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Selection of product-chemical substance combinations for illustrating a variety of Safe-by-Design approaches

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SELECTION OF PRODUCT-CHEMICAL SUBSTANCE COMBINATIONS FOR ILLUSTRATING A VARIETY OF SAFE-BY-DESIGN APPROACHES

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Publiekssamenvatting

Met Safe-by-Design wil het ministerie van Infrastructuur en Waterstaat onderzoekers, ontwerpers en bedrijven stimuleren hun verantwoordelijkheid te nemen om risico's die samenhangen met het gebruik van chemische stoffen, te voorkomen. Dit rapport beschrijft de aanpak en resultaten van een klein project met de volgende doelstelling: het selecteren van tien bestaande 'product-chemische stofcombinaties' die geschikt lijken om een verscheidenheid aan Safe-by-Design-benaderingen te illustreren. Criteria die voor de selectie zijn gebruikt, zijn onder meer een diversiteit aan producten, een diversiteit aan zorgwekkende chemicaliën en gemakkelijk te begrijpen veiligheidskwesties die bij de product-chemische stofcombinaties spelen. Overleg met deskundigen op het gebied van risicobeoordeling en productontwerp heeft plaatsgevonden om de eerste lijst met 49 gevonden product-chemische stofcombinaties terug te brengen tot en selectie van 11. De geselecteerde combinaties behoren tot de volgende sectoren: Textiel (4), Bouw (3), Elektronica (2), Papier en Karton (1), Landbouw (1). Deze selectie zal worden gebruikt om verschillende Safe-by-Design-oplossingsrichtingen te illustreren.

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1. Project Introduction and Objectives

There is significant commitment to transform the EU economy to be a resource efficient, climate neutral and less polluting one. This is evident with recent initiatives like the European Green Deal¹, the European Commission's new Action Plan for a Circular Economy², the new European Industrial Strategy and the Chemicals Strategy for Sustainability³. The use of hazardous substances in products undermines environmental protection goals and reuse of materials in the context of circular economy. Adopting a Safe-by-Design (SbD) approach towards product development is considered as an approach to contribute to these goals. The aim of such an approach is to design products so that hazardous substances are either not used, or are used in products in such a way that they do not pose risks during (multiple) product life cycles. The Dutch Ministry of Infrastructure and Water Management in collaboration with the National Institute for Public Health and the Environment (Rijksinstituut voor Volksgezondheid en Milieu (RIVM)) aims to develop practical approaches for SbD in relation to chemical substances used in products.

This report describes a small project, commissioned by Ministry of Infrastructure and Water Management, with the following objective: *to select ten product-chemical substance combinations relevant to the Dutch economy that have the potential to illustrate a variety of SbD approaches.*

Criteria used for selection include:

- cover a variety in type of products (P)
- cover a variety in type of Substances of Concern (SoC)
- suited to demonstrate a variety of SbD solutions (archetypical SbD solutions)
- encompass safety issues that can be grasped by the target groups (e.g. students and newcomers to the concept of Safe-by-Design or Circular-by-Design).

A comprehensive prioritization of product-chemical substance combinations is time consuming since there is no readily available database for this. Given the need for a quick, low-effort approach, this project identifies P-SoC combinations relevant in the Dutch context, based on using the information currently available and expert judgment.

2. Approach

From the product perspective, there are two relevant data sources: EUPROMS⁴ and COMTRADE⁵. They provide yearly production and trade information for countries and for product categories. The volume of sold production in thousands of kg for The Netherlands for the year 2018 and 495 product categories

¹ COM/2019/640

² COM/2020/98

³ COM/2020/667

⁴ A list of Eurostat with production and import/export value and physical volume of some 6000 products. The important product categories for The Netherlands was sourced from the EUPROMS website: <https://ec.europa.eu/eurostat/web/prodcom/data/excel-files-nace-rev.2>

⁵ A global trade database with import/export values and physical volume of 6000 products. Data available here: <https://comtrade.un.org/data>

(PRODCOMs)⁶ were extracted (Appendix PRODCOMS). Dominant sectors, in terms of kg, in the Dutch economy were construction, feed processing, food processing, petroleum refining intermediaries, primary chemicals, steel structures, plastics and packaging. Feed and food processing were not relevant to our aim as hazardous chemicals are not intentionally added to these products.

Chemicals used within commerce in the EU are primarily regulated under REACH⁷ and SoC are placed in candidate, authorization and restriction lists. In the Dutch context, lists on hazardous chemicals include ‘Zeer Zorgwekkende Stoffen’ (ZZS)⁸ and ‘Potentieel zeer zorgwekkende stoffen’ (pZZS)⁹, which contain over 1700 and 300 substances respectively. The ZZS list includes the most dangerous substances for the environment and human beings, and includes substances classified as hazardous as per REACH Regulation (Article 57)³, OSPAR Convention¹⁰, Water Framework Directive¹¹ and Persistent Organic Pollutant Regulation¹². PZZS include substances that are suspected to be hazardous.

The critical challenge here is that there is no direct link between SoC and P. PRODCOM categories do not map directly to REACH use descriptors (e.g. Product¹³ or Article Categories¹⁴), and all these product classifications are generic and need additional specification. Information on SoC on the ECHA website (“Substance Infocard”) based on information provided by manufacturers has been aggregated and any identifying or other sensitive business information has been removed. Further, several SoC provide diverse functionalities across different types of products, and the specific functionality provided may not always be easy to decipher by non-chemists from the aggregated information. Information at the ECHA website is not consolidated and manual extraction from different documents and dossiers was required for this research. Further, while there is information on the tonnage range of a SoC’s use within the EU, there is no information on its relevance in the Dutch economy.

On 14 September 2021, ECHA made public the Substances of Concern In articles as such or in complex objects (Products) (SCIP)¹⁵, which provides information on substances in the REACH Candidate List in products at a concentration over 0.1% weight by weight (w/w). The database is searchable by article identity (e.g. product name, product brand, ISBN number), article category (Customs Tariff Code), mixture category (matrix), Substance of Concern and reason for inclusion. While in principle this database should provide a link between SoC and P, the entries are made by manufacturers and thus inconsistent and variable. For example, in several cases examined, only the Customs Tariff Code and SoC are provided, and there is no indication of what the product is.

These challenges were discussed with risk assessment experts at RIVM, and they recognized these issues from their experience as well.

⁶ PRODCOM provides statistics on the production of manufactured goods carried out by enterprises on the national territory of the reporting countries, and covers Mining and quarrying, Manufacturing and Materials recovery, sections B, C and E of the Statistical Classification of Economy Activity in the European Union.

⁷ EC 1907/2006: <https://eur-lex.europa.eu/legal-content/en/TXT/HTML/?uri=CELEX:02006R1907-20210215>

⁸ <https://www.infomil.nl/onderwerpen/lucht-water/zeer-zorgwekkende/>

⁹ <https://rvs.rivm.nl/onderwerpen/Zeet-Zorgwekkende-Stoffen/Potentiele-ZZS>

¹⁰ <https://www.ospar.org/convention>

¹¹ https://ec.europa.eu/environment/water/water-framework/index_en.html

¹² <https://echa.europa.eu/pops-legislation>

¹³ Describes the types of chemical products in which a substance is used. Examples: PC9a: Coatings and paints, thinners, paint removers; PC39: Cosmetics, personal care products

¹⁴ Describes the type of article in which the substance has been processed. Examples: AC2: Machinery, mechanical appliances, electrical/electronic articles; AC13: Plastic articles

¹⁵ <https://echa.europa.eu/scip-database>

Given these challenges, selection of P-SoC combinations involved manually collating information from many sources and using expert elicitation to choose the most relevant combinations. We followed the steps below as an alternative approach:

Step 1: A list of 49 P-SoC combinations was compiled manually and with available information, including Priority ZYS containing flows for Circular Economy¹⁶, SCIP database⁹, SCIP 2019 report¹⁷, ECHA factsheets on SoC¹⁸, SIN List¹⁹, reports on P-SoC by environmental NGOs, etc. Suggestions from experts were also used as a source of input. Two kinds of SoC may be distinguished in the product design context: one that the product is intentionally formulated with, and another is created in the context of release (e.g. microplastics, Polyaromatic Hydrocarbons).

Step 2: Ruud Balkenende, professor of Circular Product Design at the Faculty of Industrial Design Engineering at TU Delft, was consulted on the list of 49 P-SoC combinations to determine which options are suited to illustrate a variation of Safe-by-Design approaches. Which are 'highly feasible', 'challenging but feasible' and 'not feasible'?

Step 3: RIVM experts were consulted on the most suitable P-SoC combinations from the 'feasible' and 'challenging but feasible' options identified in Step 2.

Step 4: A final expert consultation meeting was conducted between risk and design experts to evaluate P-SoC combinations according to the criteria and make the final choice of P-SoC combinations.

3. Results

Step 1: The compilation of 49 P-SoC are shown in Appendix 1 (separate document). It was attempted to cover the sectors covered in RIVM Priority ZYS list for the Dutch Economy¹⁶. The information, in so far as it is available, is organized under these headers.

Sector: Sector as classified in RIVM report¹⁶ if available, or sector name is assigned

Product: Brief description of product

SoC: Name of the chemical (Substance of Concern)

Technical Function: Brief description of function of the chemical in the product

EC Number: Unique numerical identifier that was assigned to substances by the European Commission for regulatory purposes

CAS Number: Unique numerical identifier assigned by the Chemical Abstracts Service (CAS) to every chemical substance described in the open scientific literature

EU tonnes/annum: Tonnage band in which the SoC is used per year in the EU (if available)

Hazard: Known hazards of the SoC (e.g. Carcinogenic (C), Endocrine Disruptor (ED), Mutagen (M), Reproductive Toxin (R), Skin sensitizer (Ss), Respirator sensitizer (Sr), Persistent Organic Pollutant (POP), Persistent Bioaccumulative Toxin (PBT))

¹⁶ Van Bruggen (2020) Zicht (krijgen) op Zeer Zorgwekkende Stoffen in een Circulaire Economie - Concretisering van een monitoringsstrategie. RIVM-briefrapport 2020-0208.

¹⁷https://echa.europa.eu/documents/10162/13642/data_candidate_list_substances_in_articles_en.pdf/d48a58e4-0d67-4c54-86a5-0b15877a8c93

¹⁸ <https://echa.europa.eu/information-on-chemicals>

¹⁹ <https://sinlist.chemsec.org/>

REACH status: In which REACH processes SoC currently occurs (e.g. Candidate List, Authorisation, Restriction, Evaluation)

Notes: Links with additional information about P-SoC

Step 2: Ruud Balkenende classified 16 P-SoC combinations as ‘not feasible’ (Appendix 2, separate document) as these were less relevant from a design perspective.

Step 3: Frieke Heens, Richard Luit, Martien Janssen, and Nicole Janssen provided another round of comments on the remaining 33 feasible combinations and chose 6 P-SoC combinations (Appendix 3, separate document).

Step 4: In a final discussion with Frieke Heens, Ruud Balkenende and Julieta Bolanos Arriola, the design, risk and circular economy relevance of the feasible options was discussed. Finally 11 P-SoC combinations were chosen which are presented in Table 1 below.

Table 1 Final P-SoC combinations

Serial Number	Sector	Product	SoC	Technical Function	Hazard
1	Electronics	Extension cord for domestic use	DEHP	Softner	R, ED
2	Paper and Cardboard	Moulded Fibre Plate	PFAS	Grease and water repellent	C, R, PBT, POP
3	Textile	Carpet	PFAS	Stain repellent	C, R, PBT, POP
			Chromium 6 for wool	Dye	
4	Electronics	Colour LCD monitor	Lead	Solder	C*, R
			Siloxanes (e.g. Dodecamethylcyclohexasiloxane, Decamethylcyclopentasiloxane, Octamethylcyclotetrasiloxane)	Reduce moisture sensitivity	PBT
5	Textile	Camping Tent	Tris (any flame retardant)	Flame retardant	R
6	Agriculture	Plastic Mulch Films	Microplastic release	N/A	PoP
7	Textile	Synthetic textile	Microplastic release	N/A	PoP
8	Construction	PVC Façade panels	Declorane Plus	Flame retardant	vPvB
			Phthalates	Plasticizer	R, ED
9	Construction	Pressure treated wood for external applications	Copper azole/others	Anti-bacterial and antifungal	ED (copper)

10	Construction	Coated wood for external applications	Nano copper oxide coating	Anti-bacterial and antifungal	ED (copper)
11	Textile	Face mask	Nano silver	Anti-microbial	ED (silver)

C-Carcinogen, C-Suspected Carcinogen, M-Mutagen, R-Toxic to reproduction, ED-Endocrine Disruptor, PBT-Persistent Bioaccumulative Toxic, POP-Persistent Organic Pollutant, vPvB-very Persistent very Bioaccumulative*

The extent to which the selected P-SoC combinations met our selection criteria are documented in Table 2. Similarity in products and substances have been marked in Table 2 in identical colours.

Table 2 Evaluation of P-SoC according to selection criteria

Serial Number	P-SoC	Product variety	SoC variety	Archetypical SbD solution variety	Encompass safety issues that can be grasped by multiple target groups
1	Extension Cord-DEHP	One of two electronic products- Different applications	Unique	Substitution, End of Life collection	Yes
2	Moulded fibre plate-PFAS	Unique	One of 2 PFAS P-SoC combination - Different product context	Don't know yet. Restriction of PFAS in 2025 planned, in The Netherlands, earlier restriction for packaging planned earlier. Plastic packaging in supermarkets are being replaced by biodegradable packaging even for fruits and vegetables and PFAS is being used for its water repellent properties in such packaging. Solution for recurring SoC will be repeated if applicable to the use context (PFAS)	Yes
3	Carpet-PFAS, Chromium6 dye	One of four textile products- Different applications	Chromium 6 is unique. One of two PFAS P-SoC combination - Different product context	Chromium 6 treated wool is a challenge for use in multiple lifecycles (especially for different types of applications) Solution for recurring SoC will be repeated if applicable to the use context (PFAS).	Yes

Serial Number	P-SoC	Product variety	SoC variety	Archetypical SbD solution variety	Encompass safety issues that can be grasped by multiple target groups
4	Camping tent-Tris	One of four textile products- Different applications	One of two fire retardant P-SoC combination - Different product context	Substitution. Depends if it leaches during use or end of life. Applicable to any fabric in an outdoor application and several flame retardant can be considered.	Yes
5	Colour LCD TV-Lead (solder), Siloxanes	One of two electronics P-SoC combination-Different applications	Unique	Lead solder has been replaced by regrettable substitutions like Silver and Bismuth. Recycling lead in Printed Circuit Boards is quite easy, so better solutions are available.	Yes
6	Platic mulch films - microplastic release	Unique	One of two microplastics P-SoC combination	Don't know yet. Possibly substitution to biodegradable, better mechanisms for End of Life.	Yes
7	Synthetic textiles- Microplastic release	One of four textile products- Different applications	One of two microplastics P-SoC combination	Different contexts for microplastic release-mulch films are released in the environment while textiles release microplastics in a the washing machine (confined). The pair of P-SoC combination can be used to illustrate how SbD strategies can differ with use. (substitution, filters in washing machine)	Yes
8	PVC Façade panels	One of three construction products- Different application than 9 and 10	Phthalates are unique. One of two fire retardant P-SoC combination -	Don't know yet.	Yes

Serial Number	P-SoC	Product variety	SoC variety	Archetypical SbD solution variety	Encompass safety issues that can be grasped by multiple target groups
			Different product context		
9	Pressure treated wood-copper azole/others	One of three construction products, Can be paired for comparison with #10	One of two copper based wood preservative P-SoC combination (with #10)-Similar (not identical) but different production and use context	Pressure treatment of wood with hazardous materials is a challenge to multiple life cycles. Different design solutions for pressure treated wood and antimicrobial wood coating due to different use contexts.	Yes
10	Antimicrobial wood coating-nano copper oxide	One of three construction products, Can be paired for comparison with #9	One of two wood preservative P-SoC combination (with #9)-Similar (not identical) but different production and use context	Different design solutions for pressure treated wood and antimicrobial coating due to different use contexts.	Yes
11	Facemask-nano silver	One of four textile products-Different applications	Unique	Don't know yet. SbD solutions can be applicable to several nano silver based textiles like facemask, bandages, etc.	Yes

4. Further steps

Through linking information and consulting experts, we arrived at a list of 11 P-SoC fairly diverse combinations that can be used for illustrating SbD approaches. Some of them are particularly interesting from the perspective of the SoCs limiting application across multiple lifecycles (e.g. Chromium 6 in wool dyeing, Copper based pressure treatment of wood).

A manual approach for selecting P-SoC combinations was followed in this project as there were missing links between SoC, P and country level statistics on production or trade volumes. The SCIP database is a positive step to support SbD and therefore also Circular Design, but is at an early phase of development and information is not yet standardized or user friendly²⁰. We could use one entry from the SCIP database i.e. Colour LCD monitor as a SoC-P combination. Further, economic information on SoC and products collated for circular economy researchers and policymakers would be useful to establish priorities for SbD in countries.

²⁰ One year of the SCIP database: key learnings and way forward, Kevin Pollard:
<https://www.youtube.com/watch?v=y3-CN2ftCI8>