Guide

SOLVENTS IN THE COATINGS INDUSTRY

An introductory guide to solvents: cleaning, handling and reducing dependency on solvents.

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WHAT ARE ORGANIC SOLVENTS AND VOC'S?

For solvent borne coatings, it's important to know what solvents are and how and why they are used. This helps us to think more about their storage, their disposal and perhaps the methods of cleaning and/or reducing waste. Because VOC's vaporize after application (more on this later), and an organic solvent is an example of a VOC, their health and safety regulations are becoming stricter by the day.

They have many vital uses and are highly effective as a solvent as well as a cleaning agents. In the coatings industry, they are of course also used for dispersion.

There are several different types of organic compounds that are being used as solvents such as:

- Methanol
- Acetone
- Benzene
- Hydrocarbons (both nitrated and halogenated).

Because organic solvents evaporate they can create an air pollutant. This is called 'ground-level ozone' which, in high doses can have detrimental effects on the health of both humans and the environment. That's why many types of organic solvents are not only strictly regulated, but are classified as (potentially) carcinogenic and toxic.

WHAT ARE VOLATILE ORGANIC COMPOUNDS (VOC'S) AND HOW ARE THEY CALCULATED

We've touched briefly on VOC's, but it's worth revisiting what they are, especially because they are commonplace in the paint and coatings industry. VOC's are chemical compounds that can vaporize after application, or sometimes even while they are in storage. After evaporation, the substances can enter the atmosphere, where they can do serious harm. VOC's are used in a variety of products. Organic solvents, a form of VOC, are used in many household cleaning products for example. The potential harm is exacerbated when the VOC containing product is used indoors (or an area with poor ventilation).

In order to be fully compliant with your local laws and regulations, it's important to understand how VOC's are calculated in your industry: Within the paint & coatings industry, VOC's are measured by the calculated mass of the VOC content relative to the overall volume of chemical. In most cases, this is represented as either grams/liter (g/l) or pounds per gallon (lbs./gal.). Source.

MANAGING, MONITORING AND REDUCING THE USAGE OF SOLVENTS

Because solvent use requires a lot of oversight, and potential legal ramifications, it is vital that you monitor your solvent usage. An added benefit, is that you can reduce costs. After all, improper handling and maintenance can cost a lot of money, and any improvement in efficiency is a big plus.

Solvent usage costs a lot of money and it is therefore advisable to see where and how you can reduce the amount of solvent needed. This can occur in nearly every step of the production cycle, but in this guide, we're going to focus especially on the plant management aspect.

THE BENEFITS OF REDUCING AND PROPERLY MANAGING YOUR SOLVENT USE

Here are a few ways this can have a positive impact on your plant:

- Reduce the risk of spillage or environmental accidents
- Reduce costs and increase profitability
- Add value to your product due to an increased focus on environmental responsibility
- Reduce waste and cleaning efforts
- Ensure worker safety
- Ensure you are in full compliance with local laws and regulations

HOW TO MONITOR YOUR SOLVENT USE

The type of information you will need to gather to effectively monitor your solvent usage, in order to make actual improvements, will depend on a few factors (like your objectives and capabilities). According to Netregs:

You may have to:

- carry out stock monitoring and control - eg quantities of organic solvent in materials, amounts purchased and used;
- monitor emissions periodically or continuously;
- provide total emissions data or detailed information about specific compounds;
- record the conditions under which measurements are taken - eg pressure, temperature, oxygen content and operational conditions;
- carry out calculations of mass emissions, requiring flow-rate measurements;
- comply with specific regulatory requirements.

If you are monitoring solvent use as part of a solvent management programme to help you reduce costs, you may need more regular and detailed sampling techniques.

Additionally, it's important to know the scale of your VOC emissions as this plays a major role in the requirements of the data you've gathered. According to PCImag:

> *"[...] the level of monitoring required by regulators is dictated by the scale of an operator's VOC emissions, with continuous monitoring required for the larger emitters and discontinuous monitoring for processes with lower emissions."*

Monitoring solvent usage and emissions is a complex and arduous process. There are various methods that you can choose form, and they have different use cases. Please note that a lot of the advice depends on your specific situation, but there are several important general guidelines to take into consideration.

It's important to consider a few important things, that start with the **legal** requirements. Things like the accuracy required, and the type of data that's needed how often it is necessary to log this data.

Additionally, it's important to understand the **equipment** needed. Do you have the necessary tools or do you intend to acquire these from external suppliers? Always ensure your suppliers have the necessary accreditation and their equipment is compatible with your goals.

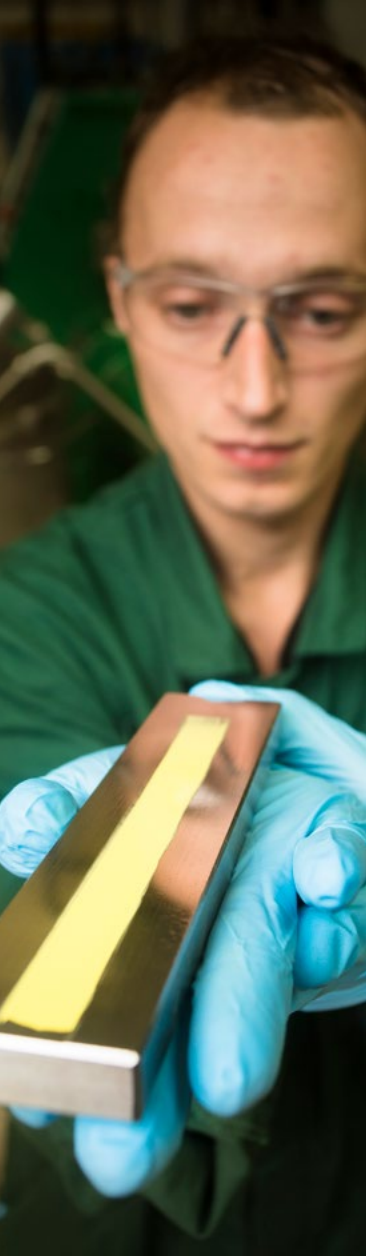
How about the **people** you intend on putting in charge of this research: do you plan on creating a dedicated team for this, or are you looking to hire external teams who specialize in this?

For each of these aspects you could hire external parties to take care of this, or you could do this internally (or at least certain parts of the process). There are pros and cons that depend on your specific situation (and the regulations you are required to follow).

Always ensure a set process so you have reliable and reproducible results. This is vital if you want to reduce solvent use and/or comply with local laws and regulations. Don't allow your data to sit dormant: submit the data from your measurements as soon as possible so you are in full compliance. Additionally, having a fixed process helps you analyze your solvent usage over time so you can identify opportunities for improvement.

- Define key parameters in advance – what are you measuring, when and in what locations?
- Establish responsibilities (who will do what and in what timeframe)
- Clearly establish reporting methods: how will you collect and standardize the results. If you cannot standardize, you cannot compare.

Monitoring



THE BENEFITS OF EVALUATING SOLVENT USAGE IN THE PAINT AND COATINGS INDUSTRY

The main goals are to ensure compliance, and to increase efficiency. Using the methods described above, you now have a baseline that can help you to see the process laid bare.

- Is your solvent usage higher or lower than expected? Now you can you compare this to a previous period and see what changes were logged. Did they have a positive or negative impact?
- Do you see any unexpected spikes? This could indicate malfunctions or problems somewhere in your manufacturing process.
- Where can you reduce solvent usage? Seeing the process laid out like this, helps identify potential weak links in the chain you can eliminate (or replace).
- Where can you combine and streamline waste management? Would it make sense to connect a few steps to be more efficient in how you dispose / handle used solvent?

MANAGING YOUR USAGE OF SOLVENTS

The main goal is to reduce the amount needed (which has a positive impact on your bottom line) as well as being able to achieve the same result without all the legislative hassle.

Using the plan you've created in the previous section, you should now have a decent overview of your solvent usage, how this increases/decreases over time and what factors influence this. You also know what steps in the process have an outsized impact on your solvent usage. The next step is to take a look at:

1. your inventory and procurement;
2. recovery;
3. handling and clean up.

When it comes to **inventory**, we advise keeping an up to date inventory of the solvents you keep in your plant, where they are stored and what your procurement process looks like. This is because it can often be the case that your procurement process can be a source of inefficiency. Depending on your jurisdiction, having a larger tock of solvents on hand can be inefficient and cost money (due to stringent regulation). Therefore it's important that you:

- Monitor usage efficiently
- Buy based on actual quantities you use, which you can validate using the data
- Ensure older materials are used before you purchase new ones – have an inventory system in place where older materials are easier to reach thereby encouraging usage of older materials (thereby reducing the chance of having to dispose of unused materials).
- Discuss, if possible, the opportunity for custom deliveries with your suppliers. Buying in bulk can significantly reduce waste, as well as increase efficiency. Discuss streamlining delivery schedules so your responsibility for storage of large amounts is limited.
- Monitor and track your procurement efforts. This can greatly help you in your analysis: if you see noticeable changes in your solvent usage, check to see if there were any modifications in your procurement approach (different product / suppliers /etc.).

Track and analyze usage: this can make a big difference in your solvent usage. Make sure you not only correctly log each purchase and the corresponding supplier, but also the area you stored this order. Additionally, make sure log the usage and cross-check that with the amount purchased. This helps you understand whether or not you are purchasing too much.

SOLVENT RECOVERY

An often overlooked, but potentially large opportunity is solvent recovery. The benefits are obvious:

- It can significantly reduce costs (by reusing or reclaiming the solvent used)
- It can help with price negotiations as well as your regulatory load
- It can also reduce your waste management requirements

There are many different methods of going about this, each has certain requirements, and pros and cons, for example:

In organic solvent recycling, the most frequent issue is the removal of water content. Even traces of water can cause unexpected solubility problems, side reactions, or the decomposition of a reactant. There are various processes to recover wet solvents such as distillation methods or fractional freezing, whereas adsorptive methods are advantageous due to their low energy consumption.

The important thing is to assess whether or not this is a feasible option for your plant. A big part of this, is to ascertain the recoverability of the solvent. This requires specialists doing in-depth laboratory research to ensure the solvent would be of value to you (or perhaps a third party).

The 3 most common methods are according to Condorchem are:

Separation by membrane technology

Organic solvent nanofiltration membranes chemically resist a wide range of organic products, such as alkanes, aromatic compounds, alcohols, ethers, ketones and esters, and separate contaminated mixtures and organic solvents at low temperatures via fractionation operations. Membrane separation can be used as a single process or in addition to basic separation operations (e.g. distillation, extraction and absorption).

This very selective process has special relevance when it is desired to recover compounds that are sensitive to high temperatures or of high economic value.

Multi-stage adsorption

Using an adsorption tower with activated carbon as filler and a desorption tower, certain organic solvents can be recovered and concentrated. The recovery efficiency can reach 95%, but depends on the concentration of the solvent, the kind of pollutants it carries and the effluent temperature. Nitrogen gas is used for desorption and final recovery of organic solvents.

Instead of activated carbon, polymeric adsorbents can be used, depending on the solvent to be recovered.

Distillation

The most sustainable and economical solution for organic solvent recovery is distillation. The raw material is subjected to a vacuum to reduce its boiling temperature and the heat required in the distillation equipment. Depending on the level of contaminants in the initial raw material, the temperature and vacuum pressure can be adjusted to achieve recovery of the solvent. One reason for this process being widely used is that it is practically viable regardless of the initial solvent mixture composition; this is a significant advantage over other processes.

The non-distilled (concentrated) material may be able to be recovered energetically. **(Source).**

There are several steps you can take to ensure the amount of solvent that can be recovered is as high as possible:

- keeping solvent residues separate to avoid cross-contamination
- pre-cleaning products to be treated with solvent, so they are free from contaminants which can cause sludge
- matching cleaning solvents to those used in product formulations to prevent contamination. **(Source).**

Here is a general overview of the solvent reclamation process, as defined by the EPA.

HANDLING AND CLEAN-UP

Another, often overlooked way to seriously improve solvent management, is making sure your staff has the adequate and up-to-date training required. Because organic solvents require very strict management protocols, it's important to ensure everyone's knowledge is up-to-date. Your staff must be able to use the latest methodologies (using specific container that are clearly labeled), so that you can be sure no gases can escape. The complexity arises when you take into account that some organic solvents are perfectly fine to store in the same container, whereas others are absolutely not. To be careful, a lot of companies simply keep combinations to a bare minimum, which while is it safe, can be unnecessary. Knowing which organic solvents are perfectly safe to combine in their disposal, and which ones are not, can be a significant boost to your efficiency.

Secondly, it is important that your waste disposal partner has the proper permits and transportation methods. This way, any solvent that cannot be reused, can be safely discarded using a trusted partner. It is vital that you monitor this aspect because in many countries, you carry the responsibility for the proper disposal of this chemical waste. It is not enough to pass it off to your waste disposal partner.

Consider using less harmful low-solvent or no-solvent alternatives. Water-based and low-emission materials are now available and can save you money. You should discuss these options with your suppliers and relevant staff.

EFFICIENT STORING OF SOLVENTS

When it comes to storing solvents, there are some local laws and regulations you have to check to make sure you are in compliance, but in general, the advice is actually quite simple:

1. Always try to keep emissions down when not using the solvents. Make sure you have proper containers that you can seal tightly to avoid gases escaping. Ensure you have containers that match the specifications of your types of solvents.
2. Ensure a proper handling of waste solvents – this also means that material used to handle solvents, like towels / wipes, should not be left out in the open. Have specific containers or sealed storage units for these as well to prevent evaporation.
3. When preparing, combining and handling solvents, always ensure this is done in a specific area created solely for that purpose.
4. Make sure you take necessary precautions. This means having proper ventilation, using personal protective equipment, using spill protection and use safe handling techniques.

"These areas should be well labelled, well ventilated and have appropriate secondary containment systems. If you use solvents for cleaning purposes, consider using equipment that will minimize emissions, e.g. a sealed system." ***(Source)***

The most important thing when it comes to transporting solvents is to make sure you have established routes that are free of any obstacles, potentially dangerous objects and are distinctly marked so your trained staff knows exactly where they should be, and that you use proper equipment when transporting solvents to minimize the risk of dangerous incidents **(source).**

REDUCE UNNECESSARY USAGE OF SOLVENTS

Solvent is an integral part of the paint and coatings industry, but it can be beneficial to your bottom line (as well as the efficiency of your plant in general) to always be on the lookout for ways to reduce solvent usage.

NiBusinessInfo has written a great guide on this aspect, which we've summarized here. Generally speaking, reducing the amount of solvent used, can happen in 3 different ways.

1. Reducing 'wasted solvent': this refers to solvent emissions due to improper sealing or not using airtight containers and other processes that might eliminate or minimize evaporation or spillage. In general, always check to make sure you are minimizing any solvent loss by:
   a. Sealing the solvents and their boxes/containers with closed and tight covers.
   b. Reducing exposure to heat and light if possible to avoid evaporation
   c. Using automatic shut off devices to ensure no leakages happen
   d. Have an alarm system in place that measures any leakage or overflow so you can be alerted immediately.

2. Minimizing usage of solvents by using more precise dosing methods and devices. The idea here is that many facilities use sub-optimal methods of applying/using solvents and that switching to different delivery methods could significantly cut back on solvent usage:
   a. Using spraying to apply solvents to ensure smaller dosages
   b. Using custom extraction systems to avoid or contain emissions – especially when the system, you are working with is closed (think of the pressure inside the system).

3. Proper handling and preparation can also reduce the amount of solvent needed. As NiBusinessInfo puts it there are several steps you can take to ensure a more efficient mixing and preparation methodology:
   a. pouring materials during mixing in order of volatility from lowest to highest
   b. marking measurements on the container side when decanting from large containers
   c. avoiding splashing when filling mixing vessels and machine reservoirs **(source)**.

CLEANING

Cleaning and plant hygiene in general, is an integral part of the coatings manufacturing process. Especially if the paint requires solvent to clean, this can cost time and money. There are several ways paint manufacturers can deal with these issues. We've already addressed minimizing solvent usage, but there are several other solutions that can minimize costs that are connected to solvent usage, and other aspects of the coating manufacturing process.

EXAMPLES

- ***Reduce hazardous waste generation:*** include use of a solvent still to turn solvents used in paint manufacturing process into wash solvents and segregating and reusing tank washings as for future batches for like solvents and colored systems (source).
- ***Use different cleaning agents:*** Using alternatives to solvents such as low-vapor-pressure (LVP) solvents, low-emission cleaning options or water based formulations. You could also consider using higher quality solvents as they are able to clean more paint per volume. This can actually decrease the amount required, which could also lower you waste costs.
- ***Use environmentally sound solvents:*** there's a large selection of 'green solvents' you can choose from that can do the trick, albeit with some adjustments in your cleaning methodology.
- ***Adjust your cleaning strategy:*** a pre-clean method can help you reduce your dependency on solvents (using a scraper initially, followed by non-solvent agents to clean the area). Also consider using CIP, or cleaning in place. These can automate difficult and labor-intensive high-pressure cleaning methods.
- ***Reuse solvents:*** As previously mentioned, solvent reclamation is a big part of this strategy, so discuss ways in which you can capture used solvents properly or at the very least minimize evaporation. From our article on plant hygiene:
- ***Use pigging:*** Another aspect we've previously touched on in our article on plant hygiene in the coating industry, is pigging. Pigging can be quite beneficial in cleaning your machinery and pipes.

A solution that could help with this issue, is a pigging system, which cleans the pipes while it still remains intact and thereby reducing the need for costly and time-consuming deconstructions. HPS Pigging explains this as follows:

> *"specialist projectile (the 'pig') to recover and remove the product residue remaining in the pipeline at the end of the transfer process. The hygienic (sanitary) pig has a diameter slightly larger than the pipeline that it is pigging. So, this enables the pig to recover nearly all the product remaining in the pipeline*
>
> *A method like this could help recover a large amount of the residue that often is left behind in the pipes. While this method can help greatly in the cleaning of the pipes, it will still require additional technical cleaning efforts for the other parts.*

- ***Bonus tip:*** use reusable cups: Granted, this one is not as related to cleaning and solvent use, but it is related to hygiene and costs. We've found that using a water based washer for cups is a really interesting idea. The company 'Brinklake' has a machine that cleans cups used for testing or developing paint/colors. Knowing that a typical paint cups costs approx. €0,75 and a typical coating company can use hundreds, if not thousands per day, this could be a serious, sustainable saving.

CONCLUSION

We hope this guide has given you an overview of the different methods and approaches to solvent management. Reducing and optimizing your handling of solvents, makes you more efficient and helps your bottom line significantly.

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