Substitution Handbook

Prepared within the project LIFE07 ENV/EE/000122
"Baltic Actions for Reduction of Pollution of the Baltic Sea from Priority Hazardous Substances"
(BaltActHaz)

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Introduction

Substitution of hazardous chemicals is one of the most important tools by which the chemical impact on humans as well as the environment may be reduced.

We are surrounded by thousands of chemical substances, of which some are suspected or known to have hazardous effects on the environment and on human health.

The best solution to this problem is to substitute the hazardous chemicals with some less hazardous ones.

The substitution will help to improve the environment as well as the working environment. Substitution of hazardous chemicals is required by present chemical legislation, and a range of tools, which are useful for the practice of substitution, already exists.

Therefore it is essential that the concept and practice of substitution is introduced to production managers and practitioners in enterprises in order to integrate this into their frame of knowledge and understanding.

This handbook is prepared within the project „**Baltic Actions for Reduction of Pollution of the Baltic Sea from Priority Hazardous Substances „ (BaltActHaz).**

The aim of the handbook is to provide help to enterprises of different industry branches in decision making regarding the substitution of hazardous chemicals in processes and products.

One thing, however, is theory and another practice, and barriers as well as challenges are plentiful when substitution is to be introduced.

It presents both theoretical overviews and several examples of already developed substitutions in order to illustrate not only the challenges, but also some ways and means, which may be utilised.

Part I. Background on substitution

1. Substitution of hazardous chemicals – what is this and is this for my company?

If you are using hazardous chemicals or use any chemicals at your company, you might be required to substitute them.

Substitution can simply be a replacement of a certain chemical substance with another, less hazardous one. But often substitution is not just the replacement of one substance by another, but also involves other technological and/or organisational changes.

DEFINITIONS:

Substitution means the replacement or reduction of hazardous substances in products and processes by less hazardous or non-hazardous substances, or by achieving an equivalent functionality via technological or organisational measures.

Hazardous substances or hazardous chemicals: chemicals that have the potential to harm people or the environment

The substitution principle is a general preventive strategy, intended to reduce the risks associated with the use of chemicals.

Substitution may be performed in a variety of ways depending on the application of the hazardous chemical. Approaches vary from substitution with a less hazardous chemical that exhibits the same technical functionality to complete product or process redesign. This allows the same desired result to be obtained by different methods and encourages innovation.

However it does not mean reduction of the emissions of a hazardous substance in a process by technical means, e.g. use of closed equipment or reduction of exposure by personal protective equipment or ventilation etc. This can only be supported by

technological and organizational measures, which lead to a reduction of chemicals quantity used or emitted.

The substitution is regarded as the most effective preventive tool for elimination or reduction of exposure to materials that are toxic or pose other hazards to workers, society or environment.

This eliminates hazard at the very source while technological or administrative measures still keep the risk existing and require additional efforts and resources to control that risk.

And even though it sometimes at first sight has looked as if the end products would turn out to be more expensive and of poorer quality after a substitution has taken place, advanced technology has in the end made it possible to produce competitive products.

One of the major challenges lies in achieving substitution without increasing energy use. Because energy is becoming a more expensive resource, there will be more incentive to develop solutions that combine the dual purpose of avoiding hazardous chemicals and saving energy.

2. Reasons and drivers for chemicals substitution – why to substitute?

We all want that our **company image** and competitive edge be better.

Changing to safer chemicals or working practices could give you competitive advantage, increase workers well being and reduce risk to the environment. This can be also a powerful sales argument.

Voluntary substitution of hazardous substances is not yet a common practice, although the important driver for substitution is the company image, i.e. care about environment, workers and clients, public concern and social responsibility. Voluntarily is possible to substitute the chemicals within the scope of green

procurement, ecolabelling of product or setting environmental management system ISO 14 001.

The substitution principle is already incorporated in **EU legislation.**

Mandatory substitution is required by legislation. Substitution of a substance on its own, in a mixture or in an article is required by EU chemicals legislation (e.g. REACH with restrictions of certain types of uses or complete bans on a number of substances). It required when manufacture, use or placing on the market of that substance causes an unacceptable risk to human health or to the environment.

Still such factors as technical functionality, risk with respect to quality of product and liability or short term economic consideration might become serious barriers for the substitution. But for many substances cheap and efficient measures already exist, which might not only enhance your company's environmental status and help in avoiding potential complications with the legal requirements, but also improve your financial performance.

3. Identification of substitution needs – what to substitute?

Substitution is required for hazardous substances with the following properties:

Substitution is required for **hazardous substances in products and processes** that cause an unacceptable risk to human health or to the environment.

- carcinogenic, mutagenic and reprotoxic,
- persistent in the environment, toxic and bioaccumulative,
- other substances of equivalent concern, i.e. causing serious threat to the environment or people if not handled properly, e.g. endocrine disrupters.

Identification of substitution needs at a company level requires adequate data on the hazardous effects of all chemical substances used in company.

This means that it is important to know the exact chemical composition of their products. But often the producers of the raw materials are reluctant to supply this information, which makes it quite challenging for downstream users to minimise the negative effects on the environment and on human health.

To have overview of hazardous chemicals management in an enterprise and to identify possible candidates for substitution look **Part C** in **„Permit Guideline"** prepared within the project BaltActHaz.

„Permit Guideline" prepared within the project „Baltic Actions for Reduction of Pollution of the Baltic Sea from Priority Hazardous Substances „ (BaltActHaz) Part C – **Hazardous chemicals management in an enterprise** – provides guidance how to identify the substances which need to be substituted, how important is to keep the inventory of chemicals used in company and how to map the hazardous substances.

IMPORTANT!
The main regulations requiring substitution of hazardous substances

The main regulations and conventions which set restrictions for use of numerous substances, therefore subsequently requiring substitution of hazardous substances are:

- **REACH Regulation - Regulation No 1907/2006 on registration, evaluation, authorisation and restriction of chemicals**

- use of substances of very high concern will need to be authorized (Annex XIV); candidate list for authorization is available on http://echa.europa.eu/chem_data/authorisation_process/candidate_list_table_en.asp.

Substitution of a substance of very high concern by suitable safer alternative substances or technologies should be considered by all those applying for authorisations of uses of such substances on their own, in mixtures or for incorporation of substances into articles by making an analysis of alternatives, the risks involved in using any alternative and the technical and economic feasibility of substitution.

- a number of substances restricted (Annex XVII)

Different kinds of restrictions apply to substances which are persistent, toxic, bioaccumulative or may cause cancer, genetic damage or endocrine disrupting. The list of REACH restricted substances is available on http://echa.europa.eu/legislation/reach_legislation_en.asp#annex_xvii.

- **WFD - Water Framework Directive 2000/60/EC, amended by 2008/105/EC**

  - provides list of 33 priority and priority hazardous substances and substances' groups; priority hazardous substances have to be phased out from use and production by 2020, progressive reduction of discharges, emissions and losses of priority substances must be enforced

- **WEEE - Directive 2002/96/EC on waste electrical and electronic equipment**

  - Lists substances which have to be removed from waste electrical and electronic equipment and treated separately

- **RoHS - Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment**

  - Restricts the use of six specific substances in electrical and electronic equipment (lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls and polybrominated diphenyl ether)

- **The Helsinki Convention and Baltic Sea Action Plan - Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area and its Baltic Sea Action Plan**

- Focuses particularly on 13 substances for which national management programs are developed. They set criteria for reduction of emissions from these substances which in some cases can mean restriction and use of these particular chemicals.

➢ The Stockholm Convention - Stockholm Convention on Persistent Organic Pollutants

- Lists 22 substances or substance groups out of which production and use has to be eliminated for 17, restricted for 2 and measures have to be taken to reduce unintentional production of another 3.

➢ IPPC Directive - Directive 2008/1/EC on Integrated Pollution Prevention and Control

- Sets requirements for industrial enterprises to assess and fix certain emission limit values for several pollutants, especially substances and substances' groups listed in Annex III

➢ IED – Directive 2010/75/EU on Industrial Emissions (Integrated Pollution Prevention and Control)

- Replaces the IPPC directive. Came into force on 6 January 2011. Transposition into national law by 6 January 2013. Extending the scope of the IPPC Directive to cover certain activities (e.g. combustion plants between 20 and 50 MW) and clarifying the scope for certain sectors (e.g. waste treatment) to increase consistency and coherence of current permitting practices.

4. How to get started with substitution? What are the steps?

Enterprises must identify dangers and problems, assess the risks associated with their activities, and draw up plans and measures to reduce these risks. All enterprises that use substances that may be hazardous to health or the environment are required to apply the substitution principle.

In order to get started with substitution in your company, you need to consider the following:

- Which chemicals in products or processes to substitute?
- What are alternatives?
- How to avoid replacing one problematic substance with another?
- How to avoid shifting problem to another area?
- How to set up a system to support substitution?
- How to communicate it internally and externally?
- How to afford the substitution in a competitive environment?

Substitution may be performed in a variety of ways depending on the application of the hazardous chemical. However to assess all potential aspects of substitution, it is advised to take the following **main substitution steps**:

- **Identifying hazards and assessing risks**

This step involves deciding whether the current substance or process is a hazard. Is there a significant risk involved in storing, using or disposing of a substance? A hazard is defined as "the potential a substance or process has to harm someone or damage the environment." Risk is "how likely this is to happen."

- **Identifying alternatives**

Investigate a a wide range of options. Compare all of the hazard assessment information available concerning alternatives. A very careful evaluation must be done before any substitution plan to ensure that the new, alternative chemical does not pose a greater hazard than the currently used product.

- **Analysing effects of using these alternatives**

Think about what could happen if you use the alternatives. It is important that you have gathered all available information before this step so that you can make a realistic comparison of both the good and bad points.

- **Comparing alternatives**

Compare the alternatives with each other, and with the substance or process currently being used. Use material safety data sheets and other sources of chemical information to compare the hazards of various materials. The important properties to compare are: short and long-term health effects, cancer-causing potential, reproductive effects, persistency in the environment, bioaccumulation etc.

- **Decision whether to substitute**

This step is the most difficult. When companies decide to substitute, it is important that they make sure that the substituting substance(s) or the new production method are in fact better for the environment and for human health. Remember that a change in one step of a process can affect many others.

- **Implementation**

Plan the change in material or process carefully. Remember to train and educate the workers involved.

➢ Assessing the change

Check to see if the substitution has produced the intended results. You may find monitoring the health of the workers, monitoring the level of contaminants in the air/wastewater, or fulfilling legal requirements useful parameters to measure.

Only when fulfilled these steps you can see overall effectiveness of your solution.

Part II. Substitution in practice

When it comes down to practice, several tools and options exist to help you with all steps of substitution – from identification of substitution need till checking of implemented alternatives. This part of guidance will bring you through main phases of substitution and offer several tools to use when you are dealing with substitution in practice.

1: Is substitution relevant for us?

When starting to think about possible need to substitute chemicals, it is important to determine if such actions would be in principle an actual issue for your company. Please go through the questionnaire below by answering to each of the questions with "yes" or "no".

Question	Yes / No	Note
Are we using chemicals?		If you could do without chemicals, you could reduce the risks to the environment and workplace safety and make your environmental permitting conditions easier. If you are in a business where chemical use is necessary, considering changing to safer chemicals is good practice. Changing can **help you reduce costs, improve performance, follow legal requirements and increase safety.**
Do we use chemicals often and /or in large amounts? Are the chemicals hazardous?		If you use hazardous chemicals or use any chemicals in large amounts and/or repeatedly, this could be of a potential harm to workers and environment. This is especially relevant if chemicals which are marked as hazardous are being used. **Changing could reduce the potential for harm**
Do we know what chemical risks substances in use are posing?		By law, you must know and control risks from chemicals you use. If you use chemicals classified as carcinogenic or mutagenic you must replace them if there is a technically suitable

Do we have a legal obligation to find less hazardous substitutes?		alternative. Certain substances or substance groups are prohibited for use at all or in specific product types. Additionally, changing chemicals may reduce your administrative burden and simplify paperwork.
Are our chemical risks controlled? Do we use technology, automation, procedures or personal protective equipment? Are environmental protection measures in place?		Control measures are specified by the supplier for each chemical – look at the safety data sheet to check you are using these. Changing to less hazardous chemicals or changing the way you work can reduce the need for control measures. You might also be able **to reduce** the cost of controlling chemical risk.
Is company image and good reputation of our products important?		Changing to safer chemicals or working practices could give you **competitive advantage, increase workers well being and/or reduce risk to the environment. This can be a powerful sales argument, especially if your product is sold to/used by wide range of consumers.**

If you answered the first and at least one of other questions with "yes", substitution could be an option to look in to. Even if after assessing the needs of company you will not decide to substitute anything, going through the next steps will help you to get a better overview of chemicals flow in your company and identify potential risks.

2: Assessment of risks

Chemical risk assessments should be always up to date for all your chemical uses and results communicated to workers and authorities. If you have not assessed your chemical risks, start on this straight away. Always do a new risk assessment when you make a change. Check at least annually that all chemical risk assessments are up to date. You may have to do chemical risk assessments for several purposes:

- Occupational health and safety impact – always
- Environmental impact (e.g. for environmental permits)

- Major accident hazard potential (use, handle or store large amounts of dangerous chemicals)
- Health and safety impacts to public or customers

It is a good idea to integrate chemical risk assessment into your overall risk assessments. It is also a good idea to assess the risk to the environment, people and property at the same time: this will save you time and effort. Make sure you can relate the chemical risk levels to other risks.

How to assess the risk:

There are three parts to the risk assessment:

A: Establish the hazard;

B: Establish how you use the chemical and what can go wrong to establish exposure potential; and

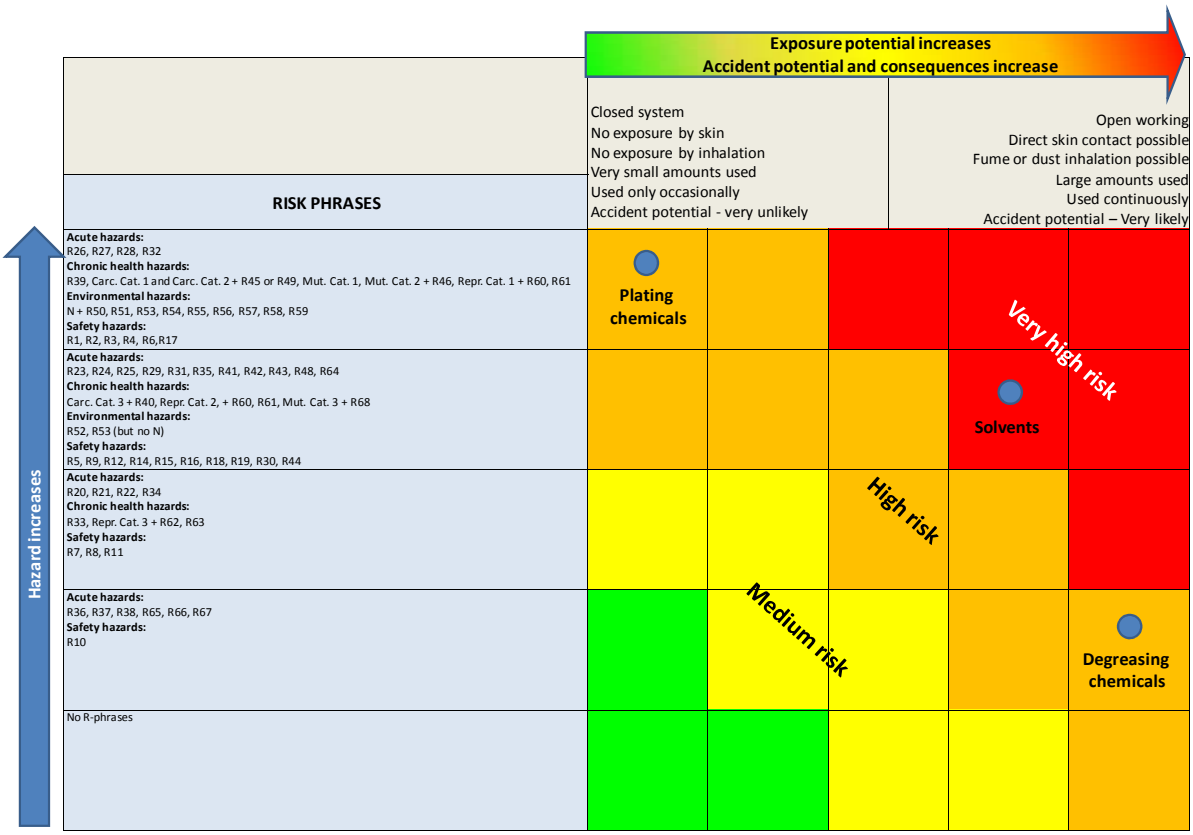
C: Evaluate the risks from normal use and evaluate the risks from incidents to the environment, people and property.

Determining the risk levels

This case illustrates how to use the risk matrix for hazard assessment.

Company makes barrels and use chemicals in several areas. The main categories are cleaning chemicals, plating chemicals, paints and solvents.

Looking at the hazards identified the plating chemicals as most hazardous. The plating is however done in a closed system, so the exposure potential is very low. The company also recycles old tanks, and as part of this, the metal has to be thoroughly cleaned. The degreasing chemicals used are labeled Xi and R38. The degreasing has been done with a pressure spray. This combination gives a high risk for the worker of inhaling the chemical from the fine spray created. The solvents used are flammable and are used in open jars to clean tools. The solvent vapor can form explosive clouds of fumes. The solvent was therefore classified as high risk.



A sample of this matrix can also be found in Annex 3 of this handbook.

Rank the chemical risks you assessed. You can rank the risks from highest risk to lowest risk for different types of risk (health, safety, environment, property etc.) or you can attempt to find the highest overall risks. Different types of risks cannot strictly speaking be directly compared, but you can use tools to help you define if each type of risk is acceptable or not. The risk matrix shown earlier is adequate for most needs. Based on hazard and exposure potential, assign all risks to the categories very high, high, medium or low. This step is vital; it allows you to find out where it is most beneficial to start the mitigation process.

Start by looking at chemicals with the highest risk for the next steps of the process. Continue down the list until you reach chemicals with the level of acceptable risk. Below is an example of a ranked list of chemicals.

Chemical	Hazards	Task	Exposure potential	Accident potential	Overall risk
Trichloro-ethylene	5	Used for sample analysis	3 Used in laboratory, in an open system, in fume cupboard. Used regularly -> medium exposure potential	2 Low safety risk, only small amounts are used -> low incident potential	Very high
Brake parts cleaner	3	Used for degreasing	5 The product is sprayed and used inside with poor ventilation -> high exposure potential	2 Low safety risk, only very small amounts are used -> low incident potential	High risk
2-propanol	3	Used as a solvent in analysis	3 Used regularly. Open vessel reaction -> high exposure potential	2 Highly flammable liquid, large amounts used in an exothermic reaction -> high incident potential	High risk
Deicer	3	Used to melt ice	2 Used seasonally, outdoors -> exposure potential low	1 Low safety risk -> Incident potential low	Low risk

Look for quality control and specific standards that have to be/are recommended to be followed (product and process). This can be particularly relevant for laboratory test chemicals and in highly regulated industries such as aerospace, pharmaceuticals and others.

The table below presents an example list of requirements, set out by company to ensure quality production processes. These may vary in each company and can be determined for each individual case.

Chemical	Task	Overall risk	Technical requirements	Supply chain requirements	Specific standards
Potassium dichromate	Used for glassware cleaning	Very high	Fast and thorough purification is needed	Check purity requirements with the customer	No specific standards

Trichloroethylene	Used for sample analysis	Very high risk	Solubilization of the sample, equipment compatibility	Required from the customer	Standard solubility test for asphalt bitumen
Phenyl hydrazine	Used for a synthesis of a pharmaceuticals	Very high risk	Cannot be replaced without changing the entire synthetic route	No supply chain requirements	No specific standards but have to meet quality standard criteria
Brake parts cleaner	Used for degreasing	High risk	Needs to remove grease effectively	No supply chain requirements	No specific standards

After assessment and ranking of risks have been done, you have a good picture on what are the potential hazards in your company and can move to the next step to identify the priorities for substitution.

3: Identification of priorities

Identification of priorities for substitution is the next step. Identification can be based on several criteria:

- *legal status of potential substitution candidates* – this aspect usually is the driving force behind most substitution initiatives due to the fact that several substances or substance groups face restrictions or bans for use, thus making impossible to use in production processes. This aspect should be considered first when evaluating status of chemicals inventory in a company – if there are substances in use which are or will become restricted, firstly their substitution options should be evaluated.
- *risk assessment* – even if particular substance is currently not in any lists of restrictions, it can pose unacceptably high risks to workers of users of ready products. If risk assessment has shown increased risk of using a particular substance, it can be a candidate for substitution.
- *financial possibilities* – often heard concept that less hazardous alternatives are definitely more expensive can be misleading and incorrect in some cases. For many hazardous substances there are large varieties of readily-elaborated

substitutes available which, especially in medium and long terms, can provide financial benefits.

- *situation in the market* – situations in different markets can change due to number of factors, like new national requirements, initiatives by competitor companies, changes in consumer demands, etc. These changes can require discontinuation of use of particular substance and therefore seeking alternative for it without loss of product quality.

To assess which are the most urgent needs for substitution based on legal perspective, sometimes tools, such as chemicals inventory table with programmed options are helpful, especially if the list of used chemicals is very long. An example of such a table is attached in CD in Annex of this handbook. The main idea is that the cell with substance/product name changes color if it is in one of priority substance lists for restrictions (e.g. WFD, REACH or IPPC lists), see a screenshot below;

No.	Product name	Substance	Concentration of substance, %	Internal code	Separate substance or preparation	Supplier	Producer	Date of SDS issue	State of aggregation	Product type	CAS-No
1	Aeron 3,5bar	Propane	30				Scharr CPC, Germany				74-986
2	Aeron 3,5bar	Butane	40				Scharr CPC, Germany				106-97-8
3	Aeron 3,5bar	Isobutane	30				Scharr CPC, Germany				75-28-5
4	Dow Corning HV 495 emulsion	Trietanolamindodecilbenzolsulfphonate	3.3				Dow Corning, Belgium				27323-41-7
5	Dow Corning HV 495 emulsion	Oktametilciklotetrasi	2.3				Dow Corning, Belgium				556-67-2
6	Dow Corning HV 495 emulsion	alfa-Izotridecil omeg	2.3				Dow Corning, Belgium				9043-30-5
7	Asposolv M	Ethanol	60				Teiko, Finland				64-17-5
8	Asposolv M	Propanol	40				Teiko, Finland				67-63-0
9	Exxol D40	Naphtha(petroleum) hydrotreated heavy	100				Exxonmobil Chemical Norden AB				64742-48-9
10	NAEPHRASIS	Petroleum with low boiling point	100				Russia				68606-11-1
11	Permetrine		94				Tagros Chemicals India Ltd				52645-53-1
12	Tetrametrine		98				Endura, Italy				7696-12-0
13	Piperonilbutoksids		94				Endura, Italy				51-03-6
14	Amonia water	Amonia	25				Russia				1336-21-6
15	Diethyltoluamide	N,N-diethyl-m-toluamide	100				McLaughlin Gormley King Company, USA				134-62-3
16	Ufablend DC	Benzenesulphonic acid,C10-C13 alkylderivs,sodium salts	60				Unger Fabrikker AS, Norway				68411-30-3
17	Ufablend DC	sodium laureth sulfate	30				Unger Fabrikker AS, Norway				13150-00-0
18	Citric acid	monohydrate	99				China				5949-29-1
19	Rokwin 80	sorbitane monooleinate					PCC Rokita SA, Poland				1338-43-8
20	Na hydroxide		100				Russia				215-185-5
21	Glucopon 215 UP	alkylpolyglycoside C8- C10	70				Broste Denmark				68515-73-1
22	Tetrachloroethylene		100				Solvay Chemicals International, Belgium				127-18-4
23	Na nitrite		100				Russia				7632-00-0
24	Na carbonate		95				Russia				497-19-8

If all chemicals documentation is managed correctly and information inserted is complete, such table gives a very good overview of potential substitution candidates towards which some legal restraints might apply. Additional beneficial aspect of such types of tools is that they can be modified freely and updated in accordance with legal developments. In case when company does not have more advanced chemicals management system, such tool can also include all necessary information to meet the requirements for good chemicals management practice in company.

4: Looking for alternatives

When substances to substitute are identified, it is necessary to find potential alternatives. Generally speaking there could be several outcomes of such a search:

a) Alternatives for the substance in question exist and are already tested in practice in other enterprises;
b) Alternatives to continue current production without the substance exist, however it requires also changes in technological processes in order to be successful;
c) There are no known substitutes for particular chemical. This shouldn't be the case in most situations, especially if they are included in lists of legally restricted substances, however, such option can not be excluded.

As industrial processes and used materials can be very various it is impossible to give any concrete advices in this handbook – the search for substitution candidates should be done by company itself. To ease this process, several databases of alternative chemicals exist, most of them are specialized by industry branches and some include really detailed information about substitutes, including costs and good practice examples. Several such database addresses can be found in the Annex 1 below.

An overall logical sequence of steps could be following:

1. *Make a list of alternatives*. List all of possible alternatives which could be technically suitable for particular case – either from databases and internet search, or from contacts with your supplier or from industry-specific guidances.
2. *Check the alternatives against legal obligations, technical, quality and standard requirements*. This will help you to narrow down your options as you will find that some of found alternatives are not suiting for your specific case.
3. *Find the alternatives that best meet your requirements*. When picking out best options don't forget to evaluate how this change could also potentially affect other processes/products – for example a substitute chemical could be perfect

from legal/environmental perspective but using it in production process could cause unwanted side effects from interactions with other chemicals.

5: Checking impacts of changes

When a seemingly suitable substitute has been found, prior to actual implementation, it is important to compare it to the existing substance and assess the impact on production process which it might bring. Based on available information, a comparison should be done between the options, to get an overview. A sample table can be found below.

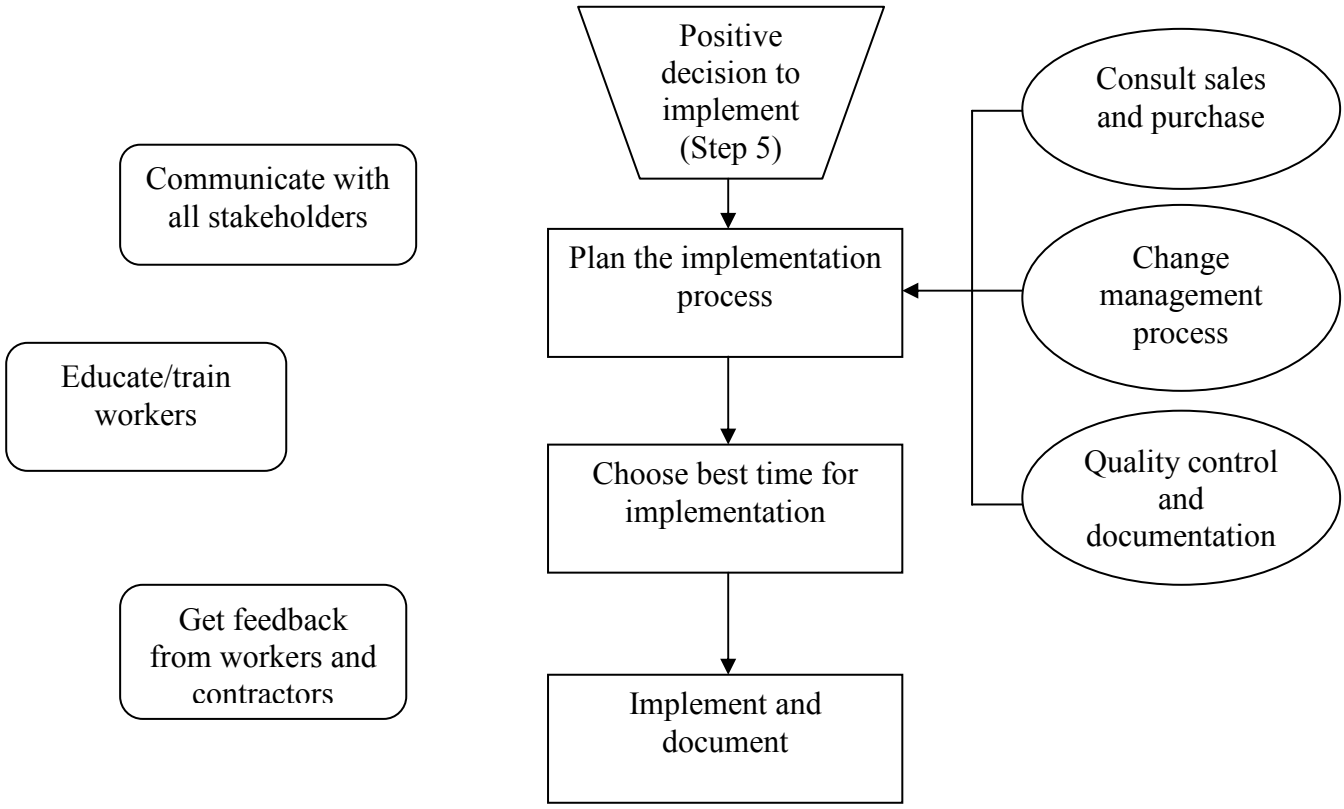
ASSESSMENT	CURRENT	ALTERNATIVE 1	ALTERNATIVE 2
Technical feasibility			
Workers wellbeing			
Technical safety level			
Performance			
Image			
Environmental permits			
Other considerations			
Overall assessment			

This table can be filled with indicators whichever seem to be giving the best overview for you – either numbers from 1 to 10 or simply writing in a brief note in each cell or any other option.

Naturally, also practical checks are in order in most cases – either by laboratorial testing or preparing test batches of a product and evaluating its quality. As for numerous cases readily elaborated and tested alternatives are not publically available, this part usually takes the longest time – testing a chemical performance in small scale laboratorical batches can greatly differ from industrial size production specifications.

6: Decision on substitution – implementation

A simplified logical scheme on how to take a decision for substitution can be seen below:



When a positive decision for implementation of substitution has been reached, implementation plan has to be developed. While doing this it is very important to consult with people/department responsible for sales and purchase to avoid any potential logistics complications, to develop changes in management process, if new production specifics require so and to do a careful quality control and documentation for internal quality management purposes. After that the best time for implementation has to be chosen not to interfere with planned production output volumes or at least to

minimize this effect. Finally comes implementation of the plan, again, accompanied with documentation of the whole process, especially if quality management systems (e.g. ISO 9001, ISO 140001, etc.) are in place.

Through all these steps continuous communication with stakeholders, training of workers and collection of feedback from workers and contractors should be maintained to ensure that all parties which are involved in the upcoming changes are aware of them and know how to act accordingly.

7: Assessing the changes/monitoring of results

When to monitor and evaluate:

Efficient evaluation and reporting should be integrated into normal hazardous substances management activities, and done during each of the steps. It is extremely important to do long-term monitoring and evaluation.

How to monitor and evaluate:

1. Check whether the new product or process meets your expectations.
    - Are there any (unexpected) problems?
    - Is it possible to reduce the risks even further?
    - If desired results are not obtained in practice or the risk is no less, you need to go back
2. Keep up with new requirements and alternatives
3. Conduct periodic audits
4. In the short-term and long-term evaluation and monitoring make sure to include customers and suppliers to improve hazardous substances management in the entire supply chain
5. Communicate with stakeholders

Possible benefits:

- Monitoring and evaluation enables you to identify success and eliminate failures in implementation of the alternative.
- Audits help in recognizing long-term impacts/problems and ensure continuous improvement. If monitoring and evaluation is neglected and incomplete, it leads to short-term benefits, rather than long-term effectiveness and sustainability.

Frequently asked questions

Below you will find most frequently asked questions when dealing with substitution issues and brief answers to them.

Q: I sell this chemical: Why should I stop a product line that brings me profit?
A: If you sell the product, you can still approach substitution by thinking of alternative ways you can meet your customers' needs (customer benefit), and see if you can meet this in a safer way. This can bring you competitive advantage

Q: I do not have any technical production processes – why do I need to do assessment of risk levels?
A: Even if you have no technical production processes, you are still using the chemical for some reason. Going through this handbook will help you define the reason for using the chemical and make it easier for you to see what could be changed. For example, if you use a paint stripper, you can assess whether you do not encounter any occupational or environmental risks due to this and if there are no better alternatives already available.

Q: What data do I need for risk assessment?
A: You need to have the hazard data and then relevant data about how you use the chemical. Relevant data about how you use the chemical are: How often, how much, how is it used (e.g. mixed, poured, painted, brushed, dipped etc.), by whom is it used, where it is used. If you are unsure about how to pull all this together, use one of the tools that will prompt you to define usage. In principle, if you can fill all the information required in chemicals inventory template found in Annex CD to this handbook, it should be sufficient.

Q: How do I rank chronic versus acute health risks or environmental versus health risks?

A: Ranking different types of risks is notoriously difficult. The easiest option is to say that all risks are equally important. However, if you are focusing on reducing occupational health risk but not specifically environmental risk or vice versa, you can reflect this by setting different thresholds for what constitutes an unacceptable risk. It would be best if your safety or risk management policy would guide you in doing this ranking of chemicals with different risk patterns (e.g. high risk for workers and low for the environment vs. low risk for workers and high for the environment). You do need to make decisions on which risks to reduce first. Be sure you involve sufficient number of people in this discussion.

Q: How do I decide what risk is acceptable?

A: You need to look at your legal obligations. These will give you the minimum level. Work from these and think about what will happen to you, your workers, your company and the environment if certain risks are realised. Are you prepared to face that occurrence or do you have to reduce it? This effectively will set your risk acceptance policy.

Q: Are all requirements (legal, technical, etc.) equally important?

A: This is dependent on your case. If you find it hard to decide which requirements to include, you can approach each one through asking the question of what will happen if this requirement is not met. For example, if you are degreasing metal, ask yourself what will happen if the metal is not fully clean? How long can it take to dry? Is there any particular dirt that must be removed?

Q: What about the cost and risk of the alternatives?

A: The cost and risk of alternatives will be assessed in the next step. To save you going through this work with chemicals that may not give you the performance you require, the technical performance is evaluated first. However, you may choose to assess the costs and risks before the technical requirements, there is no rule that requires a particular order to be followed.

Q: How do I assess advantages and disadvantages of alternatives if there are a lot of uncertainties?

A: There is no clear answer to this question. You may have to make an educated guess in some cases. Uncertainties are a drawback, and recording these will help you decide on the overall reliability of your assessment. It will also make it easier to come back and check the assessment at a later stage if you decide not to implement any changes right now.

Q: How should I compare the overall effect – i.e. how do I rank performance in different categories (such as cost versus health or waste versus potential liability)

A: This is very difficult. You can attempt to translate all categories into monetary terms. There are drawbacks with this, such as putting a value on intangible aspects. You can also assess the costs of unwanted results, such as costs of absences, cost of accidents and cost of liabilities. If you do decide to use this approach, make sure you are absolutely clear on how the assessment is going to be done before you start. Another way to do this is to assign weighting to the different categories and/or rank the alternatives within each category from best to worst. You would then choose the alternative where there overall ranking is best. Whichever way you decide to do the comparison, make sure you define the criteria before you start.

Q: How do I get support/convince the management that a change is needed?

A: The tables provided for comparing the different aspects have been constructed so that you can use these to present the case to management. You may want to summarise the tables into short bullet points. Make sure you include aspects such as investment needs, costs for use, change in health and safety levels, what the change would require in terms of internal resources (e.g. training) and how the change would benefit your business as a whole. Include assessment of productivity and workers well-being as well as customer and supply chain aspects.

Q: What if there is never a good time to start implementation? (As it is, the process is running 100%, 24/7 to satisfy customer needs)

A: There may not be a clearly best time to disrupt the process. You may have to perform maintenance that requires process run-down; this can be your best time to implement changes. Consider running parallel processes if there really is no natural

time window for change. If the task is not process related, the timing will be more dependent on ensuring sufficient training is provided. Remember, that first steps of substitution, as described in this handbook, are possible to do in parallel with your running production processes, that is, without stopping them. Also testing out new alternatives in laboratory conditions, which can go on for several months, can be done beforehand. This means that your production process has to be stopped for a while only to implement the actual changes at a production scale, when all other steps are already done. If they are done correctly, this last part will not take too long to seriously hinder your business plans.

Annex 1 : Information sources about substitution options

Acute Exposure Guideline Levels Program: www.epa.gov/oppt/aegl/index.htm

Catsub (in Danish, German, English, and French): www.catsub.dk

CleanerSolutions (in English): www.cleanersolutions.org

CLEANTOOL (in German, English, French and Spanish): www.cleantool.org/en/reinigungssuche.php

CMR substitution (in French): www.substitution-cmr.fr

COSHH Essentials (in English): www.coshh-essentials.org.uk

Design for the Environment: www.epa.gov/dfe/alternative_assessments.html

Ecology Center and Clean Production Action: www.ecocenter.org/publications/downloads/auto_plastics_report.pdf

German technical rules for hazardous substances (TRGS): http://www.baua.de/cln_135/en/Topics-from-A-to-Z/Hazardous-Substances/TRGS/TRGS.html

GESTIS-database (in English): www.dguv.de/ifa/en/gestis/stoffdb/index.jsp#

"Green" alternatives Wizard (in English): ehs.mit.edu/site/content/green-chemical-alternatives-purchasing-wizard

INCHEM - Chemical Safety Information from Intergovernmental Organizations: www.inchem.org

IRTA- Institute for Research and Technical Assistance: www.irta.us

Kemi-Arvi (in Finnish): http://kemi-arvi.tksoft.com/

Kemiguiden (in Swedish only): http://www.kemiguiden.se/

OHSAS 18004/ BS8800: www.osha-bs8800-ohsas-18001-health-and-safety.com/

"Our South West" site: http://www.oursouthwest.com/SusBus/mggchange.html

PRIO (in English): www.kemi.se/templates/PRIOframes____4045.aspx

Stoffenmanager (in Dutch and English): www.stoffenmanager.nl

TOXNET - Toxicology Data Network: www.toxnet.nlm.nih.gov

Annex 2: Tables to compare alternatives

TIME PERIOD		day /week / month /year		
Cost €/period		CURRENT	ALTERNATIVE 1	ALTERNATIVE 2
Material costs	Material cost: (mass used in time period * unit cost)			
	Additives needed			
	Other direct material costs			
	TOTAL MATERIAL COSTS			
Equipment costs	Equipment investment			
	Maintenance costs			
	Energy required /period			
	Other equipment costs			
	TOTAL EQUIPMENT COSTS			
Safety costs	Ventilation			
	Automation			
	Alarms			
	Fire /explosion protective measures			
	PPE			
	Change in cost related to permits and checks			
	Other safety control measures			
	TOTAL SAFETY CONTROL COSTS			
Time related costs	Transport of materials per time unit			
	Storage costs of materials per time unit			
	Work time per produced (hours)			
	Units produced in time period			
	Cost of 1 hour work			

	Cost of work time			
	TOTAL TIME RELATED COSTS			
Waste costs	Recycling cost (in time unit)			
	Waste			
	Emissions			
	Discharges			
	TOTAL WASTE COSTS			
Cost of risk	Insurance premium change			
	Direct cost of incident costs include: Days lost, liabilities, fines, remediation, relief workers, clean up costs, time lost on incident management. can also include intangible effects such as image, goodwill, etc.			
	Likelihood of incident per year; as times per year estimated to occur			
	Cost at risk: Cost of incident x likelihood			
	Occupational diseases it may cause			
	Lost working days to diseases or ill effects caused by chemical use per year (number of days)			
	Cost per working day lost			
	Cost of diseases			
	TOTAL COST OF RISK			
	TOTAL COST			

ASSESSMENT			
HAZARD	**CURRENT**	**ALTERNATIVE 1**	**ALTERNATIVE 2**
Acute health - inhalation			
Acute health ingestion			
Acute health skin			
Acute health eyes			

Chronic health			
Environment - air			
Environment - water			
Environment soil			
Safety			
Hazard profile change	**BASELINE**		
Risk of process /Task			
Acute health - inhalation			
Acute health ingestion			
Acute health skin			
Acute health eyes			
Chronic health			
Environment - air			
Environment - water			
Environment soil			
Safety			
RISK LEVEL change	**BASELINE**		
Supply risks	**BASELINE**		
Availability of material			
Potential for stops in deliveries?			
Risk of discontinuation of material?			
Supplier reliability			
Other supply risks			

RISK LEVEL CHANGE	**BASELINE**		
OVERALL ASSESSMENT			

ASSESSMENT	CURRENT	ALTERNATIVE 1	ALTERNATIVE 2
Technical feasibility			
Workers wellbeing			
Technical safety level			
Performance			
Image			
Environmental permits			
Other considerations			
Overall assessment			

Annex 3: Risk assessment matrix