfaces.

<b>Firma:</b>						<b>Telefon:</b>				<b>Beschäftigte:</b>					
<b>Adresse:</b>						<b>Fax:</b>									
<b>Anlagen/Kostenstelle:</b>															
<b>Bilanzzeitraum:</b> <b>bis</b>															
<b>Kontakt:</b>															
<b>Lieferant:</b>															
<b>Nr.</b>															
<b>Tätigkeit:</b>															
<b>Verfahren:</b>															

Material	SDB vor- han- den?	Produkt- bezeichnung	Artikel- Nr.	Art der Anlage	Waren- ein- gang	Lagerbestand		Ver- brauch ltr./kg	Dichte g/cm³	Ver- brauch kg	Lös- mittel		enth. Fest- stoffe		R- Satz	
						01.01.	31.12.				%	kg	%	kg		
Beize																
Grundierung																
Härter																
Lack																
Spachtel																
Verdünnung																
Wachs																
Wasserlack																
<b>Summe I/1</b>					<b>0,0</b>	<b>0,0</b>	<b>0,0</b>			<b>0,0</b>		<b>0,0</b>		<b>0,0</b>		
Wasserlack		Recycling														
Grundierung		Recycling														
<b>Summe I/2</b>					<b>0,0</b>	<b>0,0</b>	<b>0,0</b>			<b>0,0</b>						
<b>Summe I</b>					<b>0,0</b>	<b>0,0</b>	<b>0,0</b>			<b>0,0</b>						

Table 17: Example showing how an Excel worksheet can be used to compile and compute coating data

Material	Product designation	Installation	Input [l]	Density* [g/l]	Input [kg]	Solvent quantity	
						[%]	[kg]
Baseline inventory quantity:		01.01.99					
AIII cleaner	Isododecane	Vacuum installation	200	0,75	150,0	100	150,0
					0,0		0,0
					0,0		0,0
						Summe	150,0
Final inventory quantity:		31.12.99					
AIII cleaner	Isododecane	Vacuum installation	400	0,75	300,0	100	300,0
					0,0		0,0
					0,0		0,0
						Total	300,0
Purchased quantities:							
AIII cleaner	Isododecane	Vacuum installation	600	0,75	450,0	100	450,0
					0,0		0,0
					0,0		0,0
						Total	450,0
<b>Input I/1</b>							<b>300,0</b>

\*The densities and percentages for solvent content from the DIN data safety sheet are to be used.

Table 18: Compilation of input I1 data for surface cleaning and dry cleaning

Material	Recycled material	Installation	Distillation throughput [l/h]	No. of operating hours [h/d]	No. of operating hours [d/y]	Recycled material [l/y]	Density [g/l]	Total quantity [kg]
AIII cleaner	Isododecane	Vacuum installation	100	16	220	352000,0	0,75	264000,0
						0,0		0,0
						0,0		0,0
<b>Input I/2</b>								<b>264000,0</b>

Table 19: Compilation of input I2 data for surface cleaning and dry cleaning

Tables 18 and 19 show how data can be compiled for inputs I1 and I2 in surface cleaning and dry cleaning installations. 100% solvent is generally used in these installations. Solvent content computation for some preparations such as impregnation or stain removal products in dry cleaning installations can be dispensed with since the solvent content of these products is generally negligible relative to total solvent input. In addition, only solvent that is added during the solvent management plan period for purposes of topping off solvent tanks is counted.

### 5.6.2 Output

Output data can be computed on the basis of operational documentation, certificates regarding waste disposal, measurement protocols for waste gas and wastewater analyses, manufacturer, waste disposal provider or recycler data, and materials management software.

No data for outputs O2, O3, O4 or O9 need be compiled when the indirect fugitive emission (F) computation method is used. Accordingly, the operator can compile data pertaining to residual solvent for these substance flows at his discretion.

#### Output O1 (contained waste gases)

Output O1 consists of the sum of outputs O1.1 and O1.2, providing that the latter is not counted as a fugitive emission (F).

#### Output O1.1 (in scrubbed gas)

This output is deemed to be present only if the installation has abatement equipment or is hooked up to such equipment by physical or technical means. Installations subject to authorization are generally outfitted with

abatement equipment, whereas installations not subject to authorization only have such equipment in special cases, e.g. in case of odor pollution.

Apart from the substances specified in section 3, numbers of operating hours and the attendant labor costs are not regarded as adequate evidence of solvent input for purposes of routine emission measurements. VOC emission levels are ascertained by measuring the composite parameter for total carbon using thin-layer chromatography or the FID method. This parameter indicates the concentration of organic compounds in waste gases expressed as organically bound carbon in mg C/m<sup>3</sup>.

Inasmuch as O1.1 is needed to compute fugitive or total emissions, the quantity of carbon has to be converted to its solvent equivalent. To do this, solvent input and the proportions thereof, or the solvent that is mainly input, must be computed. Finally the proportion (in molecular weight) of activated carbon in the computed quantity of solvent is to be ascertained and a conversion factor is to be elaborated. From this point on, solvent input for output O1.1 is ascertained by multiplying the computed quantity of activated carbon by the conversion factor.

Solvent	Conversion factor
Toluene	1.1
Ethylacetate	1.83
Butylacetate	1.6
Ethanol	1.92
Formaldehyde	2.5
50% ethylacetate/50% ethanol	1.87

Table 20: Conversion factors for total carbon

By applying the **differential method**, an approximated or rounded off variant of the value obtained for mass flow C in waste gas (carbon volume) can also be integrated into further calculations without converting the corresponding “solvent” value.

This method has no effect on the calculation of total emissions since solvent volume O1.1 is not needed in this case.

This method yields a higher diffuse emissions value than the value obtained when diffuse emissions are calculated using the converted solvent volume

This is because volume C is always a lower value than that obtained when the solvent value is converted. If the lesser volume of solvent consumption obtained from the diffuse emissions equation ( $F = I1 - O1 - O3 - \dots$ ) is subtracted, a higher value for diffuse emissions is obtained.

If this higher value is lower than the threshold value obtained as stipulated in Annex III, a conversion to “solvent” is not required.

Following is practical example of the procedure referred to above: The waste gases in a packaging rotogravure installation are treated via a post-combustion system. The waste gases are assumed to contain equal quantities of the solvents ethanol and ethylacetate. The mass flow in contained and treated waste gases (i.e. scrubbed gas) is 900 kg C/a.

Output O1.1 is ascertained as follows: In terms of molecular weight, the ethanol is 54.53% carbon and the ethylacetate is 54.53% carbon. The mean carbon content is 53.34%, which yields a conversion factor of 1.875.

If the mass flow of 900 kg C/year is multiplied by the conversion factor, the result is 1687.3 kg or approximately 1.7 tons of solvent/year.

#### **Output O1.2 (in untreated contained waste gases)**

Output O1.2 is to be calculated when fugitive emissions (F) are calculated using the indirect method and output O1.2 is not counted as a fugitive emission.

This method is also to be used to calculate enclosed waste gases ( $O1 = O1.1 + O1.2$ ) and total emissions ( $E = F + O1$ ) for output O1.2.

VOC emissions in untreated enclosed waste gases are to be calculated either via measurement followed by conversion or on the basis of the volumes captured by ventilation equipment and the load thereupon.

The following are to be ascertained for the solvent management plan:

- the quantities (I1) and identities (e.g. in inks or cleaning agents) of solvents that were used in the installation
- the proportion of this solvent that was disposed of as waste (O6)
- the quantities and identities of solvents used that were within containment range of the installation's ventilation system (e.g. Were implements cleaned within the containment range of the ventilation system, outside of it, or both?)
- the quantity of solvent that was captured by the ventilation system (containment gradient of the installation system and manufacturer's data in this regard)

#### **Output O5 (extirpated, bound)**

In order to calculate this output, data regarding the concentrations of raw and scrubbed gas is needed. If only the mass flow or only one

concentration value is known, output O5 can still be estimated on the basis of the elimination efficiency of the abatement equipment.

Practical example (cf. O1.1): The waste gases in a packaging rotogravure installation are treated via a post-combustion system. The mass flow in treated (scrubbed) gas is 900 kg C/a. According to the manufacturer, the nominal efficiency of the post-combustion system is 96-99%. No measurement value for raw gas mass flow upstream of the post-combustion system is available.

Raw gas mass flow is computed on the basis of the worst-case efficiency value, which is 96% in this case, since it cannot be assumed that abatement equipment always functions at peak efficiency. Thus, computed raw gas mass flow is  $(0.9 \text{ t C} / 4 \times 100) = 22.5 \text{ t C/year}$ . The quantity of dissolved organically bound carbon is ascertained by subtracting scrubbed gas from raw gas mass flow, which in this case is 21.6 t C/year. This value is then multiplied by the conversion factor for the ethanol ethylacetate solvent mixture (1.875), which yields the quantity of solvent (O5) oxidized by the post-combustion process annually (40.5 tons).

#### **Output 6 (in waste)**

This output is to be calculated on the basis of certificates of disposal (Entsorgungsnachweise), certificates of transfer (Übernahmescheine), waste disposal fee statements (Abfallgebührenbescheide), hazardous waste compliance audit reports (Deklarationsanalysen), and invoices from the waste disposal provider/recycler.

Solvent content in waste is difficult to measure accurately for two main reasons. First, the composition of materials such as paint/varnish sludge is determined by the coating system, coagulation method and batch of material used. Second, representative samples cannot be obtained from a mixture consisting of various batches of substances such as distillation or paint/varnish sludge because the waste is inhomogeneous.

Measurement of the content in waste of the numerous other unidentified solvents that are found in preparations is equally impractical. Hence, it is necessary to ascertain the content of specific solvents, which cannot be realized without knowing the composition of the preparations of interest. The composite parameter (TOC) cannot be used to determine solvent content owing to the presence of other organic compounds such as paint binders or pigments. Caloric value cannot be used to measure solvent content either, although it is frequently used to substantiate solvent content in hazardous waste compliance audits for waste disposal fee certificates.

Caloric values vary depending on the content of the mixture, e.g. alcohol yields a lower caloric value whereas an oil solvent mixture produces a higher value. Nor can a substance group classification system be used since this would omit from consideration some of the solvents of interest.

For all of these reasons, solvent content in waste is to be measured on the basis of historical or estimated values. This can be done in one of two ways: (a) specific waste from the installation is measured (in a manner that the competent authority can validate) by, for example, weighing cleaning cloths before and after the solvent has evaporated from them; or (b) on the basis of historical or estimated values for the industry of interest.

Since no precise historical or estimated values are available, the operator is to cite ranges of values instead, e.g. 19-80% solvent content in dry cleaning waste designated as distillation sludge (see Table below). In such cases, the figures used for the solvent management plan are to be those that would result in the highest emissions level. In the example given here, the estimated solvent content of distillation sludge for output O6 would be 19% rather than 80%.

The table below contains historical values for a series of activities:

Type of waste	Solvent content	Quantity per year	Quantity per ton of cleaned goods
Distillation sludge	19-80 [%]	180-740 l/y	13-25 l/t
Filter sludge	51-63[%]	-	-
Cartridges	-	100-650 kg/y	5-14 kg/t
Centrifugal filters	-	170-350 kg/y	17 kg/t*
Lint filter content	< 0,1 – 0,5[%]	7-24 kg/y	0.4-0.5 kg/t
Needle trap content	< 0,1 – 90[%]	1-4 kg/y	0,1 kg/t
Contact water	3 – 97[mg/l]	720-3600 l/a	24-88 l/t

\*Single value

Table 21: Solvent content in dry cleaning waste [11]

Type of waste	EWC code	Solvent [%]
Halogen-free sludge containing solvent	080106	15
Hardened paint and varnish	080105	2
Cleaning thinner	140503	85
Aqueous sludge containing paint or varnish	080108	30
Distillation sludge free of halogenated organic elements	140505	15

Table 22: Solvent content in waste generated by the coating of wood and wood materials pursuant to HDH (German wood and plastics processing industry association)/VdL (German paint and coatings industry association) [12, 13]



The data in the table below pertaining to solvent content in cleaning cloths is based on weight measurements that were realized by a number of coating installations and cloth cleaning companies at the behest of Bundesverband Druck und Medien (German Printing and Media Industries Federation).

Type of waste	Solvent content	Remarks
Hardened residues from the following processes:		residues not hardened
Heatset web offset	33%	
Illustration rotogravure	80%	
Packaging rotogravure	70%	
water-based	5 – 10%	
Flexography	70%	
water-based	5 – 10%	
Silk-screening	60 – 70%	
Sludge:		varies according to consistency
fluid	60 – 70%	
pasty	20 – 30%	
hard	10%	
Old detergents	90 – 95%	
Screen cleaning, component cleaning	85 – 90%	
Solvent and water mixture:		varies according to isopropyl alcohol content
Fountain solution residues	5 – 15%	
Residues from washing rubber blankets	30 – 50%	varies according to washing program
Cleaning cloths:		
offset printing	10-30 g/pc.	cleaning with aqueous solvent
	30-60 g/pc.	cleaning with solvent
Rotogravure	10-30 g/pc.	cleaning cloths vacuumed
	50-80 g/pc.	cleaning cloths not vacuumed

Table 23: Solvent content of printing waste

### Output O7 (as an end product)

This output can be determined on the basis of preparation formulas, invoices, manufacturing and materials management software and similar documentation. It has proven cost efficient in coating installations to determine output O7 by comparing the solvent content indicated by the manufacturer and the quantity of solvent in the end product.

### **Output 8 (recovered and stored)**

This output is determined on the basis of warehouse inventory lists or installation records.

#### **5.6.3 Solvent and solids content**

Older DIN safety sheets rarely contain information on the solvent and solids content of individual products, but this information is available from newer DIN safety sheets. However, problems can arise if the safety sheet fails to distinguish between organic solvent as defined by the Ordinance and other volatile organic compounds or water. In such cases, the operator should ask the manufacturer for additional information.

## 6 Practical examples

The aim of the practical examples that follow is to illustrate how solvent management plans as well as simplified and specific reduction schemes are elaborated.

### 6.1 Heatset web offset printing (activity 1.1)

In this example, the procedure for elaboration of a solvent management plan and a specific reduction scheme will be described. The data used here is derived from a study realized for the German government [15].

#### Short description of the installation

This company (an “existing installation”) mainly prints medium to high quality newspaper inserts using rotogravure technology.

The company has five duplex color presses that use solvent-based ink. The solvent-loaded waste gases are conducted to a post-combustion system.

Outputs O1.1 and O5 were determined on the basis of mean process data rather than actual measurements. This calculation was based on the assumption that approximately 98% of the solvent in the ink, 7.5% of the cleaning agents and approximately 10% of the isopropanol would be conveyed to the post-combustion system. The efficiency of the post-combustion system is known to be 99%.

The following table shows the computed input, its solvent content and the resulting solvent quantities.

Input	Input quantity	Density [g/cm <sup>3</sup> ]	Input [t/y]	Solvent content [%]	Solvent consumption t/y]	Solids content [%]	Solids consumed t/y]
Ink	80 t/y	ca. 1	80,0	ca. 30	24,0	ca. 70	56,0
Isopropanol	19,873 l/y	0,785	15,6	100	15,6	0,0	0,0
Cleaning agent	5,628 l/y	0,809	4,6	ca. 90	4,1	0,0	0,0
<b>Input I1</b>					<b>43,7</b>	<b>Solids</b>	<b>56,0</b>
Solvent recovered from cleaning agent	393.96 l/y	0,809	0,3	100	0,3		
<b>Input I2</b>					<b>0,3</b>		
<b>Input I</b>					<b>44,0</b>		

Approximately 1% of the 24 t/year of ink solvent remains in the product as high-boiling petroleum. Hence, output O3 is 0.24 t/year. Approximately 29% (1.2 t/year) of cleaning agent solvent is disposed of (output O6).

The VOCs (O1.2) emitted into the installation's ambient air and removed by a ventilation system count as fugitive emissions in this type of installation.<sup>35</sup>

Solvent management plan (indirect method):

Input		Output*	
I1	43.7 t/y	O1.1	0.25 t/y
I2	0.3 t/y	O1.2	counts as O4
		O3	0.24 t/y
		O5	25.1 t/y
		O6	1.2 t/y
		O7	0.0 t/y
		O8	0.0 t/y

\*O2, O4 and O9 are disregarded when the indirect method is used

Determination of solvent consumption (SC = I1 - O8):

$$SC = I1 = 43.7 \text{ t/y}$$

Since solvent input exceeds the 15 t/year threshold, the installation falls within the scope of the Solvent Ordinance and is subject to reporting requirements unless it already has authorization as required by the Ordinance.

Compliance with the emission limit value

According to the measurement report, use of the installed post-combustion system brings the installation into compliance with the 20 mg C/m<sup>3</sup> emission limit value for contained waste gas.

Compliance with the fugitive emission limit value

The statutory fugitive emission (F) limit value is 20% of solvent input for installations with input exceeding 25 t/year.

Inasmuch as output O3 does not count as fugitive emissions for heatset web offset printing,<sup>36</sup> it is to be subtracted from I1.

- ☐ Fugitive emission calculation using the indirect method: (F = I1 - O1.1 - O3 - O5 - O6 - O7 - O8):

$$F = 43.7 \text{ t/y} - 0.25 \text{ t/y} - 0.24 \text{ t/y} - 25.1 \text{ t/y} - 1.2 \text{ t/y} - 0.0 \text{ t/y} - 0.0 \text{ t/y} = 16.91 \text{ t/y}$$

---

<sup>35</sup> See Annex III(1.1.2) sentence 1, German Solvent Ordinance (31. BImSchV)

<sup>36</sup> See Annex III(1.1.2) sentence 2, German Solvent Ordinance (31. BImSchV)

- Calculation of the proportion of fugitive emissions in solvent input ( $x = F * 100 / (I1 + I2)$ ):

$$x = 16.91 \text{ t/y} * 100 / (43.7 \text{ t/y} + 0.3 \text{ t/y}) = 38.4\%$$

The installation exceeds the fugitive emission limit value of 20% of solvent input.

### Reduction scheme

In this case the installation operator is entitled to implement a reduction scheme in lieu of compliance with emission limit values. This involves the following:

- Determination of the annual reference emission:

Reference emission = (tons of solids/y) \* (multiplication factor)

$$\text{Reference emission} = 56.0 \text{ t/y} * 1 = 56.0 \text{ tons of solvent/year}$$

- Determination of target emission as at Nov. 1, 2007 (for existing installations):

Target emission = reference emission \* percentage

$$\text{Target emission} = 56.0 \text{ t/y} * (30 + 5)\% = 19.6 \text{ tons of solvent/year}$$

- Determination of maximum allowable emission as at Jan. 1, 2005 (for existing installations):

$$\text{Target emission} * 1.5 = 19.6 \text{ tons of solvent/year} * 1.5 = 29.4 \text{ tons of solvent/year}$$

- Documentation of actual total emissions ( $E = F + O1.1$ ):

$$E = 16.91 \text{ t/y} + 0.25 \text{ t/y} = 17.16 \text{ t/y}$$

- In this case, the operator is not required to calculate an emissions reduction requirement since the installation is in compliance with the reduction scheme

Result: The installation is not in compliance with the fugitive emission limit value of 20%. However, under a reduction scheme applied as at mid-2005, the installation would not exceed the target emission, which means that the target emission for heatset offset printing as determined under the reduction scheme is higher than that specified in Annex III of the

Ordinance. This discrepancy is attributable to the fact that the multiplication factor for calculation of the reference emission was set too high. An Institute for Environmental Strategies (Ökopol) study of VOC emissions reduction in heatset offset printing installations calculated a multiplication factor of 0.65 for this type of installation [15].

## 6.2 Other printing activities apart from rotogravure (activity 1.3)

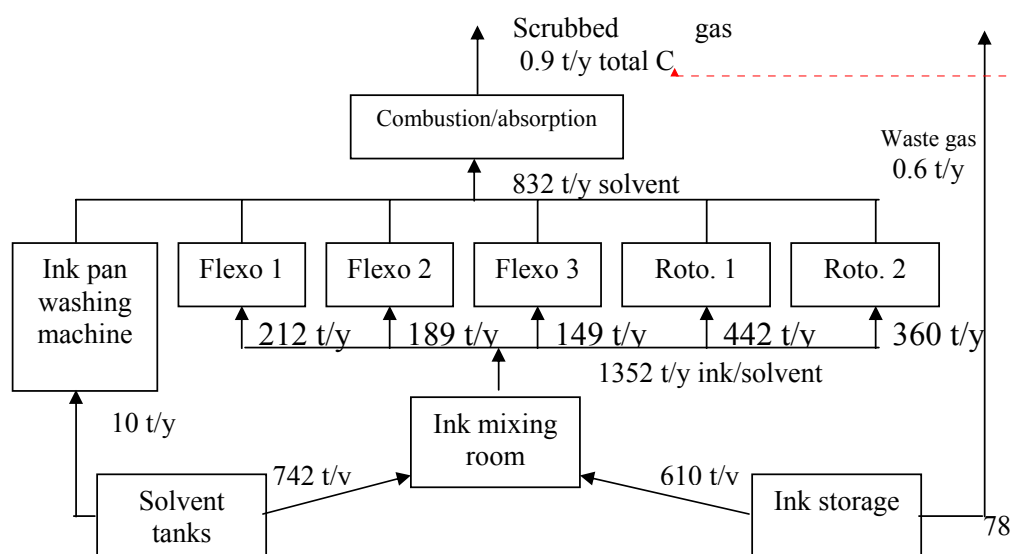
### Practical example 1: packaging printing [16]

This example describes (a) the procedure whereby the solvent management plan is used to verify compliance with emission limit values and (b) the application of a specific reduction scheme.

The installation in this example has three flexography presses and two rotogravure presses that are used for packaging printing. Waste gas scrubbing is realized by means of absorption and a downstream post-combustion system.

The procedure illustrated in Figure 17 is recommended for compiling and computing the relevant data.

Input I1 was determined by compiling data from material consumption lists of ready to use inks employed, as well as supplementary solvent consumption data based on volumetric measurements as determined by a counter at the withdrawal point, and then comparing these data with purchasing data. The installation's flexography activities consume 550 tons of ink/year with solids content of approximately 17%, while 802 tons of ink/year with solids content of approximately 15% are used for rotogravure.



Formatiert: Schriftart: 12 pt, Englisch (Großbritannien)

Figure 17: Substance flows for a packaging printing installation

Input I2 is the quantity of solvent recovered from the absorption system and reused in the same process. 10 tons of this material are used per year to clean floors and presses, as well as in the ink pan washing machine.

Input I baseline data:

Press	Input, ready to use ink (t/y)	Solids content[%]	Solids [t/y]	Solvent [t/y]
Flexography press 1	212	17	36	176
Flexography press 2	189	17	32	157
Flexography press 3	149	17	25	124
Rotogravure press 1	442	15	66	376
Rotogravure press 2	360	15	54	306
<b>Total input I1</b>				<b>1139</b>
Ink pan washing machine				10
Cleaning floors and presses				10
<b>Total input I2</b>				<b>20</b>
<b>Total input I</b>				<b>1159</b>

Total annual carbon content in scrubbed gas is 0.9 t/year, which is then multiplied by a conversion factor<sup>37</sup> of 1.87 for a 1:1 mixture of ethanol and ethylacetate solvent. Hence, output O1.1 is 1.7 t/year.

To calculate O5, annual raw gas mass flow is computed on the basis of mass concentration of less than 5.0 g C/m<sup>3</sup> and volume flow of 15,000 m<sup>3</sup>/h and 6000 operating hours, and is then multiplied by the 1.87 conversion factor. This yields a figure of approximately 832 t/year, from which O1.1 (1.7 t/year) is subtracted, yielding O5 of 830.3 t/year.

The quantity of solvent in waste (O6) consists of 81 t/year of residual ink with a solvent content of approximately 17% (13.8 t/year), as well as 30 t/year of cleaning cloths generated by machine and floor cleaning with a solvent content of approximately 30% (9 t/year). Outputs O7 and O8 are disregarded.

<sup>37</sup> The conversion factor in Table 20

Solvent management plan (indirect method):

Input		Output*	
I1	1139.0 t/year	O1.1	1.7 t/year
I2	20.0 t/year	O1.2	counts as O4 <sup>38</sup>
		O5	830.3 t/year
		O6	22.8 t/year

\*O2, O3, O4 and O9 are disregarded when the indirect method is used

Solvent consumption (SC = I1 – O8):

In this case, solvent consumption is equal to input I1, i.e. 1,139 t/year. Thus, the installation is well over the threshold value specified in the Solvent Ordinance and in *Ordinance on the restriction of emissions of highly volatile halogenated hydrocarbons - 4. BImSchV* of  $\geq 15$  t/year and 25 kg/h. The installation is subject to authorization, which also fulfills the reporting requirement (i.e. the reporting requirement is waived).

Compliance with the emission limit value

The installation is in compliance with the  $< 20$  mg C/m<sup>3</sup> emission limit value for contained waste gases.

Compliance with the fugitive emission limit value

The statutory fugitive emission (F) limit value is 20% of solvent input for installations with input exceeding 25 t/year.

- ☐ Fugitive emission calculation using the indirect method:<sup>39</sup> ( $F = I1 - O1.1 - O5 - O6 - O7 - O8$ ):

$$F = 1139 \text{ t/year} - 1.7 \text{ t/year} - 830.3 \text{ t/year} - 22.8 \text{ t/year} - 0 \text{ t/year} - 0 \text{ t/year} = 284.2 \text{ t/year}$$

- ☐ Calculation of proportion of fugitive emissions in solvent input ( $x = F * 100 / (I1 + I2)$ ):

$$x = 284.2 \text{ t/year} * 100 / (1139 \text{ t/year} + 20 \text{ t/year}) = 24,5\%$$

The installation is non-compliant with the fugitive emission limit value of  $< 20\%$  of solvent input. This means that the operator is required to reduce

<sup>38</sup> See Annex III(1.3.2), German Solvent Ordinance (31. BImSchV)

<sup>39</sup> See Annex IV(2.2.1), German Solvent Ordinance (31. BImSchV)



fugitive emissions by upgrading installation encapsulation or by optimizing cleaning solvent handling methods. Following is an example of how compliance with the reduction scheme target emission can be verified in lieu of compliance with emission limit values.

#### Determination of solids content

Flexography: 550 t/year * 17% =	93.5 t/year
Rotogravure: 802 t/year * 15% =	120.3 t/year
Solids content of ink input:	213.8 t/year

#### Determination of target emission

Target emission = (Solids content \* multiplication factor)\* reduction factor  
 Target emission = 213.8 t/year \* 2.5 \* 0.25 = 133.6 t/year  
 Maximum allowable total emission as at 2005 = target emission \* 1.5 = 200.4 t/year

#### Determination of total emissions from the installation

$E = F + O_{1.1}$   
 $E = 284.2 + 1.7 = 285.9 \text{ t/year}$

Compliance with the reduction scheme is not achievable on the basis of the solids content computed above. Thus, emission reduction measures are required above and beyond those that have been realized to date via existing abatement treatment. Such measures include more efficient handling of cleaning solvents or switching to low-solvent inks.

### **Practical example 2: packaging printing [15]**

In this example, the procedure for elaboration of a solvent management plan and a specific reduction scheme will be described.

#### Short description of the installation

The installation (an “existing installation”) realizes rotogravure printing of packaging film. The installation operates seven rotogravure presses with a total of 38 printing mechanisms that use solvent-based ink. The solvent-loaded waste gases are conducted to abatement equipment.

Outputs O1.1 and O5 are determined on the basis of the mean data from a process in which 80% of the solvent from ink, 70% from varnish and

thinner/inhibitor and 10% from cleaning agents are captured, whereupon 95% of this solvent is combusted in the abatement equipment.

The following table shows the computed input, its solvent content and the resulting solvent quantities.

Input		All inputs [t/year]	Solvent content [%]	Solvent input [t/year]	Solids content [%]	Solids content [t/year]
Ink		1169,36	68,8	804,52	32,2	376,53
Printing varnish		359,23	60,0	215,54	40,0	143,69
Inhibitor		0,62	100,0	0,62	-	-
Thinner	Ethylacetate	1074,94	100,0	1074,94	-	-
	Ethanol	340,19	100,0	340,19	-	-
	Benzene	18,23	100,0	18,23	-	-
	Ethoxypropanol	14,81	100,0	14,81	-	-
	n-Butanol	5,08	100,0	5,08	-	-
	Isopropylacetate	2,21	100,0	2,21	-	-
	Isopropanol	0,60	100,0	0,60	-	-
Cleaning agent	Ethylacetate	268,73	100,0	268,73	-	-
	Ethanol	85,05	100,0	85,05	-	-
<b>Input I1</b>				<b>2830,52</b>		<b>520,22</b>
Recovered solvent	recovered from contaminated solvent	88,00	100,0	88,00		
<b>Input I2</b>				<b>88,00</b>		
<b>Input I</b>				<b>2918,52</b>		

The following table shows the computed input, its solvent content and the resulting solvent quantities.

Waste	Solids [t/year]	Solvent content [%]	Solvent input [t/year]
Paint and varnish	100,0	ca. 66,7	<b>66,7</b>
Total mixed solvent, of which	144,0	100,0	<b>144,0</b>
<input type="checkbox"/> thinner and inhibitor	ca. 104,0	100,0	104,0
<input type="checkbox"/> cleaning agent	ca. 40,0	100,0	40,0
<b>Output O6</b>			<b>210,7</b>

#### Solvent management plan (indirect method):

Input		Output*	
I1	2,830.5 t/year	O1.1	92.5 t/year
I2	88.0 t/year	O1.2	counts as O4 <sup>40</sup>

<sup>40</sup> See Annex III(1.3.2), German Solvent Ordinance (31. BImSchV)

		O5	1,757.1 t/year
		O6	210.7 t/year
		O7	-pq
		O8	-

\* O2, O3, O4 and O9 are disregarded when the indirect method is used

#### Determination of solvent consumption (SC = I1 - O8):

$$SC = I1 = 2830.52 \text{ t/year}$$

The input exceeds the 15 t/year threshold value, which means that the installation falls within the scope of the Ordinance. Since the installation's > 25 kg/h solvent consumption renders it subject to authorization pursuant to BImSchG, its reporting requirements are fulfilled.

#### Compliance with the emission limit value

In this example, it is assumed that the installation is in compliance with the 20 mg C/m<sup>3</sup> emission limit value for contained waste gases.

#### Compliance with the fugitive emission limit value

The statutory fugitive emission (F) limit value is 20% of solvent input for installations with input exceeding 25 t/year.

- ☐ Fugitive emission calculation using the indirect method:<sup>41</sup> (F = I1 - O1.1 - O5 - O6 - O7 - O8):

$$F = 2830.52 \text{ t/year} - 92.5 \text{ t/year} - 1,757.1 \text{ t/year} - 210.7 \text{ t/year} - 0 \text{ t/year} - 0 \text{ t/year}$$

$$F = 770.22 \text{ t/year}$$

- ☐ Calculation of the proportion of fugitive emissions in solvent input (x = F \* 100 / (I1 + I2)):

$$x = 770.22 \text{ t/year} * 100 / (2830.52 \text{ t/year} + 88.00 \text{ t/year}) = 26.4\%$$

The installation exceeds the fugitive emission limit value of 20% of solvent input.

- ☐ Calculation of total emissions (E = F + O1.1):

$$E = 770.22 \text{ t/year} + 92.5 \text{ t/year} = 862.72 \text{ t/year}$$

<sup>41</sup> See Annex IV(2.2.1), German Solvent Ordinance (31. BImSchV)

### Reduction scheme

The installation operator is entitled to implement a reduction scheme in lieu of compliance with emission limit values. This involves the following:

- ☐ Determination of the annual reference emission:

Reference emission = (tons of solids/y) \* (multiplication factor)<sup>42</sup>

Reference emission = 520.22 t/y \* 2.5 = 1300.55 tons of solvent/year

- ☐ Determination of target emission:

Target emission = reference emission \* percentage

Target emission = 1300.55 t/y \* (20 + 5)% = 325.14 tons of solvent/year

- ☐ Determination of maximum allowable total emission for 2005:

Target emission \* 1.5 = 325.14 t/year \* 1.5 = 487.71 tons of solvent/year

- ☐ Determination of minimum reduction requirement

Reduction = current total emission E – target emission

Reduction by 2005 = 862.72 t/year – 487.71 t/a = 375 t of solvent/year

Reduction by 2007 = 862.72 t/year - 325.14 t/a = 537.58 t of solvent/year

The operator can realize one of the following courses of action:

- ☐ Reduce fugitive emissions by approximately 185 tons through the implementation of technical measures such as retrofitting washing systems and stations with abatement equipment, as well as organizational measures, so as to comply with the 20% limit value.
- ☐ Realize measures such as changing manufacturing methods and training staff to handle solvent preparations more efficiently, so as to limit emissions to the levels specified in the reduction scheme and achieve a solids content reduction of approximately 540 tons below that given in the present example and above and beyond that achieved by existing abatement equipment.
- ☐ Switch to low-solvent preparations for all production processes, which would automatically reduce solvent consumption.

---

<sup>42</sup> See column 3 of Table in Annex IV(B)(2), German Solvent Ordinance (31. BImSchV)

### 6.3 Surface cleaning (activity 2.1)

Surface cleaning installations can be small cleaning receptacles, cleaning tables or open or closed cleaning installations. The solvents used in such installation include hydrocarbons, alcohols, ketones, esthers, cleaning oils, plant-based esters and mixtures of the foregoing [17].

The present example describes the procedure for elaboration of a solvent management plan. Since the Solvent Ordinance does not specify a dedicated reduction scheme for this type of activity, the operator is entitled to elaborate any type of reduction scheme desired, providing that he ensures and proves that the installation's solvent emissions are as low as they would be if the installation complied with the applicable emission limit values.

#### Short description of the installation

The installation is an intermittently operated vacuum installation that cleans the surfaces of stamped stainless steel, iron, and non-ferrous metal components for cars, household appliances and electrical products using a working chamber volume of 0.7 m<sup>3</sup>. A non-halogenated hydrocarbon solvent (isododecane) is used. The vacuum cleaning machine holds 550 l of solvent (a 200 l tank for clean solvent, a 200 l tank for contaminated solvent, and 150 l in the distillation unit). Contaminated solvent is distilled continuously at a throughput of 100 l/h and in two work shifts.

The extent of solvent contamination is determined by the quantity of oil that is carried over within the process cycle. The solvent is changed after each approximately 1200 component baskets are cleaned. The solvent is replaced about eight times yearly, but only the distillery is emptied and refilled, i.e. 8 x 150 l annually.

The following table shows the computed input, its solvent content and the resulting solvent quantities.

Material	Product name	Installation	Input [l]	Density* [g/l]	Input [kg]	Solvent quantity	
						[%]	[kg]
Baseline inventory quantity:		01.01.99					
AIII cleaner	Isododecane	Vacuum installation	200	0,75	150,0	100	150,0
Final inventory quantity:		31.12.99					
AIII cleaner	Isododecane	Vacuum installation	400	0,75	300,0	100	300,0
Purchased quantities:							
AIII cleaner	Isododecane	Vacuum installation	1800	0,75	1350,0	100	1350,0
Input II							1200,0

\*The densities and percentages for solvent content from the DIN data safety sheet are to be used.

Material	Distillation throughput [l/h]	Operational hours [h/d]	Operational days [d/y]	Recovered solvent [l/y]	Density [g/l]	Total amount [kg]
Contaminated isododecane	100	16	220	352000	0,75	264000
<b>Input I2</b>						<b>264000</b>

The operator estimates that the distillation residue is composed of approximately 40% oil. No analysis was conducted to determine exact oil and solvent content. In the interest of simplicity, the density of 1 g/cm<sup>3</sup> was used to calculate solvent content in waste. Hence, output O6 is 0.72 t/year.

Outputs O1.1 and O5 are disregarded in this case since the solvent that is blown out of the working chamber at the conclusion of the cleaning process is removed via condensation, is conducted back into the process cycle and is not extirpated or bound.

The waste gases from the abatement system are counted as fugitive emissions since they escape into the ambient air of the facility before being discharged via the roof stack.

Outputs O7 and O8 are not present in this case.

#### Solvent management plan (indirect method):

Input		Output*	
I1	1.2 t/year	O1.1	Not applicable
I2	264.0 t/year	O1.2	Not applicable
		O5	Not applicable
		O6	0.72 t/year
		O7	Not applicable
		O8	Not applicable

\* O2, O3, O4 and O9 are not computed when the indirect method is used

#### Determination of solvent consumption (SC = I1 - O8):

$$SC = I1 = 1.2 \text{ t/year}$$

Input exceeds the 1 t/year threshold value; thus the installation falls within the scope of the Ordinance and is subject to reporting requirements.

### Compliance with the emission limit value

No measured emission values for untreated contained waste gases (O1.2) are available. The Ordinance does not require verification of emissions levels in organic solvent installations for purposes of immissions control.

A recent study of techniques for the reduction of VOC emissions in surface cleaning installations [9] showed that output from an enclosed vacuum cleaning machine exceeds the mandated 75 mg C/m<sup>3</sup> VOC emission limit value. Inasmuch as these machines represent the best available technique, it seems warranted to classify as fugitive emissions those emissions from installations that consume less than 10 t/year of solvent, that escape into the production facility from the machine and that are then discharged as untreated contained waste gas, insofar as this procedure is allowable under workplace safety laws

### Compliance with the fugitive emission limit value

The fugitive emission (F) limit value is 20% of solvent input for installations with input of 10 t/year or less.

- ☐ Determination of fugitive emissions (indirect method):

$$F = I1 - (O1.1 + O1.2) - O5 - O6 - O7 - O8$$

$$F = 1.2 \text{ t/year} - 0.0 \text{ t/year} - 0.0 \text{ t/year} - 0.72 \text{ t/year} - 0.0 \text{ t/year} - 0.0 \text{ t/year} \\ = 0.48 \text{ t/year}$$

- ☐ Determination of amount of fugitive emissions in solvent input:

$$x = F * 100 / (I1 + I2)$$

$$x = 0.48 \text{ t/year} * 100 / (1.2 \text{ t/year} + 246 \text{ t/year}) = 0.19\%$$

The installation is compliant with the fugitive emission limit value of 20% of solvent input.

## **6.4 Dry cleaning (activity 3.1)**

### Short description of the installation

The installation uses a two-bath solvent regeneration process that is linked operationally to a vacuum distillation installation. The maximum filling amount is 22 kg of goods to be processed.

Processed goods are counted using integrated batch counters in the machines. The numbers on the counters are then multiplied by 70-80% of

the maximum filling volume in accordance with a presorting gradient.<sup>43</sup> Owing to the high sorting gradient in the installation used for the present example, a filling volume of 70% of nominal load (0.7 load factor) was applied.

The computed volume of goods cleaned in the installation was 64,665 kg with a batch count of 4199, a nominal load of 22 kg and a loading factor of 0.7.

The following table shows the computed input, its solvent content and the resulting solvent quantities.

Material	Product name	Installation	Input [l]	Density* [g/l]	Input [kg]	Solvent quantity	
						[%]	[kg]
<b>Purchased quantities:</b>							
Solvent	Total DC 301		1700	0,744	1264,8	100	1264,8
Cleaning enhancer	Mean of x				770	22,5	173,3
Impregnation agent	Mean of y				240	77,5	186,0
<b>Input I1</b>							<b>1624,1</b>

\*The densities and percentages for solvent content from the DIN data safety sheet are to be used.

Input I2 is disregarded since dry cleaning installations are subject to a total emission limit value only, and input I2 applies only to compliance with the fugitive emission limit value.

Outputs O1, O5, O7 and O8 are likewise disregarded for the determination of total emissions.

The key parameters for dry cleaning installations are solvent content in waste, distillation sludge, filters/filter sludge, and contaminated solvent, all of which have differing solvent content.

In the present example, all waste containing solvent was disposed of according to a single waste classification code, which is in keeping with standard industry practice. Inasmuch as no solvent content data was available, the calculations were realized on the basis of a plausible

<sup>43</sup> The items that are to be cleaned are sorted by color, cleaning properties, drying temperature, impregnation etc. Whether or not a loading factor of 0.7 or 0.8 is used to calculate the volume of goods to be cleaned depends upon the presorting gradient. A lower presorting gradient is to be applied (in accordance with the daily volume of goods recommended by Deutscher Textilreinigungs-Verband (German dry cleaners' association)) when organic solvent is used since the risk of bleeding and soiling is lower relative to goods treated with tetrachloroethene. Retail dry cleaners generally sort according to criterion 3, i.e. normal, light, impregnation. Application of a lower sorting gradient improves machine capacity use.



estimated value (40%) provided by the operator<sup>44</sup>. In lieu of changing or cleaning filters while the installation is in operation, this is done over the weekend or after the installation has been shut down for at least eight hours, thus reducing filter cartridge solvent content. The solvent was not changed (i.e. contaminated solvent was not replaced) during the solvent management plan period. 1.4 m<sup>3</sup> of waste was disposed of, and output O6 amounted to 560 kg with a 40% solvent content.

#### Solvent management plan:

Input		Output*	
I1	1.62 t/year	O1.1	0 t/year
I2	0 t/year	O1.2	0 t/year
		O5	0 t/year
		O6	0.56 t/year
		O7	0 t/year
		O8	0 t/year

\*O2, O3, O4 and O9 are not applied to the determination of fugitive emissions (F) when the indirect method is used

#### Solvent consumption

Dry cleaning installations are not required to ascertain solvent consumption since they are not subject to a threshold value. Accordingly, **all** dry cleaning installations **are** subject to a **reporting requirement**.

#### Compliance with the total emission limit value

In addition to the specific requirements to which installations that use organic solvents are subject, such installations are also subject to a total emission limit value of 20 g of solvent/kg of dry cleaned goods.<sup>45</sup>

Compliance with allowable total VOC emissions can be verified using the two-stage calculation shown below. This amount can be approximated on the basis of the worse-case solvent content as shown in Table 21, or on the basis of other plausibly proven solvent content data.

##### **Stage 1 (E = I1):**

solvent input/cleaned goods

$$1624100 \text{ g} / 64665 \text{ kg} = 25.1 \text{ g/kg}$$

---

<sup>44</sup> Other solvent content data can be provided if it is accompanied by plausible supporting evidence such as data from the recycler, studies, expert's reports or analysis results.

<sup>45</sup> See Article 4 in conjunction with Annex III(3.1), German Solvent Ordinance (31. BImSchV)

► Total emission limit value exceeded

**Stage 2 (E = I1 – O6):**

□ E = I1 – O6<sub>20%</sub> (worst case)

Solvent input with a solvent content of 20%, minus  
waste volume, divided by the quantity of processed goods  
/ cleaned goods:

$$(1624100 - 280000) \text{ g} / 64665 \text{ kg} = 20.8 \text{ g/kg}$$

► Total emission limit value exceeded

□ E = I1 – O6 (calculation on the basis of plausibly proven solvent content  
in waste)

(solvent input, waste with 40% solvent content)  
/ cleaned goods:

$$(1624100 - 560000) \text{ g} / 64665 \text{ kg} = 16.5 \text{ g/kg}$$

► Compliance with total emission limit value achieved

## **6.5 Other coating activities (activity 8.1)**

### **6.5.1 Agricultural machinery**

The present example describes the procedure for elaboration of a specific reduction scheme as described in Annex IV(B).

The company in this example (which is subject to authorization) manufactures agricultural machinery and operates an installation that coats metal surfaces as per activity 8.1 in the Solvent Ordinance.

Waste gases from cathodic immersion and drying are conducted to a post-combustion system. The installation is in compliance with the < 20 mg C/m<sup>3</sup> emission limit value for contained waste gases, but is noncompliant with the fugitive emission limit value. Waste gases from the spray booths are captured, and are then discharged via a roof stack without being treated. Pursuant to Annex III requirements, the contained untreated waste gases are counted as fugitive emissions. Inasmuch as the installation cannot comply with the fugitive emission limit value, the possibility of applying a reduction scheme in lieu of the fugitive emission limit value is assessed. Toward this end, after solvent and solids input are calculated, solvent

consumption is determined on the basis of 22 operating hours per day and 250 operational days per year.

Baseline data for input I1:

Code	Installation designation	Solvent [kg/h]	Solvent [t/year]	Solids [kg/h]	Solids [t/year]
A	Spray booths with evaporation zones	9	49,5	9	49,5
B	Spray booths/conservation booths with evaporation zones	8	44,0	4	22,0
C	Coating installation (cathodic immersion facility and manual spray booths with dryers and cooling areas)	80	440,0	119	654,5
			<b>533,5</b>		<b>726</b>

Calculation of reference emission:

Reference emission = (tons of solids/year) \* (multiplication factor)

Multiplication factor for installation no. 8.1: 1.5

Reference emission = 726 t/year \* 1.5 = 1089 t/year

Calculation of target emission:

Target emission = reference emission \* percentage (solvent > 15 t/year)

Percentage for installation no. 8.1: (20 + 5)%

Target emission = 1089 t/year \* 25% = 272.3 t/year

Calculation of maximum allowable total emission as from 2005:

maximum allowable total emission = target emission \* 1.5 =

maximum allowable total emission = 272.3 t/year \* 1.5 = 408.4 t/year

If it is assumed that the installation's entire solvent input is emitted, total emission for the installation is equal to input I1 and is thus 533.5 t/year. This means that the installation cannot comply with the maximum

allowable total emission and the target emission as at 2005 and that the operator is required to realize emission reduction measures.<sup>46</sup>

	Emissions	Minimum emission reduction
Total installation emissions	533.5 t/year	-
Maximum allowable total emission as at 2005	408.4 t/year	125.1 t/year
Target emission	272.3 t/year	261.2 t/year

### Reduction procedure for this installation:

Coating installation C is to be replaced by installations D, E and F and the existing cathodic immersion coating unit will be replaced with a new one. A powder coating unit for the topcoat and a wet-spray unit for the application of special colors is to be purchased and installed. Installations A and B will be operated while the new units are being installed, and will then be decommissioned. Solvent input will be reduced, mainly owing to the implementation of powder coating, and solids input will be reduced by approximately 100 t/year on account of improved coating efficiency.

### Input I1

No.	Installation designation	Solvent [kg/h]	Solvent [t/year]	Solids [kg/h]	Solids [t/year]
D	New cathodic immersion coating unit	9	49,5	63	346,5
E	New wet-spray coating unit	6,3	34,7	6,3	34,7
F	New powder coating unit	-	-	47,3	260,2
			<b>84,2</b>		<b>641,4</b>

### Calculation of reference emission:

Reference emission = 641.4 t/year \* 1.5 = 962.1 t/year

### Calculation of target emission:

Target emission = 962.1 t/year \* 25% = 240.5 t/year

<sup>46</sup> Owing to a lack of data, total emissions attributable to the cleaning of application equipment (approximately 20% of total emissions) and emissions conducted to the post-emission system from the cathodic immersion installation (approximately 20% of total emissions) could not be included. However, since these would for the most part offset each other, their absence does not affect the general tenor of the statements made here.

Calculation of maximum allowable total emission as from 2005:

$$\text{Target emission} * 1.5 = 240.5 \text{ t/year} * 1.5 = 360.8 \text{ t/year}$$

If it is assumed that the installation's entire solvent input is emitted, total emission for the installation is equal to input I1 and is thus 84.2 t/year. The aforementioned reduction measures will bring the installation well into compliance with the target emission.

Installations whose total emissions do not exceed the target emission and that are subject to authorization in accordance with the best available technique (see BImSchG 5(1)(2)) are also subject to *TA Luft* requirements such as compliance with emission values for organic substances pursuant to no. 3.1.7 class I, as well as the post-dryer waste gas emission limit value of 50 mg C/m<sup>3</sup>.

**6.5.2 General machine construction**

In this example, a reduction scheme and the attendant reduction options are shown. This type 8.1 installation ("coating of other metallic and plastic surfaces") is operated by an industrial machine manufacturer. A primer and topcoat are applied to the machines. The baseline data was determined by computing input. Output was not computed separately since it was assumed that VOC emissions would equal input. Conversely, it was assumed that the cleaning solvent input for the installation's enclosed tool cleaning facility would not be emitted. Liter to kilogram conversions were adjusted for a solvent density of 0.89.

Input/baseline data

Process	Solids content[%]	Solvent content [%]	Throughput/year		Solids [kg/year]	Solvent [kg/year]
Manual tool cleaning in unenclosed facility	0	100,0	5677	l	0	5053
Coating						
1K primer	32,4	63,0	6027	kg	1953	3797
Topcoat	46,7	53,3	16827	kg	7858	8969
Thinner	0	100,0	2524	l	0	2247
					<b>9811</b>	<b>20066</b>

Calculation of reference emission

Reference emission = (solids/y)\* (multiplication factor)

Multiplication factor for type 8.1 installation: 1.5

Reference emission =  $9811 \text{ kg/year} * 1.5 = 14,716.5 \text{ kg/year}$

#### Calculation of target emission

Target emission = reference emission \* percentage

Percentage for type 8.1 installation (solvent consumption > 15 t/year): (20 + 5)%

Target emission =  $14,716.5 \text{ kg/year} * 25\% = 3,679.1 \text{ kg/year}$

#### Calculation of maximum allowable emission as from 2005

Target emission \* 1.5 =  $3679.1 \text{ kg/year} * 1.5 = 5,518.7 \text{ kg/year}$

#### Total emissions for the installation

In order for the installation to be in compliance, its actual emissions must be lower than the target emission. The total emissions for the installation in the present example (assuming that all VOCs are emitted) are 20,666 kg/year, which includes cleaning agents, primer and topcoat solvents, and thinners. Any solvent that is disposed of with the installation's waste can be subtracted from total input.

	Emissions	Exceeds emission limits by the following amounts
Total emissions for the installation	20,066 kg/year	-
Maximum allowable total emission (as at 2005)	5,518.7 kg/year	14,547.3 kg/year
Target emission	3,679.1 kg/year	16,386.9 kg/year

The installation exceeds the reduction scheme target emission. The operator will make efforts to comply with the target emission by implementing reduction measures such as realization of an enclosed tool cleaning facility and increasing primer and topcoat solids content.

Reduction option 1: Installation of an enclosed tool cleaning facility and increasing primer solids content.

This will reduce solvent consumption to 5-15 t/year, and consequently the (25 + 15)% percentage for < 15 t/year solvent consumption (see Table 6) will be applied.

Process	Solids content [%]	Solvent content [%]	Throughput t/year		Solids [kg/year]	Solvent [kg/year]
Distillation, enclosed cleaning tool	0	100,0	1145	1	0	(1019)*
Coating						
1K primer	58	42	3896	kg	2260	1636
Topcoat	46,7	53,3	16827	kg	7858	8969
Thinner	0	100,0	2524	l	0	2247
					<b>10118</b>	<b>12852**</b>

\*Not counted for the calculation of total emissions since the solvent is used in an enclosed cleaning facility. \*\*not counting solvent from the enclosed tool cleaning facility

#### Calculation of reference emission

Reference emission = 10,118 kg/year \* 1.5 = 15,177 kg/year

#### Calculation of target emission

Percentage for type 8.1 installation (solvent consumption < 15 t/year): (25 + 15)%

Target emission = 15,177 kg/year \* 40% = 6,071 kg/year

#### Calculation of maximum allowable emission as from 2005

Target emission \* 1.5 = 6,071 kg/year \* 1.5 = 9,107 kg/year

#### Total emissions for the installation:

	Emissions	Minimum emission reduction
Total emissions for the installation	12,852 kg/year	-
Maximum allowable total emission (as at 2005)	9,107 kg/year	3,745 kg/year
Target emission	6,071 kg/year	6,781 kg/year

Reduction option 1 will not bring the installation into compliance with the target emission. Hence, additional reduction measures will have to be realized.

### Reduction option 2: Increasing topcoat solids content

Process	Solids content [%]	Solvent content [%]	Throughput/year		Solids [kg/year]	Solvent [kg/year]
Distillation, enclosed tool cleaning	0	100,0	1145	1	0	1019*
Coating						
1K primer	58	42	3896	kg	2260	1636
Topcoat	54,8	45,2	13660	kg	7486	6174
Thinner	-	100,0	2051	l*	-	1825
					<b>9746</b>	<b>9635**</b>

\*Not counted for the calculation of total emissions since the solvent is used in an enclosed cleaning facility. \*\*not counting solvent from the enclosed tool cleaning facility

### Calculation of reference emission:

$$\text{Reference emission} = 9,746 \text{ kg/year} * 1.5 = 14,619 \text{ kg/year}$$

### Calculation of target emission:

Percentage (solvent consumption > 15 t/year) for type 8.1 installation: (25 + 15)%

$$\text{Target emission for 2007: } 14619 \text{ kg/year} * 40\% = 5,848 \text{ kg/year}$$

### Calculation of maximum allowable total emission as from 2005:

$$\text{Target emission} * 1.5 = 5,848 \text{ kg/year} * 1.5 = 8,772 \text{ kg/year}$$

### Total emissions for the installation:

	Emissions	Installation exceeds target emission by a minimum of
Total emissions for the installation	9,635 kg/year	-
Maximum allowable total	8,772	863 kg/year



emission (as at 2005)	kg/year	
Target emission	5,848 kg/year	3,787 kg/year

The combination of reduction options 1 and 2 will not bring the installation into compliance with the target emission. Hence, additional measures are required, which means that the operator will have to switch his entire coating process to the primer or topcoat with the highest solids content.

## **6.6 Coating of wood or wood materials (activity no. 9)**

### **6.6.1 Window manufacturer**

This company is a window manufacturer with a computer controlled production line. The company makes windows of various types and sizes, and produces 40 one-pane windows daily, including their frames. The company's coating installation consists of a flood painting facility for the primer and an electrostatic painting facility (painting robots) for the topcoat. Only water based paint and varnish are used. 90% of the overspray from the topcoat application process is captured and recycled into the painting process, resulting in a 1:2 old/new paint ratio.

#### Input I1

In light of the high degree of automation achieved by this installation's production process, it is assumed that this installation is a type 9.1 facility pursuant to Annex I of the Solvent Ordinance (coating of wood and wood materials). The requisite calculations were realized using manufacturer's data.

Material	Consumption	VOC content		Solids content	
	kg	%	kg	%	kg
Paint	11954,67	0,00	0,00	34,67	4148,10
Paint	1949,33	0,00	0,00	41,72	813,22
Paint	12,00	0,00	0,00	33,95	4,07
Paint	93,33	0,00	0,00	55,09	51,41
Paint	6162,67	3,48	214,71	16,38	1009,63
Paint	76,00	3,79	2,88	14,63	11,12
Paint	114,67	4,13	4,74	16,27	18,65
Paint	270,67	4,33	11,71	17,01	46,05
Paint	7544,00	4,58	345,67	40,59	3062,34
Primer	7929,34	4,35	344,61	24,62	3127,04
Primer	4928,00	3,31	162,97	49,98	2463,01
Varnish	521,33	3,49	18,20	14,82	77,24
Paint	70,67	5,15	3,64	45,09	32,16
Auxiliary materials	132,00	60,00	79,20	32,04	42,29
Thinner	34,67	100,00	34,67	0,00	0,00
Cleaner	12,00	20,78	2,49	0,00	0,00
<b>Coatings</b>	<b>41805,35</b>	<b>Input I1</b>	<b>1225,48</b>	<b>solids</b>	<b>14906,33</b>

#### Solvent consumption (SC = I1 – O8):

The calculation realized in the table shows that despite the high volume of coating used, the installation only consumes 1.2 t/year of solvent, which is well under the threshold value of 5 t/year. This is attributable to the fact that nearly all of the coatings are aqueous. Hence, this installation does not fall within the scope of the Ordinance and is therefore **not** subject to a reporting requirement.

In the interest of being on the safe side and avoiding periodic queries from the competent authority, it is recommended (though not required) that the operator elaborate a simplified reduction scheme in the form of a legally binding declaration to the effect that the installation uses coatings that are free of or contain no solvent.<sup>47</sup>

The target emission calculation in the present example shows that even when reduction scheme requirements are applied that are more stringent than those to which type 9.2 installations are subject (i.e. a multiplication factor of 3 in lieu of 4), the computed total emissions are well below the target emission (here, the value for I1).

<sup>47</sup> See: Annex IV(C)(3), German Solvent Ordinance (31. BImSchV); section 4.3 p. 37 herein

Target emission = (Solids content \* multiplication factor) \* reduction factor

$$\text{Target emission} = 14,906 * 3 * 0.4 = 17,887 \text{ kg}$$

### 6.6.2 Furniture manufacturer (solvent consumption 5-15 t/year)

#### Short description of the installation [18]

This is a chair spray-coating installation that coats approximately 60 chairs per hour. The installation is in operation eight hours daily, 220 days per year, which means that approximately 105,000 chairs are coated annually. The installation's wet-rinsing system for booth overspray exhaust generates approximately 12,000 tons of coating sludge annually (50-60% of coating input).

#### Baseline data for input I1:

Process	Quantity (kg/chair)	Quantity [kg/year for 105,000 chairs]	Solvent content [%]	Solvent [kg/chair]	Solvent [kg/year for 105,000 chairs]
Spray coating (aqueous powder stain)	0,15	15750	0	0	0
Primer (dipping in nitrocellulose lacquer)	0,14	14700	70	0,098	10290
Final electrostatic spray coating (UV water based coating)	0,10	10500	8	0,008	840
Total	0,39	40.950	-	<b>0,106</b>	<b>11.130</b>

#### Solvent consumption (SC = I1 – O8):

The installation's solvent consumption is 11.1 t/year, which means that it far exceeds the 5 t/year threshold value for this type of installation. The installation is therefore subject to a reporting requirement.

However, section 5(6) and Annex III(9.1) of the Ordinance stipulate that every three years until 2013 the operator is to elaborate a solvent

management plan and that thereafter a reduction scheme is to be elaborated. New installations will be required in order to comply with the best available technique criteria (i.e. coatings containing the lowest amount of solvent).

#### Reduction procedure for this installation

A chair coating facility with a UV drying and paint recovery system was installed that features a stepless, automatically regulated 234 meter-long carousel and a 292 chair carrier that can be rotated 4 x 90°. The carousel transports the chairs to the spray robot where the chairs are coated while being rotated four times by the chair carrier. The coating is applied electrostatically. The sprayed paint is also sprinkled on the walls of the flooding spray booth. This paint then “catches” and integrates the overspray generated by the spray process, and the resulting mixture is recycled back into the spraying system.

When the new system was rolled out, the following problems were detected: the current stain bled, rendering it unuseable; immersion lacquering using a product that can be thinned with water must be realized in a stainless steel or plastic immersion tank; and a filter module must be installed when immersion lacquer is recirculated to remove wood dust or gel particles from the immersion tank. The drying time at ambient temperature in the suspended conveyor was lengthened. The lacquering procedure comprised the following processes:

Process	Quality (kg/item)	Quantity [kg/year for 105,000 chair]	Solvent content [%]	Solvent [kg/chair]	Solvent [kg/year for 105,000 chairs]
Spray coating with solvent-based stain	0,15	15750	9	0,0135	1417,5
Primer (immersion in 1K nitrocellulose lacquer)	0,14	14700	9	0,0126	1323
Final electrostatic spray coating (UV water based coating)	0,10	10500	8	0,008	840
	0,39	40.950	-	<b>0,0341</b>	<b>3580,5</b>

This process reduced solvent consumption from 0.11 kg to 0.04 kg per chair and the installation's total solvent consumption dropped from 11.1 to 3.6 t/year. As a result, the installation does not fall within the scope of the Ordinance and is therefore **not** subject to a reporting requirement.

Modifying the coating process in this manner resulted in the following additional advantages:

- ☐ Reduced solvent vapor from the immersion bath
- ☐ Reduced cost through reduced waste generation

### **6.6.3 Coating of wood or wood materials (solvent consumption > 15 t/year)**

#### **Coffin manufacturing**

Wood coffins in this manufacturing and processing operation are sprayed with aqueous lacquer (spray robot, flooding process, lacquer recycling, drying in circulating air). However, special orders are manually coated with solvent lacquer. The facility does not have abatement equipment, and untreated contained waste gases are discharged through a roof stack. The VOCs in these waste gases are counted as fugitive emissions.<sup>48</sup>

Approximate calculations showed that input I is emitted in the form of fugitive emissions, minus a negligible quantity of waste which can be disregarded in this case. Hence, this installation is non-compliant with the fugitive emission limit value of 25% of solvent input (input I). Consequently, the installation can apply the alternative method, i.e. a reduction scheme, in order to comply with the emission limit values.

#### Baseline data for inputs I1 and I2:

(approximate data supplied by the installation operator for the 1999 solvent management plan)

Material	Consumption	VOC content		Solids content	
	kg	%	kg	%	kg
Stain	710	95	675	3	21
Paint	1,076	92	990	9	97
Primer	14,904	54	8,048	45	6,707
Primer	5,714	1	57	55	3,143
Hardener	18	55	10	45	8
Auxiliary materials	101	15	15	8	8

---

<sup>48</sup> See Annex III(9.2.2), German Solvent Ordinance (31. BImSchV)

Material	Consumption	VOC content		Solids content	
	kg	%	kg	%	kg
Auxiliary materials	565	94	531	6	34
Paint	3,011	75	2,258	20	602
Paste	151	3	4	52	79
Thinner	1,311	100	1,311	0	0
Wax	2,130	76	1,619	20	426
Aqueous lacquer	5,116	26	1,330	10	512
<b>Input I/1</b>	<b>34,807</b>		<b>16,848</b>	<b>Solids</b>	<b>11,637</b>
Recycled aqueous lacquer	860	26	223		
Recycled primer	1,570	1	16		
<b>Input I/2</b>			<b>239</b>		
<b>Input I</b>			<b>17,087</b>		

Solvent consumption (SC = I1 – O8):

16.8 t/year

Since the installation exceeds the 15 t/year threshold value, it must comply with the requirements for installation type 9.2 pursuant to Annex I of the Ordinance. The installation is also subject to authorization pursuant to 4.BImSchV.

Solids

11.6 t/year

Reduction scheme:<sup>49</sup>

- Reference emission  
computed using the following formula: kg solids/year \* multiplication factor of 3  
= 34.8 t/year
- Maximum allowable total emission as from 2005  
computed using the following formula: reference emission \* percentage (25+15) \* 1.5  
= 20.9 t/year
- Target emission  
computed using the following formula: reference emission \* percentage (25+15)  
= 13.9 t/year

<sup>49</sup> Cf. the Table in Annex IV(B)(9), German Solvent Ordinance (31. BImSchV)

Total emissions for the installation:

	Emissions	Exceeds emission limits by the following amounts
Total emissions for the installation	17.08 t/year	-
Maximum allowable total emission (as at 2005)	20.9 t/year	None
Target emission	13.9 t/year	2.9 t/year

The installation is in compliance with the maximum allowable emissions for 2005. However, it is required to implement additional emission reduction measures by Oct. 31, 2007 such as reducing aqueous lacquer solvent content, which at 26% is relatively high at present.

## 6.7 Footwear manufacturing (activity no. 15)

### Emission reduction measures

A footwear manufacturing company (an “existing installation”) far exceeds solvent input of 25 g/pair of completed footwear. The company cannot comply with the total emission value of < 25 g/pair of completed footwear without the use of abatement equipment. The performance specifications for the company’s products (durability and resistance upon exposure to oil, grease, acids, and benzene) necessitate the use of solvent adhesives.

The company decided to install abatement equipment that uses a biological method, owing to the relatively low solvent concentration in the waste gas flow. VOCs are conducted into a bioreactor in which they are converted by microorganisms into carbon dioxide, water and biomass.

The biological abatement equipment allows for the treatment of airflows with a load of up to 2.5 g/m<sup>3</sup>. As much as 96% of the VOCs are removed from the waste gases, thus bringing the installation into compliance with the total emission limit value [19].

## 7 Existing guidelines and relevant computer applications

In the following, previously issued documents or documents that are slated for publication containing implementation guidelines for the Solvent Ordinance are described (as at Oct. 2001).

### 7.1 Studies and guidelines

Prior to enactment of Germany's Solvent Ordinance, various studies were issued that describe possible emission reduction measures and that investigated the extent to which these measures achieve compliance with the EU Solvent Ordinance (EC/13/1999) for specific activities.

#### 7.1.1 Studies regarding emission reduction potential

In recent years, Germany's Federal Environmental Agency (Umweltbundesamt) has commissioned a number of studies containing summaries and analyses of recent statistical data on VOCs and VOC emissions, as well as information regarding various reduction measures.

- *Stand der Technik und Potentiale zur Senkung der VOC-Emissionen aus Anlagen zur Reinigung von Oberflächen* ("The state of art and the potential to reduce VOC Emissions from surface cleaning installations")[9]
- *Ermittlung des Standes der Technik und der Emissionsminderungspotentiale zur Senkung der VOC-Emissionen aus Druckereien* („Examination of Best Available Technologies and Emission Reduction potentials to decrease VOC Emissions in printing operations“)[16]
- *Einsatzmöglichkeiten lösemittelarmer Produkte – Wissensspeicher zur Förderung von Innovationen in der lösemittelverwendenden Industrie* („[10]

#### 7.1.2 Guidelines

##### 7.1.2.1 Lösemittelbilanz und Reduzierungsplan für Druckereien [6]

These guidelines (available in German only) describe the procedure for the elaboration of a solvent management plan and solvent reduction scheme for printing installations.



The document briefly explains why it is necessary to reduce VOC emissions, as well as the legal regulations, requirements and obligations to which installation operators are subject pursuant to the EU solvent directive. The document also provides a complete description of the procedure for elaborating a solvent management plan and reduction scheme. The case studies in the document illustrate the application of the solvent management plan and reduction scheme, both of which are new emission reduction mechanisms. The VOC input and output tabulation forms in the Annex are readily understandable and clearly laid out.

Although there are no plans to update the document in light of the German Solvent Ordinance, the document contains useful recommendations for the determination of inputs and outputs for the elaboration of solvent management plans and reduction schemes.

The document can be obtained by writing to:

Ministerium für Umwelt und Verkehr Baden-Württemberg

- Broschürenversand -

Kernerplatz 9

70182 Stuttgart

Germany

#### *7.1.2.2 Reduction of VOC emissions in cabinetmaking workshops*

These documents (available in German only) investigated possible VOC reduction measures in cabinetmaking workshops. The documents are reports on four EU Solvent Directive-related projects that were commissioned by the Ministerium für Umwelt und Verkehr Baden-Württemberg (Baden-Württemberg ministry of the environment and transport) in 1999. The study was carried out in collaboration with the Freiburg-based Umweltzentrum für Handwerk und Mittelstand (UIZ; Environmental center for the construction trades and SMEs). The reports [20,21] provide information in regard to the following:

- ☐ Which substances generate VOC emissions in cabinetmaking workshops
- ☐ Methods for reducing VOC emissions such as the use of aqueous varnish
- ☐ Methods for ensuring that working with aqueous varnish is as ergonomic as working with conventional varnish, e.g. by building a dedicated rack trolley for aqueous varnish application
- ☐ How VOC emissions generated by oil and wax can be reduced; current application domains for oil and wax

- An Excel worksheet simplifies the task of elaborating a solvent management plan called for by the EU Solvent Ordinance

The project reports can be downloaded under the *Klima- und Immissionsschutz* rubric at [http://www.uvm.baden-wuerttemberg.de/uvm/home/ind\\_pub.html](http://www.uvm.baden-wuerttemberg.de/uvm/home/ind_pub.html).

There are no plans to revise the documents in light of the German Solvent Ordinance.

#### 7.1.2.3 Treating wood with low-solvent varnishes

The Hauptverband der Deutschen Holz und Kunststoffe verarbeitende Industrie und verwandter Industriezweige (HdH; Association of German wood and plastic processing and related industries) and the Verband der Lackindustrie (VdL; Varnishing industry association) have compiled and published a booklet (available in German only) entitled *Holz lösemittelarm lackieren – Praxis-Ratgeber zur Umsetzung der europäischen VOC-Richtlinie in der Holz- und Möbelindustrie* [12].

The booklet contains information regarding EU Solvent Ordinance requirements, data calculation methods and mean solvent content for various types of varnish and stain, as well as instructions for software (included with the document) that calculates quantities of solvent for elaboration of a solvent management plan and reduction scheme. The program allows for the calculation of various reduction options.

For further information (in German) see [www.hdh-ev.de](http://www.hdh-ev.de).

#### 7.1.2.4 Use of aqueous coatings for vehicle refinishing installations

In 2000, the Ministerium für Umwelt und Verkehr Baden-Württemberg (Baden-Württemberg ministry of the environment and transport) commissioned two projects pertaining to the use of aqueous coatings in vehicle refinishing installations. The titles of the attendant project reports are as follows:

- *Leitfaden zum Einsatz von Wasserlacken in der Kfz-Reparaturlackierung* [22]
- *Wasserlacke in der Reparaturlackierung von Kraftfahrzeugen* [23]

These reports contain information regarding the use of aqueous coatings and low-solvent or solvent-free auxiliary materials in vehicle refinishing installations, as well as problem areas and possible solutions.

The reports can be downloaded under the *Klima- und Immissionsschutz* rubric at [http://www.uvm.baden-wuerttemberg.de/uvm/home/ind\\_pub.html](http://www.uvm.baden-wuerttemberg.de/uvm/home/ind_pub.html) or are available upon request from Ministerium fuer Umwelt und Verkehr

Baden-Wuerttemberg, - Broschuerenversand -, Kernerplatz 9, 70182 Stuttgart, Germany.

## **7.2 Computer applications/internet**

### **7.2.1 Federal Environmental Agency (Umweltbundesamt) *Wissensspeicher* (knowledge base) and internet portal**

One of the major sources of VOC emissions is the use of solvents and solvent products in unenclosed facilities, and by small businesses and end users, for the application of paint, varnish, lacquer, and adhesives, as well as in the printing industry and for surface cleaning. These applications accounted for approximately one million tons of VOC emissions in 1999. Inasmuch as the installation of abatement equipment is generally not a practicable solution in such settings, VOC emissions can only be reduced by switching to different products.

In the interest of promoting the use of low-solvent products and providing SMEs and other businesses in the relevant industries with support, the Federal Environmental Agency (Umweltbundesamt) asked the Fraunhofer Institute for Systems and Innovation Research ISI in Karlsruhe (Fraunhofer Institut für Systemtechnik und Innovationsforschung) to compile a comprehensive list of all currently available low-solvent coating products and the application techniques that are available for them [10]. This information has been integrated into the *Wissensspeicher* (knowledge base) and can be downloaded (in German only) from <http://www.umweltbundesamt.de/voc/>. A database for paint, varnish, lacquer, flooring adhesives and flooring materials (for interior applications) was also elaborated. This database (in German only) provides online data and application related information regarding the relevant low-solvent products.

### **7.2.2 Implementation support for the printing industry**

#### **Determination of capacities, consumption and emissions**

Software is available from the Bundesverband Druck und Medien (bvdv; German Printing and Media Industries Federation) that provides implementation assistance for the Solvent Ordinance as well as capacity calculations pursuant to *Ordinance on the restriction of emissions of highly volatile halogenated hydrocarbons - 4. BImSchV* [14] for the printing

industry. The program (available in German only) is intended to simplify the process of implementing the ordinances, and also provides explanations of various aspects of these. The program is mainly aimed at printing professionals, but is also useful for other interested parties.

The program enables the following functions:

- ☐ Elaboration of a solvent management plan pursuant to the Solvent Ordinance
- ☐ Elaboration of a reduction scheme (pursuant to the Solvent Ordinance) that allows for the realization of alternative emission prognoses and calculations regarding the efficacy of the envisaged measures
- ☐ Determination of solvent consumption in accordance with column 1 and of solvent input in accordance with column 2 of *Ordinance on the restriction of emissions of highly volatile halogenated hydrocarbons - 4. BImSchV*.

Comprehensive help files explain the tasks associated with each template and how to obtain capacity, consumption and emissions calculation data.

For further information (in German only) visit [www.bvdm-online.de](http://www.bvdm-online.de).

### 7.2.3 Applications referred to in the present report

The Excel worksheets referred to in section 5.6.1 herein (Table 17) as well as the report entitled *Implementation guide for the German Solvent Ordinance (31. BImSchV)* can be downloaded from [www.umweltbundesamt.de](http://www.umweltbundesamt.de).



## 8 References

- [1] Protokoll zum Genfer Übereinkommen über grenzüberschreitende Luftverunreinigungen von 1979 zur Bekämpfung von Versauerung, Eutrophierung und Bodenozone, UN/ECE (United Nations/Economic Commission for Europe – Wirtschaftskommission der Vereinten Nationen für Europa), 1999
- [2] Richtlinie 1999/13/EG des Rates vom 11.03.1999 über die Begrenzung von Emissionen flüchtiger organischer Verbindungen, die bei bestimmten Tätigkeiten und in bestimmten Anlagen bei der Verwendung organischer Lösemittel entstehen, Amtsblatt der EG L85/1
- [3] Verordnung zur Umsetzung der Richtlinie 1999/13/EG über die Begrenzung von Emissionen flüchtiger organischer Verbindungen, BGBl. I, No. 44, S. 2180
- [4] 31. Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes (Verordnung zur Begrenzung der Emissionen flüchtiger organischer Verbindungen bei der Verwendung organischer Lösemittel in bestimmten Anlagen – 31. BImSchV), Art. 1 der Verordnung zur Umsetzung der Richtlinie 1999/13/EG über die Begrenzung von Emissionen flüchtiger organischer Verbindungen, BGBl. I, No. 44, S. 2180
- [5] Erste Allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz (Technische Anleitung der Luft – TA Luft) vom 27.02.1986, GMBI. S. 95, 202
- [6] Ebinger, F.; Ch. Tebert: Lösemittelbilanz und Reduzierungsplan für Druckereien; Öko-Institut e.V. i.A. des Ministeriums für Umwelt und Verkehr Baden-Württemberg (Hrsg.), 2000
- [7] Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, (Hrsg.): VOC-Richtlinie 1999/13/EG - Erstellung von Lösungsmittelbilanz und Reduzierungsplan; Schriftenreihe des BMLFUW, Bd. 12/2000; Wien 2000
- [8] Schmidt, W., G. Schmidt, U. Nolte: Abwasser bei Lackierprozessen – Entstehung, Mengenermittlung, analytische Beurteilung und Behandlungstechniken; Labor für Abwasser Technik der Fachhochschule Gelsenkirchen; Umweltbundesamt Berlin (Hrsg.); Forschungsbericht 102 06 517, Berlin 1995

- [9] Leisewitz, A., W. Schwarz: Stand der Technik und Potentiale zur Senkung der VOC-Emissionen aus Anlagen zur Reinigung von Oberflächen; Öko-Recherche; Umweltbundesamt Berlin(Hrsg.); Forschungsbericht 297 44 906/2, 1999
- [10] Umweltbundesamt (Hrsg.): Einsatzmöglichkeiten lösemittelarmer Produkte - Wissenspeicher zur Förderung von Innovationen in der Lösemittel verwendenden Industrie; Fraunhofer-Institut für Systemtechnik und Innovationsforschung (ISI), von Thienen-Consulting und ERM Lahmeyer International GmbH; Forschungsvorhaben 298 44 307, 3. Zwischenbericht; Berlin 2001
- [11] Bluhm, T., J. Bohnen, H. Krüssmann: Untersuchungen zum umweltverträglichen Einsatz der KWL-Reinigungstechnik; wfk - Forschungsinstitut für Reinigungstechnologie e.V., Kurzbericht zum Forschungsvorhaben B 1731 UF, Krefeld 1996
- [12] Baums, M., W. Hansemann: Holz lösemittelarm lackieren - Praxis-Ratgeber zur Umsetzung der europäischen VOC-Richtlinie in der Holz- und Möbelindustrie; Hrsg.: Verband der Lackindustrie VdL e.V. und Hauptverband der Deutschen Holz und Kunststoffe verarbeitende Industrie und verwandter Zweige H9DH e.V., Frankfurt 1999
- [13] Ministerium für Umwelt und Verkehr Baden-Württemberg (Hrsg.): Nutzbarmachung des VOC-Minderungspotentials im Schreinerhandwerk: Praxisgerechte Lösemittelbilanzierung in Schreinereien; Umweltzentrum für Handwerk und Mittelstand e.V., Freiburg 2000
- [14] Gruhlke, A., H. Rech: Umsetzungshilfe für die Druckindustrie - Bestimmung von Verbräuchen, Kapazitäten, Emissionen; EDV-Anwendungsprogramm, Hrsg. Bundesverband Druck und Medien e.V. (bvdm), Wiesbaden 2001
- [15] Jepsen, D., A. Grauer, Chr. Tebert: Ermittlung des Standes der Technik und der Emissionsminderungspotentiale zur Senkung der VOC-Emissionen aus Druckereien; Hrsg. Umweltbundesamt Berlin Forschungsbericht 297 44 906/01, Hamburg 1999
- [16] Gert Rentzel Ingenieur GmbH (Hrsg.): Tagungsband zum Seminar „Emissionsminderung Bedrucken und Beschichten“, Gelnhausen Mai 2001
- [17] Hauptverband der gewerblichen Berufsgenossenschaften (Hrsg.): ZH 1/562 Regeln für die Sicherheit und Gesundheitsschutz beim Reinigen von Werkstücken mit flüssigen Reinigungsmitteln, Entwurf Nov. 1997

- [18] Informationszentrum für betrieblichen Umweltschutz (Hrsg.): Tagungsbericht zum Fachseminar „Lösemittelreduzierung und Energieeinsparung beim Lackierprozess“, Landesgewerbeamt Baden-Württemberg, Stuttgart Juli 1999
- [19] CEFIC-Fachverband European Solvent Industry Group (ESIG) (Hrsg.): Solutions – Nachrichten der Europäischen Lösemittelindustrie, Ausgabe No. 4, 1998/99
- [20] Ministerium für Umwelt und Verkehr Baden-Württemberg (Hrsg.): Förderung des Wasserlackeinsatzes im Schreinerhandwerk durch optimierte Trocknungssysteme; Umweltzentrum für Handwerk und Mittelstand e.V.; Freiburg 2000
- [21] Ministerium für Umwelt und Verkehr Baden-Württemberg (Hrsg.): Nutzbarmachung des VOC-Minderungspotentials im Schreinerhandwerk; Umweltzentrum für Handwerk und Mittelstand e.V., Freiburg 1999
- [22] Ministerium für Umwelt und Verkehr Baden-Württemberg (Hrsg.): Leitfaden zum Einsatz von Wasserlacken in der Kfz-Reparaturlackierung; Deutsch-Französisches Institut für Umweltforschung (DFIU), Dezember 2000
- [23] Rentz, O. et al.: Wasserlacke in der Reparaturlackierung von Kraftfahrzeugen - Entwicklung eines praxisorientierten Leitfadens zum verbesserten Einsatz von Wasserlacken in kleinen und mittleren Kfz-Reparaturlackierungen; Deutsch-Französisches Institut für Umweltforschung (DFIU) i.A. des Ministeriums für Umwelt und Verkehr Baden-Württemberg (Hrsg.), Dezember 2000





## 9 Figures

Figure 1: Requirements and applicability flowchart for textile coating and printing installations.....

Figure 2: Requirements and applicability flowchart for heatset web offset installations .....

Figure 3: Requirements and applicability flowchart for publication rotogravure installations .....

Figure 4: Requirements and applicability flowchart for other printing installations .....

Figure 5: Requirements and applicability flowchart for surface cleaning installations .....

Figure 6: Requirements and applicability flowchart for dry cleaning installations .....

Figure 7: Requirements and applicability flowchart for vehicle refinishing installations.....

Figure 8: Requirements and applicability flowchart for installations that coat metallic or plastic surfaces.....

Figure 9: Requirements and applicability flowchart for installations that coat wood or wood materials .....

Figure 10: Requirements and applicability flowchart for textile coating and printing installations .....

Figure 11: Reduction scheme variants.....

Figure 12: Possible content and format for a legally binding  
declaration of compliance with a reduction scheme for the  
installations listed in no. 9.1.....

Figure 13: Application domain of the solvent management plan...

Figure 14: Input and output flows .....

Figure 15: Utilization options for recovered solvent

Figure 16: Contained waste gases and fugitive emissions in ambient  
air .....

Figure 17: Substance flows for a packaging printing installation



## 10 Tables

Table 1:	Contents of the Solvent Ordinance
Table 2:	Installations and activities that fall within the scope of the Solvent Ordinance
Table 3:	Transitional rules and compliance deadlines for existing installations
Table 4:	Initial proof of compliance with the Solvent Ordinance
Table 5:	Deadlines and timeframes for compliance with target emissions
Table 6:	Calculation factors for the elaboration of specific reduction schemes
Table 7:	Installations that are permitted to apply a simplified reduction scheme
Table 8:	Definitions and code designations for input and output
Table 9:	Total emission limit values for certain types of installations
Table 10:	Steps in the calculation of total emission
Table 11:	Procedure for verifying compliance with a reduction plan
Table 12:	Substance flows to be applied for the indirect method
Table 13:	Table for determination of qualitative substance flow in painting/varnishing installations
Table 14:	Substance flows in wood coating installations
Table 15:	Substance flows for vehicle refinishing installations
Table 16:	Allowable sources of input, output and solids content data
Table 17:	Example showing how an Excel worksheet can be used to compile and compute coating data
Table 18:	Compilation of input I1 data for surface cleaning and dry cleaning
Table 19:	Compilation of input I2 data for surface cleaning and dry cleaning
Table 20:	Conversion factors for total carbon
Table 21:	Solvent content in dry cleaning waste ..
Table 22:	Solvent content in waste generated by the coating of wood and wood materials pursuant to HDH (German wood and plastics processing industry association)/VdL (German paint and coatings industry association)
Table 23:	Solvent content in waste generated by printing processes.....