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Coating Innovations
for Electronics

TI TECHNICAL INFORMATION

The EU-VOC regulation – Contents and consequences for the pcb industry –

TI 15/110

The EU-VOC regulation on the limitation of emissions of volatile organic compounds regulates by means of defined limit values emissions of volatile organic compounds for lacquer users and lacquer manufacturers. Volatile organic compounds belong to the precursor substances of ground ozone (summer smog). Even many middle-sized companies are affected regarding the reduction of emissions by the new regulation. Alternatively to the observance of limit values smaller companies have the possibility of implementing a reduction plan.

Contents

LP 010705 E-0/ TI15-110e.000

1. Introduction

The regulation 1999/13/EG [1] "on the limitation of emissions of volatile organic compounds that develop in case of certain tasks and in certain plants when organic solvents are used“ was passed on March 11, 1999 by the council of the European Union and published in the official gazette of the European Union.

Aim of this so-called solvent or VOC regulation is to achieve a European-wide regulation regarding the reduction in the emissions of **v**olatile **o**rganic **c**ompounds – **VOC**. Volatile compounds are more or less quickly released to the air depending upon their vapour pressure. Volatile compounds not only have an impact at their point of emission but also in areas that are far away. Volatile organic compounds contribute to the formation of photochemical oxidants in the outer layers of the troposphere and thus belong - besides nitrous oxides - to the precursor substances for ground ozone. In case of intense sun radiation ozone may damage the natural resources and affect human health (summer smog).

In Europe the reduction of emissions is treated as an integral part of the so-called multi component protocol on trans-boundary air pollution. The protocol is a continuation of the UN-ECE protocol [2] of 1979 on the limitation of long range trans-boundary air pollution for specific materials. In the Geneva protocol the commitment to reduce emissions by 30% between 1988 and 1999 was already stipulated for volatile organic compounds (excluding methane). This was realized by means of measures regarding road traffic and emission reducing measures in the supply and distribution of fuel.

For Germany a total VOC emission upper limit for industry, road traffic and households was determined [3] to achieve the middle-term European Imission protection target by 2010. To be able to keep within this upper limit it is necessary to achieve a clear reduction in the VOC emission.

Approx. 52% of the 1 million tons of solvents [4] that are currently emitted per year through the use of solvent are not affected by the regulation (e.g. "open applications such as coatings used to protect buildings). There remain approx. 48% for uses that fall under the purview of the EU-VOC-RL. Owing to the low consumption quantity 18% of the uses are below the threshold values of the regulation. Thus, only uses with approx. 300 000 t VOC emissions remain, which have to be reduced by at least 50% by means of the regulation.

2. Requirements of the EU regulation

The EU regulation [1] specifies measures and processes for the reduction of volatile organic compounds for certain applications. Appendix I of the regulation contains a list of these applications while appendix II A contains a table with branch specific threshold values for the solvent consumption per year. All factories that execute applications according to supplement I with a solvent consumption that exceeds the threshold values fall under this regulation.
The plants of these factories either have to

- keep within the limit values for waste gas emissions and diffuse emissions (see chapter 7),

or

- fulfil the requirements of the reduction plan according to supplement II B of the regulation (see chapter 9).

To control the observance of the limit values and be able to determine the possibilities of solvent reduction the companies and responsible public authorities need a solvent balance (see chapter 8).

State-specific plans for the reduction of emissions are accepted. But the reduction of the emissions have to be realizable at least in the same volume and the same period of time as intended by EU-RL.

Once a year or upon demand data allowing the control of observance of this regulation have to be presented to the public authority. In case of exhaust pipes with devices to reduce emissions and an exhaust volume of more than 10 kg/h organic carbon a continuous measurement has to be effect-

ed; in case of other plants a periodic control with at least three separate measurements is sufficient. In particular the following values have to be verified to the public authority:

- emission limit values as regards waste gas;
- data on diffuse emission (see chapter 7 "limit values“ and 8.3 "Determination of emissions“);

or

- requirements and/or realization of the reduction plan.

In case of continuous measurements the mean values over 24 hours must be below the limit values and the mean values per hour must not exceed factor 1.5 of the limit value.

3. Who is affected by this regulation?

To date the German technical guideline air "(TA) Luft" and/or the German "**B**undes-**Im**mission**sch**utz-**V**erordnung (**BImSchV**)" applies only to larger companies in the pcb industry (acc. to the 4th BImSchV equipment for the coating, lacquering, ... of objects,.... with a solvent consumption of 25 kg and more per hour and/or equipment for the manufacture of lacquers,... using more than 5 tons of solvents per day are subject to approval.). The EU-VOC regulation applies to a high number of factories that were not covered up to now.

It is estimated [2] that nation-wide approx. 170 000 factories fall under the regulation. Approx. 15 000 are above the branch-specific threshold values of which, according to the present law, approx. 1 000 factories are subject to approval acc. to the 4th BImSchV.

As users of organic volatile solvents pcb manufacturers fall under the branches in the category "plants to coat miscellaneous metal and plastic surfaces" listed in the appendices I and II A.

As manufacturers of formulations with a VOC content manufacturers of coating materials, clear lacquers, printing inks and glues also fall under the category "plants to coat..." of the regulation.

4. Timetable

Existing plants have to be registered and approved by October 2007 at the latest. New plants or existing plants where essential changes are planned have to be registered and approved prior to start of operation and the aimed emissions have to be met or beaten by October 2004:

February 1999	EU-VOC-RL is passed
April 2001	Implementation to national law and thus use of the reduction plan for new plants
31 October 2004	Implementation deadline for new plants
31 October 2005	Implementation deadline for the use of the reduction plan for existing plants (target emission times factor 1.5)
31 October 2007	Implementation deadline for existing plants
2013	Final deadline to observe the emission limit values for existing exhaust air cleaning plants under certain conditions

5. What is the definition of volatile organic compounds (VOC)?

Volatile **o**rganic **c**ompounds – **VOC** are organic compounds that have a vapour pressure of 0.01 kPA (0.1 mbar) or more at 293.15 K (20°C) [68°F] or that display a corresponding volatility under the corresponding application conditions, as for instance, increased temperature. Organic compounds contain carbon and at least one of the elements hydrogen, oxygen, nitrogen, halogens, sulphur or silicon, except carbon oxides and inorganic carbonates.

Examples for the classification as VOC and/or non-VOC:

			Vapour pressure at 20°C [68°F]		VOC
Solvent	MEK	(methylethylketone)	10.5	kPa	yes
	PM	(methoxypropanol)	1.2	kPa	yes
	Xylen	(xylene)	0.9	kPa	yes
	PMA	(MPA, methoxypropylacetate)	0.5	kPa	yes
	DPM	(dipropyleneglycolmonomethylether)	0.05	kPa	yes
	MDG	(methyldiglycol)	0.03	kPa	yes
Cleaning agents of Lackwerke Peters to remove lacquers					
	R 5817		8.5	kPa	yes
	R 5821		1.0	kPa	yes
	R 5899		0.008	kPa	no
Developers	GBL	(γ-butyrolactone)	0.04	kPa	yes
	EC	(ethyldiglykol) carbitol	0.013	kPa	yes
	BC*	(butyldiglykol) butylcarbitol	0.002	kPa	no

6. The planned German implementation

The EU regulation contains minimum requirements and the member countries had to implement it in national law.

According to German law there shall be an " Act for the realization of the European VOC regulation and the modifications of regulations on the realization of the Federal immission protection law".

The conceptual draft [5] of the Federal environmental public authority of September 20, 1999 still has to be approved by the parliamentary committees (at the time this technical information went to press). When implementing the EU regulation in national law an intensification of the demanded limit values is intended.

On the ground that in this field more than 30% of the emissions originate from the application of lacquers and as a rule 70–90% of the formulated solvents are emitted the reduction plan is in particular considered technically realizable and economically reasonable for plants with a solvent consumption of 5-15 t/a. According to the state-of-technology the requirements for plants that are subject to approval (BImSchV; TA Luft) will be adopted with regard to the waste gas limit values when using a thermal post-combustion [5] (20 mgC/m³) for plants >15 t/a.

7. Limit values

Threshold values and emission limit values for the pcb industry:

Threshold value solvent consumption (t/a)	**Emission limit values for controlled, treated waste gases (mg C/m³)**		**Limit values for diffuse emission in % of the used solvents**	
	EU-RL	Germany	EU-RL	Germany
5 – 15	100	75	25	25
> 15	75*[1]	50	20	20
	50*[2]			
> 15 when using a "thermal post-combustion"	75*[1]	20	20	20
	50*[2]			

*[1] Application process

*[2] Drying process

Threshold values and emission values for plants for the production of paint or coating materials (ink manufacturers):

Threshold value solvent consumption (t/a)	Emission limit values for composed, treated waste gases (mg C/m³)		Limit values for diffuse emission in % of the used solvents	
	EU-RL	Germany	EU-RL	Germany
100 – 1000	150	100 20*1	5	3
> 1000	150	100*2 90*3 50 20*1	3	1

*1 when using a "thermal post-combustion"“

*2 is valid for waste gas cleaning units with recovery by means of condensation

*3 is valid for printing ink manufacturers with bio-filter plants)

Specific limit values apply for particularly critical materials. An emission value of 2 mgC/m³ has to be observed in case of carcinogenic, mutagenic or genetically damaging materials with the R-phrases 45, 46, 60 or 61 and a mass current ≥ 10 g/h. In case of halogenated organic materials with the R-phrase 40 and a mass flow ≥ 100 g/h an emission value of 20 mgC/m³ has to be observed.

8. Solvent balance

8.1 Fundamentals

The solvent balance serves to determine the appropriate threshold values, limit values, diffuse emissions and options for the reduction plan and to provide information to the public.

The solvent balance is a mass balance for a specified period of time, any twelve month period, and is based on the following mass flows:

$$I1 + I2 = O1 + O2 + O3 + O4 + ...+ O9$$

- Input of organic solvents in a plant (input, I):
  - I1 VOC (in a pure form or as a part of a preparation)
  - I2 after recycling reused VOC
- Output of organic solvents from a plant (output, O):
  - O1 emissions in controlled waste gases (treated or non-treated)
  - O2 emissions in waste water
  - O3 remaining solvents in the final product
  - O4 non-controlled emissions to the air (e.g. airing through window)
  - O5 solvents that are eliminated by means of chemical or physical reaction (e.g. by means of waste gas combustion, absorption)
  - O6 solvents in waste material
  - O7 sold solvents (as pure material, mixture or preparation)
  - O8 solvents and recovered preparations planned to be reused
  - O9 solvents that are released by other means

The way in which the solvent balance used depends upon the specific requirement to be checked.

8.2 Determination of solvent consumption

The solvent balance is used to determine the yearly consumption (c) of volatile organic compounds. By means of this balance it can be determined if a plant falls under the scope of the regulation and which requirements have to be fulfilled in according to the threshold value:

$$C = I1 - O8 = \Sigma\, m_{\text{VOC-content of raw materials}} - m_{\text{recycling}}$$

The consumption corresponds to the accumulated VOC contents of, for instance, lacquers, solvents, thinners and cleaning agents minus the recovered quantities from re-distilled solvents or collected preparations for reuse. The VOC contents of preparations correspond to the mass of the

lacquers minus the mass of all non highly volatile materials. Polymers, pigments and filling agents but also water or solvents with a correspondingly low vapour pressure are non highly volatile materials. These figures are available from the corresponding supplier.

As example we take a middle-sized pcb factory with the following yearly consumption:

	VOC content	**solids content**
15 t curtain coating lacquer (50% VOC)	7.5 t	7.5 t
0,5 t thinner (100% VOC)	0.5 t	
0,5 t cleaning agent (100% VOC)	0.5 t	
45 t developer (100% VOC, recycling quota 80%)	9.0 t	

Thus the following mass balance results:

C = (15 x 0.5 + 0.5 + 0.5 + 45) t/a – (45 x 0.8) t/a = 53.5 – 36 t/a = 17.5 t/a

i.e. in case of a threshold value of 5 or 15 t/a resp. this factory falls under the regulation.

8.3 Determination of emissions

The diffuse emission (D) comprises of the sum of solvent quantities that are present in waste water, remain as residues in the final product, are released to the air as non-controlled emissions or otherwise released:

D = O2 + O3 + O4 + O9

But the calculation is effected via the known or measurable values. Thus the diffuse emission comprises the addition of all VOCs excluding the emissions in waste gas, the eliminated quantities (waste gas combustion), the quantities in waste, the sold quantities and the recovered quantities according to the following equation:

D = I1 – O1 – O5 – O6 – O7 – O8

The determined value for the diffuse emission must not exceed the limit values listed in chapter 7.

The total emissions (E), or acc. to the reduction plan the target emissions, consist of the diffuse emission (D) and the emission in controlled waste gases (O1).

E = D + O1 = I1 – O5 – O6 – O7 – O8

9. Reduction plan

9.1 General demands

The reduction plan according to Appendix II B is a further central element of the regulation. It is supposed to enable the user of a plant to reduce emissions without investing in expensive waste gas reduction processes as for instance a waste gas combustion plant. But the achieved reduction of emissions has to be in the same range as it would be in case of the use of emission limit values.

To achieve this the user can make use of an individual reduction plan that was established especially for his plant. An extension of the deadline can be effected if low-solvent or solvent-free substitute materials are still in development.

9.2 Reduction plan for the application of lacquers

When implementing the reduction plan for the application of coating materials, clear lacquers, glues and printing inks explained in the appendix of the regulation it is presumed that an equal reduction of emissions will be achieved and thus the equivalence does not have to be proved in this case.

To establish the reduction plan some key quantities are required.

The yearly reference emission (B) is the fictive average total emission of a plant of a particular type that would be released in case of using conventional coating materials that contain solvents without any emission reducing measures. The reference emission is calculated from:

- the solids content F (e.g. binding agents, filling agents, pigments) of the yearly used coating materials / lacquers;

- an operation-dependent multiplication factor.

For the pcb industry the factor for miscellaneous coatings is: 1.5*.
(*A request by the committee of the pcb industry (VdL) to the Federal office of the Environment, to increase the multiplication factor for the calculation of the reference emission from 1.5 (miscellaneous coatings) to 2.33 (air- and aerospace technology), was refused on the grounds of the fixed specification in the EU regulation.)

reference emission B = solids content F (kg/a) x 1.5

The target emission (Z) corresponds to a specific percentage of the annual reference emission that comprises the limit value of the diffuse emission and an increment that is dependent upon the threshold value. The German concept assigns lower limit values to the diffuse emission and thus also to the target emission for automatic coating units. Since in case of automatic coating only the pure coating of coil coating is meant the processes in the pcb industry are not affected by this.

Threshold value	Limit value diffuse emission	Increment	Percentage	Target emission Z
5 – 15 t/a	25%	+ 15%	40%	B x 0.4
> 15 t/a	20%	+ 5%	25%	B x 0.25

The requirements are fulfilled if the real solvent emissions determined by means of the solvent balance do not exceed the 1.5 fold value of the target emission by October 31, 2005 and do not exceed the target emission by October 31, 2007.

Please find corresponding model calculations on this topic under item 11.3 "Reduction of emissions according to the reduction plan“.

9.3 Simplified proof of conformance

The simplified proof of conformance represents a simplification in the German concept. In the case of plants for coating of miscellaneous metal and plastic surfaces that are not subject to approval the target emission of the reduction plan is considered as far as in these plants only coating materials with a maximum VOC value of 250 g/l as well as cleaning agents with a VOC value below 20% are used. The VOC value of the coating materials refers to the ready-to-process lacquer, thus including the required thinners.

10. Consequences for the pcb industry

The EU-VOC regulation affects especially smaller and middle-sized companies of the branches, that owing to their production quantities fall below the lower limits of the German technical guideline "(TA) Luft" of 1986 (see also 4th BImSchV) and to date did not have to make larger investments in the reduction of solvent-containing emissions. Up to now more than 90% of the solvent emissions from lacquer processing were not affected by the "TA Luft". Depending upon the application field and the yearly used solvent quantity in future the regulation will specify compulsory limit values.

All companies affected that - owing to the EU-VOC regulation - are forced to make large investments now face the pretentious task of making the correct strategic decisions. The kind and extent of measures to reduce or avoid solvent-containing emissions at one production facility are regulated also by the location-related and location-affecting company development, i.e. in case of the expansion or new construction of a coating line the decision regarding the location should also be made with regard to the expected solvent balances and the resulting control by public authorities.

By means of technical measures, emissions can be specifically controlled and e.g. channelled to a post-combustion plant. By means of organisational measures there is a possibility to avoid or reduce emissions already at the place of origin e.g. by changing to solvent-free and low-solvent products, recycling cleaning agents and developers or by using products with a lower vapour pressure than 0.1 hPa (20°C) [68°F]. By these measures volatile organic compounds and their emissions are reduced while with waste gas treatment the remaining high quantity of volatile organic compound has to be disposed of at great expense and controlled.

More essential sources of diffuse emissions are working in open or only partially closed systems, the displacement of solvent-containing air during refilling operations and the cleaning of stationary

equipment. By means of capsulation and direct exhaust air entrapment these emissions can be reduced considerably. However, the conversion of diffuse emissions in a direct exhaust air entrapment also has to be considered in the treatment of waste gas. A reduction of the VOCs in exhaust air can be effected by means of thermal exhaust air cleaning processes, condensation absorption or adsorption.

In case of controlled emissions the main emission sources are the mixing containers and cleaning plants at lacquer manufacturers as well as coating and drying plants at lacquer users. By switching to cleaning agents with a lower vapour pressure than 0.1 hPa (20°C) [68°] there is a considerable reduction potential. If this is not possible, a reduction in the proportionate cleaning operations and thus in emissions can be achieved by increasing the batch quantity. Switching to solvent-free or low-solvent products is the best opportunity to reduce the relevant emissions for both manufacturers and most of all for users. The training of staff members in a conscious handling of highly volatile materials represents a reduction potential (closing of VOC material containers, correct use of direct exhaust air ducting e.g. by means of throttle valves).

11. Possible plans of action

There are various plans of action to observe the EU-VOC regulation. These are, among others, keeping below the threshold values, the observance of the emission limit values, the reduction of emissions acc. to a reduction plan or compliance with the simplified proof of conformance acc. to the German concept.

11.1 Keeping below the threshold values

VOC reduction by means of:

- Use of low-solvent or high solids content lacquers. Examples of these are the 2-pack solder resists of the series'
  Elpemer® SD 2467 for screen printing 77% solids content
  Elpemer® SD 2469 SM for screen printing 73% solids content
  Elpemer® GL 2467 for curtain coating/spraying 63% solids content
  Elpemer® GL 2469 SM for curtain coating/spraying 64% solids content
  Elpemer® AS 2467 for air spraying 75% solids content
- Use of solvent-free UV curing lacquers such as our
  1-pack solder resists of the series **SD 2368 UV** 100% solids content
  1-pack marking inks of the series **SD 2513 UV** 100% solids content
- Use of solvent coatings as for instance our
  Twin-Cure® DSL 1600 FLZ 100% solids content
- Changing the process e.g. switching from curtain coating/spraying to screen printing. Screen printing lacquers have a low solvents content.
- Cleaning agents that do not fall under the VOC-RL as for instance our cleaning agent **R 5899** that has been especially developed for screen washing units

Vapour pressure at 20 °C [68°F]	0.008 kPa
Flash point acc. to DIN 53 213	> 100 °C [212°F]
Evaporation index acc. to DIN 53 170	900

- Developing media that do not fall under the VOC-RL as for instance butylcarbitol or aqueous developers,
- Recycling of used solvents (cleaning agents, thinners).

By means of these corrections our model plant in chapter 8 is able to stay below the threshold value.

From the 15 t of curtain coating lacquer with a solids content of 50%, 7.5 t of solids result. In case of a solids content of 64% the model plant only needs 11.7 t of curtain coating lacquer.

	VOC content	Solids content
11.7 t curtain coating lacquer (36% VOC)	4.2 t	7.5 t
0.5 t thinners (100% VOC)	0.5 t	
0.5 t cleaning agents (100% VOC, 80% recycling quota)	0.1 t	
45 t developer (100% VOC, recycling quota 80%)	9.0 t	

Thus a mass balance results of:

C = (4.2 + 0.5 + 0.5 + 45) t/a – (0.5x0.8 + 45x0.85) t/a = (50.2 – 36.4) t/a = 13.8 t/a

i.e. in case of a threshold value of 5 - 15 t/a the factory continues to fall under the regulation but with the moderated limit values.

By switching to a developer that does not fall under the VOC-RL the factory can clearly further improve its balance: 45 t developer (0% VOC).

Thus the following mass balance results:
C = (4.2 + 0.5 + 0.5) t/a – (0.5 x 0.8) t/a = (5.2 – 0.4) t/a = 4.8 t/a

i.e. in case of a threshold value of < 5 t/a the factory no longer falls under the regulation! As long as the consumption quantities do not change considerably, the factory does not need to take emission measures. But he has to establish the mass balance each year for control purposes.

11.2 Observance of emission limit values

To observe the total emission limit values or the limit values for diffuse emission the latter have to be minimized specifically and collected in controlled, post-treated exhaust air flows.

A reduction of the VOCs in exhaust air is only possible by means of corresponding exhaust air cleaning plants. Therefore, numerous processes have been developed that are based upon the principle of oxidation, bio-oxidation or the combination of enrichment and separation.

thermal post-combustion	oxidation
catalytic post-combustion	oxidation
biological filters	microbial bio-oxidation
absorption in bio cleaners	separation / bio-oxidation
adsorption processes (active charcoal, molecular filters)	enrichment / separation
gas cleaning	enrichment / separation
condensation processes	enrichment / separation

The targetted efficiency, investment costs and operating expenses are decisive for the choice of one of the plant types. The oxidation processes require a more or less high primary energy input and for economic processing a higher pollutant concentration. High initial investment costs and running costs are disadvantages of this kind of procedure.

During the combustion of the energy sources that are partially necessary to warrant the VOC oxidation nitrous oxides are also produced and emitted that are rated as precursor substances for ozone.

The Federal environment public authority has a different opinion on this ultimately negative eco balance to avoid solvent emissions and the fact that this method creates nitrous oxides which could not be disclosed further.

11.3 Reduction of emissions according to the reduction plan

The possibilities to reduce VOC emissions already listed under 11.1 are valid for the reduction. In this case the target emission a theoretical value calculated from the solids content of the lacquers has to be observed or beaten (see also chapter 9). If a company already uses low-solids lacquers it has already won time with regard to the technical realization of the reduction in volatile organic

compounds. Lacquers adjusted to application viscosity that are used in the pcb industry typically show the following VOC contents:

- liquid photo resist for roller-coating 50 – 75%
- photoimageable curtain coating inks 35 – 60%
- conventional screen printing inks 20 – 50%
- photoimageable screen printing inks 10 – 30%
- 1-pack UV solder resists 0 – 1%

The example of a model plant shall further illustrate the calculation of the reference and the targetted emissions once more:

The model plant has a yearly consumption of:

	VOC content	**Solids content**
30 t curtain coating ink (60% VOC)	18 t	12 t
6 t screen printing ink (50% VOC)	3 t	3 t
90 t developer (100% VOC/80% recycling)	18 t	
8 t cleaning agent (100% VOC)	8 t	
Sum	47 t	15 t

Based on the solids contents, the ink solids amount to 15 t and the VOC emissions to 47 t. The reference emission is calculated by means of the branch-dependent factor of 1.5:

15 t x 1.5 = 22.5 t reference VOC

For a factory that lies above the threshold value of 15 t (factor 0.25) the target emission is calculated as follows:

22.5 t x 0.25 = 5.6 t target-VOC emission

or initially, as a primary measure until 2005 the 1.5 fold:

5.6 t x 1.5 = 8.4 t target-VOC emission by 2005

By means of a reduction the factory can reach the threshold value range of 5 – 15 t. The reduction could, for instance, be achieved as follows:

	VOC content	**Solids content**
20 t **Elpemer** curtain coating ink (40% VOC)	8 t	12 t
6 t screen printing ink (50% VOC)	3 t	3 t
90 t developer (0% VOC)	0 t	
8 t cleaning agent (100% VOC, 50% recycling)	4 t	
sum	15 t	15 t

The resultant total balance would be 8 + 3 + 4 = 15 t VOC consumption. The target emission is calculated by applying factor 0.4:

22.5 t x 0.4 = 9 t target-VOC emission

or, initially, as a primary measure until 2005 the 1.5 fold:

9 t x 1.5 = 13.5 t target-VOC emission by 2005

The reduction to achieve the target emission could be effected as follows.

The model plant has a yearly consumption of:

	VOC content	Solids content
18.4 t **Elpemer** curtain coating ink (35% VOC)	6.4 t	12 t
3.4 t **Elpemer** screen printing ink (11 % VOC)	0.4 t	3 t
90 t developer (0% VOC)	0 t	
8 t cleaning agent (100 VOC/50% recycling)	4 t	
sum	10.8 t	15 t

While the ink solids are still 15 t, the VOC emission is only 10.8 t. Thus the model plant A is able to achieve the first step of the reduction plan by the deadline of October 31, 2005. By switching to a recycling quota of 80% in case of the cleaning agent (equating to 1.6 t VOC) a VOC emission of 8.4 t results, i.e. the reduction plan is already achievable for the model plant as of now.

11.4 Simplified proof of requirements

The sole use of lacquers with a maximum VOC content of 250 g/l, e.g. the photoimageable screen printing solder resists of the series **Elpemer® SD 2467** and cleaning agents with less than 20% VOC (e.g. the VOC-free **R 5899**).

12. Summary

Environmental protection concerns all of us - and indeed there is a continuously increasing sensitivity regarding environmental protection but environmental protection causes enormous cost increases in many branches. This is particularly the case in the pcb industry, the assembly industry, for coating companies and also numerous suppliers to these branches.

Owing to the immense impact of the EU-VOC regulation, its rigorous requirements, the time frame that has to be observed (see also chapter 4) and last but not least also owing to the associated time and cost intensive measures that have to be taken and implemented by all participants (lacquer manufacturers and lacquer consumers) we have compiled this TI 15/110 as extensively as possible. The indicated sample calculations should be a valuable aid in realizing the regulation.

For a technology choice that ensures a safe future on the one hand the VOC regulation grants a time period until 2007 in case of existing plants to realize this regulation but on the other hand in case of new equipment or extensions of existing plants the VOC regulation becomes immediately effective.

Therefore it is necessary to develop strategies in time and then to realize them as economically as possible for which the below examples shall be corresponding impulses:

- prefer high solids content lacquers, i.e.
- introduction of low-solvent coating processes
- switch to UV lacquer systems that do not fall under the VOC regulation where ever it is possible
- already to develop strategies to realize the VOC regulation
- to plan the use of "aqueous inks" where possible, as for instance, in case of the application of conformal/permanent coatings or to use our new solvent-free "thick film lacquers" (**TWIN-CURE®**)
- to devise existing coating processes more efficiently
- to simulate and plan sensibly regarding the VOC reduction in case of new coating plants
- an important aspect in this connection is an increase in the degree of process efficiency
- the year 2007 comes faster than expected (!); thus start planning in time and develop entire concepts (reduction and process efficiency degrees)
- and never forget:
- There is a close connection between environmental technological (solvent economy plan, disposal economy plan, dangerous goods register) and economic balancing (process cost calculation).

The creation of this TI 15/110 surely shows that we have attended to the EU-VOC regulation in detail and can and will be a competent partner of our lacquer users to realize this regulation. The best example for this should be that already in autumn 2000 we have presented our cleaning agent **R 5899** to the experts which neither falls under the VOC regulation nor under the "regulation for flammable liquids (VbF)" and which according to the dangerous goods regulation does not have to be marked.

13. List of abbreviations

BimSchG	Federal immistion protection law
BimSchV	Federal immision protection decree
EC	European Community
EU	European Union
K	Kelvin
kPa	kilo-pascal
mbar	milli-bar
RL	regulation
t	ton (s)
TA Luft	Technical instruction to keep the air clean
UBA	Umweltbundesamt (Federal ministry of the environment)
VdL	Verband der Leiterplattenindustrie (committee of the pcb industry)
VOC	volatile organic compounds
VOC-RL	regulation on volatile organic compounds

14. Further literature

[1] Regulation 1999/13/EG of the committee, official gazette of the European Communities, 11.03.1999, No. L85/1

[2] European agreement about Control of Long Range Transboundary Air Pollutants, 1979

[3] Background paper to implement the EU solvent regulation in German law; Federal ministry of the environment; 03.12.1999

[4] BMU/VCI report, status end of 1997

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