UN environment programme

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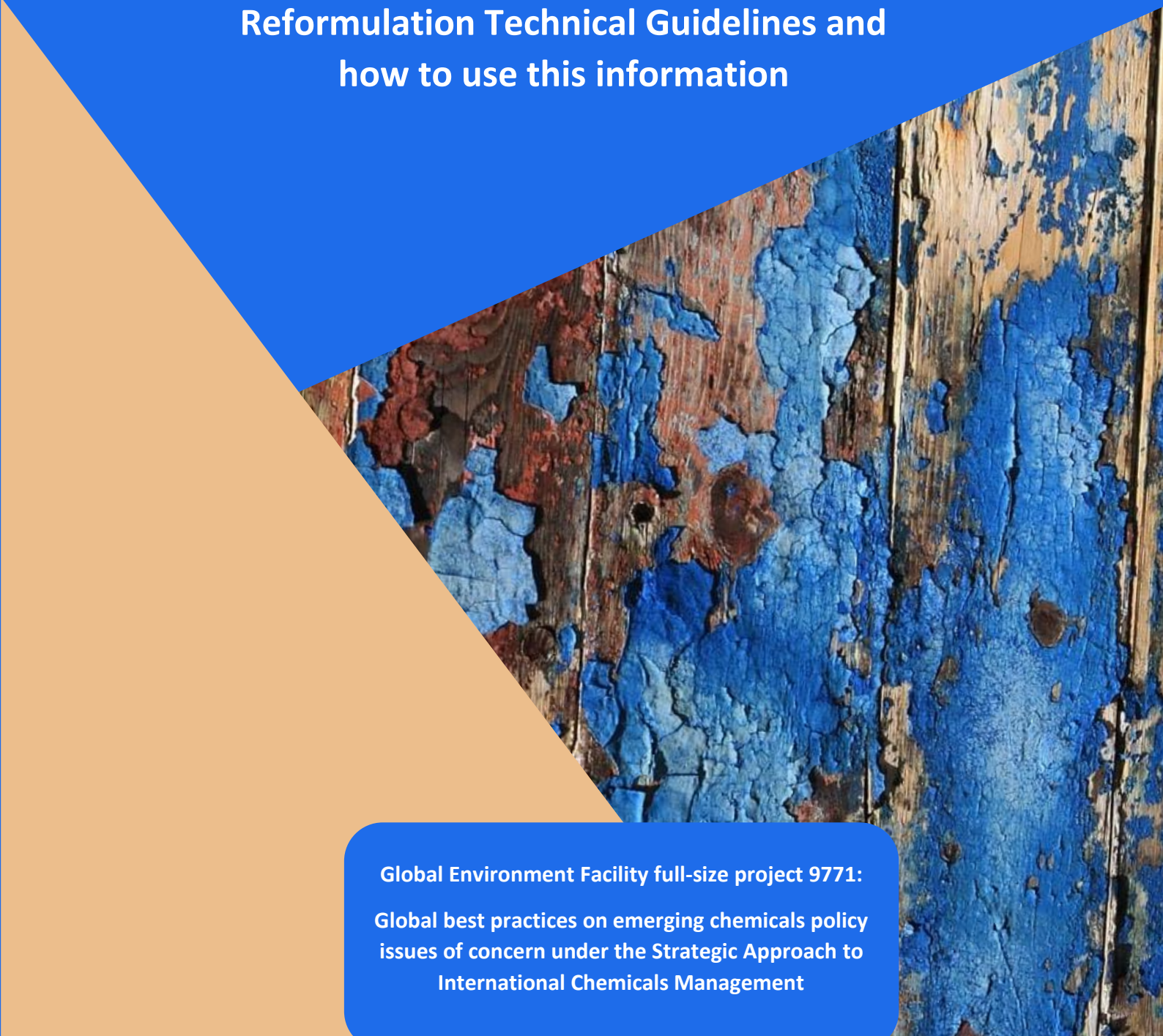
REFORMULATION IS ENTIRELY POSSIBLE

Summary of the Lead Paint Reformulation Technical Guidelines and how to use this information



Global Environment Facility full-size project 9771:

Global best practices on emerging chemicals policy issues of concern under the Strategic Approach to International Chemicals Management

Background and introduction

The full-length Lead Paint Reformulation Technical Guidelines (hereinafter the Guidelines) were prepared under the Global Environment Facility (GEF) full-sized project 9771: Global best practices on emerging chemical policy issues of concern under the Strategic Approach to International Chemicals Management (SAICM) (hereinafter SAICM GEF project). The Guidelines were developed by the National Cleaner Production Centre (NCPC) of Serbia, and include results from small and medium-sized enterprise (SME) pilot demonstrations for paint reformulation in seven countries: China, Colombia, Ecuador, Indonesia, Jordan, Nigeria and Peru. SAICM GEF project partners (NCPC China, NCPC Colombia, NCPC Ecuador, NCPC Jordan, NCPC Peru, the International Pollutants Elimination Network partner organization Nexus 3 Foundation in Indonesia, and Sustainable Research and Action for Environmental Development in Nigeria) worked with selected SMEs on pilots to demonstrate the replacement of added lead compounds with non-lead alternatives. SMEs voluntarily chose to participate in the SAICM GEF project.

The Guidelines were developed to help address both capacity constraints and technical barriers to the substitution of lead compounds in paints, focusing on the needs of SMEs for the effective and efficient reformulation of paint. The Guidelines provide general information on paint reformulation processes, as there are many different initial lead-containing formulations for colour and other paint properties. In-depth analyses and more specific data from pilot demonstrations were provided through the SAICM GEF project to participating companies, and are described in the case studies in the Guidelines. The **key message** from the Guidelines clearly states that **reformulation is entirely possible**.

Box 1: Who the Guidelines are for

Paint manufacturers are intended to be the primary target audience of the Guidelines, in order to help guide the reformulation of their products, as paint reformulation is a key action for the removal of lead from paint and compliance with lead paint laws. Nevertheless, the information provided in the document may also be helpful to policymakers working to eliminate lead paint through lead paint laws, as it will help them understand how reformulation works. Lead paint laws are meant in the broadest sense to include any mandatory legal requirement with consequences for non-compliance. They can be statutes, regulations or standards, as long as they include an enforcement mechanism. Governments can help promote compliance while developing, enacting and implementing lead paint laws by using the information in the Guidelines to raise awareness about the feasibility of and need for reformulation by paint manufacturers.

The Guidelines can also be helpful to civil society organizations and industry stakeholders engaged in reformulation, and to inform paint retailers and their customers of the human health benefits of using paint which does not contain added lead compounds.

This document summarizes information from the Guidelines, the findings and recommendations of the reformulation pilot demonstrations, and two case studies of paint manufacturers which have reformulated paint products. This summary is also intended to highlight how the information from the Guidelines can be used by different stakeholders involved in the phasing out of lead paint.

Box 2: How can stakeholders use the Guidelines to support the discussion and implementation of lead paint laws?

The Guidelines can also be used in conjunction with other materials developed by the Global Alliance to Eliminate Lead Paint (Lead Paint Alliance), such as the *Model Law and Guidance for Regulating Lead Paint*, the *Technical Brief on Global Elimination of Lead Paint*, and the Toolkit for establishing laws to eliminate lead paint. The Lead Paint Alliance is a voluntary partnership formed by the United Nations Environment Programme (UNEP) and the World Health Organization (WHO) to prevent exposure to lead through promoting the phasing out of paints containing lead.

The Guidelines can support the discussion around the drafting and implementation of lead paint laws in different ways, as presented below.

The Guidelines could support evidence-based policymaking to inform decisions at all stages of the policy development process. The findings and evidence available in the Guidelines can inform policymakers in developing lead paint laws. By featuring considerations linked to paint reformulation and presenting case studies, the Guidelines can help policymakers identify what works, and highlight the gaps where evidence of legal effectiveness is lacking. For instance, policymakers can use the document to assess how long it would take for companies to reformulate their paint production, which is essential in defining a phasing out time.

Inputs from the document will also support the design and development of a system to monitor implementation and measure key outcomes.

The Guidelines could be used to guide implementation of an existing lead paint law. One important feature of laws regulating paint is the focus on establishing mechanisms to promote enforcement and compliance. The Guidelines can help government and industry decision makers to identify best practices for reformulation to promote compliance with lead paint laws. Technical information from the document can also improve governments' understanding of reformulation systems to facilitate enforcement of lead paint laws. The Guidelines can also be used to promote compliance through highlighting benefits of moving to paints without added lead compounds, such as increased worker health and safety, corporate stewardship (transitioning to safer paints gives companies the opportunity to build their brand with new "green" credentials and innovative branding) and cost-saving practices by ensuring compliance with existing laws.

The Guidelines can inform the dialogue between the paint industry, civil society and governments on the development of new paint laws. Based on the experience of countries that have already adopted lead paint laws, or are following the suggested steps for establishing lead paint laws, dialogue and multistakeholder engagement, particularly with civil society and industry, and are crucial to ensuring that all interested parties can provide their perspectives while a law is being developed. This will ensure greater effectiveness of the law and ownership by all involved stakeholders, and will facilitate its implementation. The paint industry is an important stakeholder which is directly impacted by lead paint laws, as compliance with a law will entail the reformulation of paint products by manufacturers. During these discussions, the Guidelines could be shared with stakeholders to highlight that paint reformulation is entirely possible, and to provide helpful tools (such as a list of suppliers of alternatives) to support the reformulation process.

Technical information found in the Guidelines can inform the technical aspects raised during a lead paint law discussion. Depending on the type of legal instrument chosen, the technical level of a regulation might vary, and the Guidelines provide key technical information that could be taken into account. For instance, while the *Model Law and Guidance for Regulating Lead Paint* provides lists of recommended international standards for sample preparation and test methods for measuring lead concentrations in paint, the Guidelines provide additional standards for testing paint properties and performance. If relevant, these standards could be mentioned in provisions about paint properties and performance.

The Guidelines can help make a case for the feasibility of paint reformulation. As the Guidelines was tested in more than thirty SME pilot demonstrations around the world for over two years, the document demonstrates that it is possible to reformulate paint to achieve a lower lead content by following the technical explanations in the Guidelines and adding raw materials not containing added lead. The Guidelines have been refined and fine-tuned based on the SME pilot demonstrations, and include case studies, lessons learned, and best practices. For instance, by following the Guidelines and replacing a lead-based yellow pigment with an alternative, a case study from Ecuador showed that the final product presented similar properties to the product which contained added lead. Lead paint testing showed that the lead content dropped from 34,689 parts per million (ppm) to less than 56 ppm after reformulation (see pages 71 to 73 of the Guidelines and the case study section of this document).

Paint manufacturers could be encouraged to use the Guidelines to reformulate lead paint and expand trade markets as more and more countries regulate lead in paint, thus contributing to increased revenue for both industry and the governments. When a manufacturer produces paint with low lead content on a voluntary basis or in compliance with existing regulation, exports to and trade with countries which legislate low lead limits in paint become possible. The *Model Law and Guidance for Regulating Lead Paint* suggests a 90 ppm limit as a feasible regulatory lead limit for most paints. Currently, over 40 per cent of countries have lead paint laws in place (UNEP, forthcoming), most setting a low legal limit, and there is momentum for more countries to do so. This will result in a growing international market for companies able to produce paint without added lead. With the dissemination of the Guidelines and encouragement of companies to apply its principles, government and industry can help promote international trade, ensuring increased profits for companies and increased government revenues through import taxes and customs fees.

Structure of the Guidelines

The Guidelines begins with a summary of the contents (chapter 1) and background on the efforts of the Global Alliance to Eliminate Lead Paint (chapter 2). It then provides terms and definitions (chapter 3) and a short description of the hazardous properties of lead and the

lead compounds used in paint formulations (chapter 4).

Subsequently, the Guidelines provides the general approach and the steps of the substitution process (chapter 5) to help SMEs choose less hazardous alternatives to the lead compounds they may currently be using. Since there are many different initial lead-containing formulations for colour and other paint properties, the Guidelines provides only general information on paint reformulation processes.

The Guidelines presents the properties of alternative pigments and details of key lead pigments, such as function (durability, dispersibility, heat stability, bleeding, gloss retention), environmental qualities, health and safety properties, economic feasibility, and availability (chapter 6). Information about dispersion (a heterogeneous mixture of at least two materials, which are insoluble or only sparingly soluble in each other and not chemically bonded) is also available, as paint colour and properties depend largely on the dispersion process and additives for dispersion. The next chapter (chapter 7) provides information on the role and types of driers, and alternatives to lead driers.

Finally, the last part presents the conclusions and key findings from the pilot demonstrations of reformulation.

In addition, the Guidelines' appendices provide information including SME case studies from pilot demonstrations of reformulation, a list of selected International Organization for Standardization standards for general test methods for paints and varnishes, and a non-exhaustive list of suppliers.

The key features of chapters 4 to 7 and the conclusions are summarized below.

Lead in paint (chapter 4)

Chapter 4 of the Guidelines presents why lead paint is an issue. **There is no safe level of lead exposure, and even relatively low levels of exposure can lead to cause serious and irreversible neurological damage, resulting in decreased IQ and increased behavioural issues.** Lead exposure may also cause anaemia, increase the risk of kidney damage and hypertension, and impair reproductive function. The Institute for Health Metrics and Evaluation has estimated that, in 2019 alone, lead exposure accounted for 901,700 deaths and 21.6 million years lost to disability and death due to long-term health issues (Institute for Health Metrics and Evaluation, 2020).

Lead also has hazardous impacts on the environment: its release on ecosystems from any source, including lead paint, is toxic to plants, animals and microorganisms. In all animals studied, lead has been shown to cause adverse effects in multiple organs and organ systems, including the blood, central nervous system, kidneys, reproductive system and immune system. Lead bio-accumulates in most organisms, with environmental exposure occurring through multiple sources and pathways (UNEP 2020a).

Lead compounds used in paints are extremely hazardous to human health and the environment, and should take priority in substitution efforts. Switching to alternatives should result in reduced overall risks to human health and the environment.

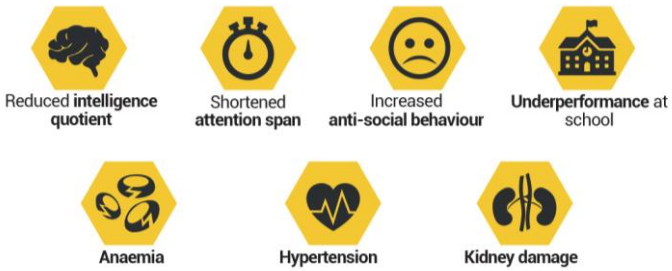
Paint is defined as a pigmented coating material that, when applied to a substrate, forms an opaque dried film having protective, decorative or specific technical properties. Paints are formulated to meet different technical properties, including specific chemical or weather resistance, signal or camouflaging effects, decorative effects, insulation or conductive properties and antibacterial properties. Paint is also

formulated to adapt to a variety of substrates and methods of application.

Historically, lead compounds have been added to decorative and industrial paints and other coatings materials to enhance colour, reduce corrosion of metal surfaces or shorten drying time. While lead compounds used in paints meet strict technical requirements, they are nevertheless extremely hazardous to the environment and human health. Today, non-leaded pigments and driers are widely available for use in paints, making the use of raw materials containing lead unnecessary (WHO, 2020).[1]

After the application of lead paint, the weathering, peeling or chipping of the paint releases lead particles into dust and soil in and around homes, schools, playgrounds and other locations. Decorative paint for household use has been identified as the main source of children's exposure to lead found in paints. Besides, occupational exposure to lead can occur during the manufacture, application and removal of paint if the appropriate engineering controls and occupational safety measures are not in place, and workers do not have adequate personal protective equipment (WHO, 2020).

Effects of children's exposure to lead



The cost of removing existing decorative lead paint from surfaces in homes, schools and other buildings may be substantial. By contrast, the economic cost of eliminating lead compounds in the production of new decorative paints is low. In fact, many manufacturers have already successfully reformulated their paint products to avoid the addition of lead-containing ingredients. According to the paint industry, the reformulation of residential and decorative paints to eliminate lead compounds is feasible, and the technical and cost impacts are manageable. Increasingly, paint producers are going public in saying that it is possible to eliminate lead compounds in all types of paint.

Lead exposure from paint is preventable. The elimination of lead exposure at its source, through the establishment of laws promoting reformulation to the use of raw materials not containing added lead in paint production, is the most effective action to protect people and the environment from the harmful effects of lead. Increasingly, governments around the world are looking to develop laws to eliminate lead in paint. Paint manufacturers should be aware of such activities in their country or in

[1] It is important to note that some raw materials used in paint can still naturally contain high levels of lead. However, the lead compound alternatives used should have the least hazardous properties possible.

the countries to which they are exporting their products, in order to inform their decisions for paint reformulation.

Raw materials used in paints that may contain lead include pigments, fillers and driers that can be used in oil-based paints, primers, intermediate coats and top coats.

There is also the possibility of the cross-contamination of paint during production.

Lead contamination occurs if the same equipment that was used to produce paint containing lead is used to produce paint intended to be lead-free without proper cleaning of the equipment.

The Guidelines also present the hazardous properties of the most common paint raw materials containing lead.

Substitution process: lead paint reformulation (chapter 5)

Paint reformulation is a key element for ensuring product safety and sustainability.

Box 3: What is lead paint reformulation?

Lead paint reformulation is the process of replacing lead paint components used in the paint formulation (such as solvents, additives, driers, fillers and pigments) with safer alternatives. An important requirement is that these components are not hazardous to human health and the environment.

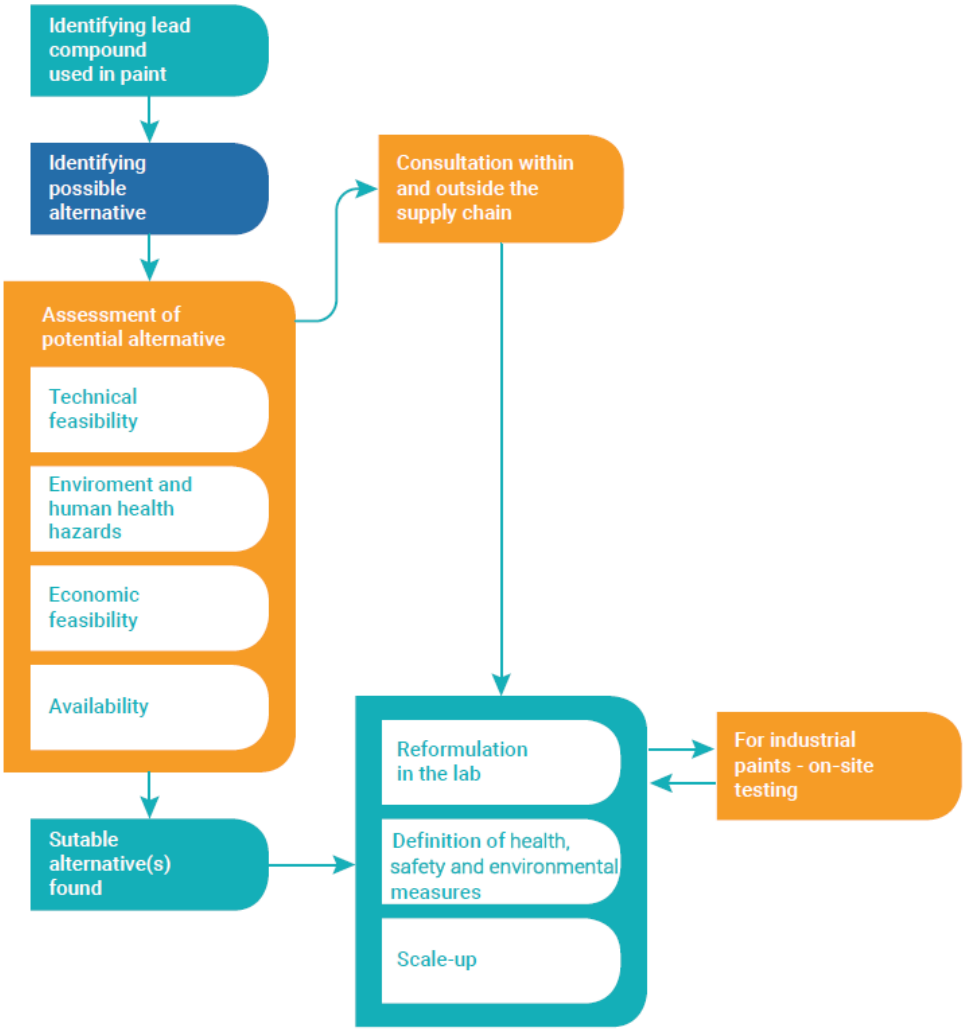
Chemical substitution states that hazardous chemicals should be systematically substituted with less hazardous alternatives or, preferably, alternatives for which no hazards have been identified (Hansson *et al*. 2011). Substitution usually leads to more than just the replacement of one chemical for another. Differences in the properties of the two chemicals may create the need for other changes (technical, but possibly also organizational). Substitution may include the replacement of a hazardous substance using a technological alternative instead of the initial substance, using an organizational measure as a replacement for a hazardous substance, or total product redesign.

Paint manufacturers around the world are still producing lead paint for various reasons, including a lack of technical knowledge on how to do otherwise, a lack of awareness of the health and environmental hazard of lead or of where to source lead-free alternatives, or a lack of lead paint laws in the countries where they are based (or exporting to). As 58 per cent of the market share of the global paint market is composed of SMEs, it is important to ensure that they are not left out of the reformulation effort (for a snapshot of the global paint market, see UNEP 2020b). Reformulation can be particularly challenging for SMEs that lack the resources for research and development to reformulate paint without added lead compounds. As the paint market is expected to continue to expand following the growing trend in construction and housing, the use of paint will also increase globally, including lead paint unless concerted action is taken. Despite these barriers, **manufacturers of paint products across the globe have demonstrated that the elimination of lead compounds is feasible**, and the technical and cost impacts are manageable.

The following flow chart presents the steps necessary to substitute lead-containing

ingredients in paints.[2] This will help in either meeting existing or anticipated lead concentration limits (for instance in Kenya, the Philippines and Uruguay), or meeting requirements for the phasing out of specific lead compounds (for instance under the European Union's Registration, Evaluation, Authorisation and Restriction of Chemicals, or EU REACH). The different steps of the substitution process are detailed on pages 23 to 25 of the Guidelines.

Steps in lead compound substitution



Source: Lead Paint Reformulation Technical Guidelines (UNEP 2022)

Substitution of lead pigments (chapter 6)

When substituting any raw material in a paint, it is necessary to select the right replacement to achieve optimum paint performance, such as how it is applied (e.g. by spraying or dipping), adhesion to a specific surface, the curing process, requested mechanical and/or chemical protection and decorative requirements. This chapter provides

[2] These activities apply to any hazardous chemical for which alternatives are available on the market.

information on task and performance requirements for pigments and extenders, and relevant information on the basic elements of colour theory, the dispersion process, and additives. Together, these are the different aspects which inform efforts to match paint characteristics (and performance) in reformulated paint. The paint production process is also outlined.

The Guidelines provides an assessment of alternative pigments for red lead anti-corrosive pigment, lead white, lead chromate, and inorganic and organic pigments, including comparative function, technical feasibility and availability, and environmental and human health hazards.

Substitution of lead driers (chapter 7)

This chapter provides information on the most common driers (lead octoate and lead naphthenate), but literature references are provided for readers seeking information on other driers or more detailed information on the most used driers.

Lead drier replacement does not require complex reformulation. As a result, the Guidelines provides information on the general principles of the role of driers, individual characteristics, and principles of dosage and paint testing as suggestions for substitution and future formulations of air-drying paints without lead additives.

Conclusion and key findings and recommendations of the pilot demonstrations of reformulation

The Guidelines demonstrates that the reformulation of lead paint is entirely possible. As lead paint reformulation has been conducted for decades, there are many raw materials on the market that could replace lead compounds in paints. Besides, paint reformulation is not a new technology or approach. However, while making the switch to paint reformulations without added lead compounds is technically achievable, obtaining the right raw materials can still be a challenge for manufacturers. Care also needs to be taken to source raw materials not contaminated with lead. Some raw material suppliers are trying to help paint manufacturers meet these challenges. Technical barriers faced by companies can also be addressed through information provided in the Guidelines.

Through various policy actions and information-sharing, government and industry decision makers can promote the production of paint without added lead compounds. This will help manufacturers change their industry practices towards sustainable production and will contribute to effective implementation and compliance with lead paint laws. The global momentum to phase out lead in paint is growing, and all interested stakeholders are encouraged to take action on lead paint, towards the goal of lead paint elimination.

While the Guidelines are primarily a theoretical document explaining the different aspects of lead substitution in the paint formulation process, it is essential to emphasize that companies that have followed the principles stated in the Guidelines have managed to successfully reformulate their products.

Box 4: Key findings and recommendations

The following findings and recommendations are based on the experience of the paint reformulation pilot demonstrations with more than thirty SMEs under the SAICM GEF project. All pilot demonstrations involved reformulation of paint using pigment substitution. Lead driers were not used by any of the SMEs in the project.

- Finding: Lead pigments are used in solvent-based and water-based paints.
    - Recommendation: When drafting a lead paint law, the scope of the paint included should be as broad as possible to cover both water-based and solvent-based paint.
- Finding: Some small enterprises do not have all the necessary equipment to carry out paint performance testing and scale-up.
    - Recommendation: Lack of grinding equipment can be addressed by using pigment pastes.
- Finding: Suppliers appear to have less commercial interest in smaller markets, and the availability of alternative pigments might be limited in these locations as a result.
    - Recommendation: Encourage suppliers of alternatives to provide their raw materials in smaller markets as well, such as through trade fairs or facilitating meetings with SMEs.
- Finding: All pilot demonstration participants agreed that the provision of technical support by suppliers of alternatives is important.
    - Recommendation: Meeting with suppliers for technical support before initiating the reformulation can result in a better understanding of the process, accelerate the selection of the right alternative and lead to efficient reformulation.
- Finding: Economic costs of reformulation varied. In some cases, the lead alternative raw material was less expensive, lowering the cost. In other cases, the price of the paint increased significantly.
    - Recommendation: As part of routine business planning, companies should make estimates of the economic costs of reformulation.
- Finding: Pilot demonstration companies reformulated their lead paints successfully. However, to comply with lead paint laws, companies may need additional time to fine-tune shades and optimize costs. Further work implies a longer period to perfect similar paint products without added lead compounds
    - Recommendations: Compliance deadlines in lead paint laws should allow reasonable time for manufacturers to alter paint formulations and production processes.

Case studies on paint reformulation

Two case studies are detailed below and highlight considerations for policymakers while they coordinate the development and implementation of a lead paint law.

Case study 1: reformulation of alkyd anti-corrosive paint, used as solvent-based and water-based industrial coatings

In China, Zhejiang Yutong New Material Co., Ltd. decided to reformulate an anti-corrosive paint and some alkyd products, both using a red lead pigment (PR105). This would ensure that there would be no more lead used in the production programme. The company selected two alternatives for testing: iron oxide and iron titanium powder. The choice of the alternatives was based on the use of a similar production process to that involving red lead, the absence of heavy metals and a lower price. Once the paint was reformulated and tested, adhesion, hardness and dry time appeared similar, with minimal difference between the product containing red lead and products containing iron oxide and iron titanium powder. Retaining the same colour as the original product was more difficult to achieve; the colour of the paint with iron oxide red was significantly different from the original, but the iron titanium powder paint colour was similar.

RESULTS OF PARALEL LAB TESTINGS

Request (according to technical specifications)	Lead paint (Red lead)	Paint free of lead (Iron Oxide Red)	Paint free of lead (Iron titanium powder)
Colour			

For this company, lower cost and availability of alternatives also made reformulation feasible. The price of red lead pigment is fairly high as the raw material used has limited availability, and the alternatives are more cost-effective: the iron titanium powder pigment price is lower than red lead by 40 per cent, and the red oxide pigment is lower by 50 per cent. Both were also readily available on the market.

This case study was one of the few instances during the pilot projects where the economic evaluation was cost-effective and feasible. In many of the other cases, due to the high costs of organic alternatives, the overall costs of reformulated paints were higher than the leaded paints.

Despite the positive technical and cost-effective results, Zhejiang Yutong New Material Co. mentioned their clients' preference for paint with red lead pigment as a challenge that still needed to be overcome. **Further awareness-raising is needed to inform customers and paint retailers of the human health and environmental benefits of lead-free paint, regardless of the economic price of reformulated paint. Policymakers can highlight this message in their regulation.**

Case study 2: reformulation of yellow alkyd paint used to protect metal and wood

In Ecuador, the company LiP 04as[3] decided to reformulate a bright yellow enamel paint (alkyd enamel used as a topcoat on metal or wood surfaces) and remove the lead pigments contained in some alkyd products. This would ensure that there was no more lead paint in the company's production programme. The lead compound to be substituted was medium chrome yellow (PY34). To select the alternative, samples of paint colours were sent to Mathiesen (a major supplier of raw materials for paint and coatings in Latin America) for analysis and recommendations; the suggestion was to use a hybrid pigment called "canary yellow" (LF761). The choice of the alternative was based on the similar characteristics between the products.

RESULTS OF PARALEL LAB TESTINGS

Request (according to technical specifications)	Lead paint	Paint free of lead
Test method and a value		
Lead content on dry base (NTE-INEN 2093)	34,689 ppm	<56 ppm

Once the paint was reformulated and tested, many paint properties such as the hardness and the drying time did not significantly differ.[4] However, regarding adhesion the paints slightly differed.[5]

For this pilot test, the SME also tested the lead content in the paints. **The test results were striking: the lead paint had a total lead content of 34,689 ppm, while the reformulated paint contained less than 56 ppm total lead, much lower than the limit in place in Ecuador (600 ppm).** This result was obtained by reformulating the existing paint following the Guidelines, and replacing the yellow lead pigment with an alternative.

In this case study, the cost of the alternative yellow pigment was higher than the compound it replaced, as has been commonly observed globally. Consequently, the cost of the reformulated paint product increased by over 40 per cent. It is important to note that with different colours, the price of the lead pigments can be more expensive than their alternatives. **To reduce the financial and logistical burden on paint manufacturers, governments can provide a longer effective date to allow companies to conduct the research necessary to identify lead-free alternatives, consider the feasibility of these alternatives and conduct the testing necessary to manufacture a paint product in compliance with a low lead concentration limit.** This will allow time for manufacturers to request lead-free raw materials from their suppliers. Manufacturers may be able to reformulate their paint to comply with a lead paint regulation more easily. Besides, if the demand increases, the unit price of the raw materials may drop, and it may be easier to access those products directly in the country

[3] Ecuadorian companies in the pilot tests requested anonymization.

[4] Drying includes all the stages through which an applied coating material passes in going from a liquid to a solid state. Drying time is the duration needed for this.

[5] This concerns the phenomenon of attachment at the interface between a solid surface and another material caused by molecular forces.

without importing raw materials from elsewhere, reducing the logistical strain.

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