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Institut für angewandte Ökologie
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ROHS Annex II Dossier for Cobalt dichloride, cobalt sulphate, cobalt dinitrate, cobalt carbonate and cobalt di(acetate).
Restriction proposal for substances in electrical and electronic equipment under RoHS

Report No. 7
Substance Names: Cobalt dichloride, cobalt sulphate, cobalt dinitrate, cobalt carbonate and cobalt di(acetate)

Version 2
25/09/2019

EC Number(s):	Cobalt dichloride 231-589-4
	Cobalt sulphate 233-334-2
	Cobalt dinitrate 233-402-1
	Cobalt carbonate 208-169-4
	Cobalt di(acetate) 200-755-8
CAS Number(s):	Cobalt dichloride 7646-79-9
	Cobalt sulphate 10124-43-3
	Cobalt dinitrate 10141-05-6
	Cobalt carbonate 513-79-1
	Cobalt di(acetate) 71-48-7

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Abbreviations

AEM	Association of Equipment Manufacturers
CDI	Cobalt Development Institute
CLP	Regulation (EC) No 1272/2008 on Classification, Labelling and Packaging
CMR	Carcinogenic, Mutagenic or Reprotoxic
DNEL	Derived No-Effect Level
ECHA	European Chemicals Agency
EEE	Electrical and Electronic Equipment
dw	Dry Weight
IC	Integrated Circuit
IED	Industrial Emission Directive
KEMI	Swedish Chemicals Agency
MCCP	Medium-Chain Chlorinated Paraffins
OEM	Original Equipment Manufacturer
Op. cit .	Opus citatum, the work cited
PCB	Printing Circuit Board
PNEC	Predicted No-Effect Concentration
REACH	Regulation (EU) No 1907/2006 on the Registration, Evaluation, Authorisation and restriction of Chemical substances.
RoHS	Directive 2011/65/EU (RoHS 2) on the restriction of the use of certain hazardous substances in electrical and electronic equipment
SIN	SIN (Substitute it Now!) List of the NGO ChemSec
SVHC	Substances of Very High Concern
WEEE	Waste of Electrical and Electronic Equipment
ZVO	Zentralverband Oberflächentechnik (Central Association of Surface Treatment Professionals Germany)
[explanation]	Editorial explanation by the authors of the substance assessment

CONTEXT and SCOPE of the DOSSIER / substance assessment

This substance assessment of cobalt salts is being performed as part of the "*Study on the review of the list of restricted substances and to assess a new exemption request under RoHS 2 – Pack 15*". With contract No. 07.0201/2017/772070/ENV.B.3 implementing Framework Contract No. ENV.A.2/FRA/2015/0008, a consortium led by Oeko-Institut for Applied Ecology, has been assigned by DG Environment of the European Commission to provide technical and scientific support for the review of the list of restricted substances and to assess a new exemption request under RoHS 2. This study includes an assessment of seven substances and group of substances[1] with a view to the review and amendment of the RoHS Annex II list of restricted substances. The seven substances have been pre-determined by the Commission for this task. The detailed assessment is being carried out for each of the seven substances in line with a uniform methodology[2].

According to the terms of references of the study the scope of the assessment concerns cobalt dichloride and cobalt sulphate. For this purpose, the evaluation has compiled relevant background information for understanding whether the two cobalt compounds are used in the manufacture of EEE and whether they remain present in final EEE articles placed on the EU market. However, the terms of reference of the study further points out that the *"grouping of substances (e.g. for cobalt or nickel compounds or for MCCPs) shall be possible by following the approach determined in the updated methodology, once agreed."* In the course of the assessment, it became apparent that the European Chemicals Agency (ECHA) was considering a restriction on the manufacturing, placing on the market and use of five cobalt salts as substances on their own or in mixtures. These five cobalt salts are: cobalt dichloride and cobalt sulphate together with cobalt dinitrate, cobalt carbonate and cobalt di(acetate). Therefore, it was recommended to the European Commission to extend the scope of this assessment under the RoHS Directive to the five cobalt salts as proposed by ECHA for a REACH Annex XVII restriction. The European Commission agreed in January 2019 to this scope adjustment.

However, further cobalt compounds including cobalt metal and cobalt alloys are not considered in this dossier. Their impact on human health and the environment during use or in the waste phase will not be assessed.

In the course of the substance assessment under RoHS, a 1st stakeholder consultation was held from 20 April 2018 to 15 June 2018 to collect information and data for the seven substances under assessment. Information on this consultation can be found at the Oeko-Institut's project webpage at: http://rohs.exemptions.oeko.info/index.php?id=289.

This consultation - as held before the scope adjustment - focused solely on cobalt dichloride and cobalt sulphate. For cobalt dichloride and cobalt sulphate, a total of seven contributions were submitted by different stakeholders. An overview of the contributions submitted during this

[1] For the sake of better readability hereafter the term substance will be used for single substances as well as for group of substances.

[2] This methodology includes a dossier template for substance assessment which had been prepared by the Austrian Umweltbundesamt GmbH in the course of a previous study. The methodology for substance assessment has been revised based on various proposals from and discussions with stakeholders. Among others, revisions have been made to clarify when the Article 6(1) criteria are considered to be fulfilled and how the precautionary principle is to be applied. The methodology has also been updated in relation to coherence to REACH and other legislation and publicly available sources of relevance for the collection of information on substances have been updated and added. The methodology is available at https://rohs.exemptions.oeko.info/index.php?id=341

consultation is provided in Appendix I. The contributions can be viewed at: http://rohs.exemptions.oeko.info/index.php?id=296.

Based on the stakeholder input and publicly available information, the current version of the dossier has been prepared, which is now subject to a 2nd stakeholder consultation. The aim of the 2nd consultation is to receive further information, data and comments:

- To provide clarity as to aspects on which data gaps still exist;
- to provide specific data for basing estimations where these are currently based on assumptions in lack of data;
- to provide sector specific data where current information does not allow making relevant distinction as to the differing use of the assessed substances by various EEE sectors;
- to comment on the general interpretations made as to the current base of knowledge.

After the revision of the dossiers and their completion, a final stakeholder meeting shall be held to allow stakeholders to comment on the dossiers and particularly on conclusions and recommendations.

1. IDENTIFICATION, CLASSIFICATION AND LABELLING, LEGAL STATUS AND USE RESTRICTIONS

1.1 Identification

1.1.1. Name, other identifiers, and composition of the substance

The following information on the substance identity of the five cobalt salts, cobalt dichloride[3],cobalt sulphate[4] cobalt dinitrate[5], cobalt carbonate[6] and cobalt di(acetate)[7] are extracted from the ECHA database on substances.

Table 1-1: Substance identity and composition of cobalt dichloride, cobalt sulphate, cobalt dinitrate, cobalt carbonate, cobalt di(acetate)

Chemical name	Cobalt dichloride	Cobalt sulphate	Cobalt dinitrate	Cobalt carbonate	Cobalt di(acetate)
EC number	231-589-4	233-334-2	233-402-1	208-169-4	200-755-8
CAS number	7646-79-9	10124-43-3	10141-05-6	513-79-1	71-48-7
IUPAC name	Cobalt(2+) dichloride	Cobalt (2+) Sulfate Cobalt Sulfate Cobalt Sulphate Cobalt sulphate heptahydrate cobalt(2+) sulfate Cobalt(II) sulfate cobalt(II) sulphate-1-water Cobalto(II) Sulfato 7-hidrato Cobaltsulfat CoSO4 λ²-cobalt(2+) ion sulfate	λ²-cobalt(2+) dinitrate	λ²-cobalt(2+) carbonate	λ²-cobalt(2+) diacetate
Index number in Annex VI of the CLP	027-004-00-5	027-005-00-0	027-009-00-2	027-010-00-8	027-006-00-6

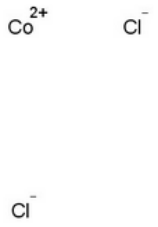
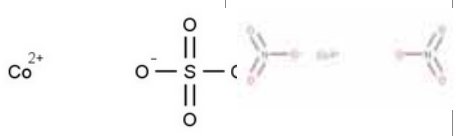
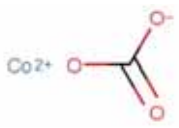
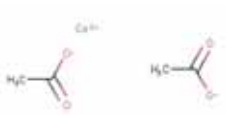
[3] ECHA Brief Profile: Entry for Cobalt dichloride; https://echa.europa.eu/de/brief-profile/-/briefprofile/100.028.718, last viewed 04.06.2018

[4] ECHA Brief Profile: Entry for Cobalt sulphate; https://echa.europa.eu/de/brief-profile/-/briefprofile/100.030.291, last viewed 04.06.2018

[5] ECHA Brief Profile: Entry for Cobalt dinitrate: https://echa.europa.eu/brief-profile/-/briefprofile/100.030.353,last viewed 22.02.2019

[6] ECHA Brief Profile: Entry for Cobalt carbonate: https://echa.europa.eu/brief-profile/-/briefprofile/100.007.428, last viewed 22.02.2019

[7] ECHA Brief Profile: Entry for Cobalt di(acetate): https://echa.europa.eu/brief-profile/-/briefprofile/100.000.687, last viewed 22.02.2019

Regulation					
Molecular formula	Cl_2 Co	Co H_2O_4S	CoN2O6	CCoO3	C4H6CoO4
Molecular weight (range)	129.84 g/mol	154.99 g/mol	182.96 g/mol	118.94 g/mol	177.02 g/mol
Synonyms	cobalt (II) chloride Cobalt (II) chloride hexahydrate Cobalt Chloride Cobalt(2+) dichloride Cobalt(II) chloride Hexahydrate [for General Organic Chemistry] Cobaltdichlorid Cobalto(II) Cloruro 6-hidrato λ²-cobalt(2+) ion dichloride	cobalt sulfate Cobalt sulphate cobalt sulphate Cobalt(II) sulphate Cobalt (2+) Sulfate Cobaltsulfat Cobalto(II) Sulfato 7-hidrato cobalt(II) sulphate-1-water	Cobalt dinitrate Cobalt(II) dinitrate cobalt(2+) dinitrate cobalt(II) nitrate Cobaltdinitrat λ²-cobalt(2+) dinitrate Cobalt Dinitrate Cobalt Nitrate	Cobalt carbonate Cobalt(II) carbonate Cobalt Carbonate cobalt(2+) carbonate Cobalt(II)carbonic cobalte carbonate λ²-cobalt(2+) carbonate	Cobalt di(acetate) Cobalt(II) diacetate Acetic acid, cobalt(2+) salt (2:1) Bis(acetato)cobalt cobalt (II) ethanoate 4-water Cobalt Acetate Cobalt diacetate cobalt(2+) diacetate Cobalto(II) Acetato 4-hidrato λ²-cobalt(2+) diacetate
Structural formula					
Degree of purity	No data	No data	No data	No data	No data
Remarks	-	-	-	-	-

Source: European Chemicals Agency ECHA, Brief Profile: Entries for Cobalt dichloride, Cobalt sulphate, Cobalt dinitrate , Cobalt carbonate, Cobalt di(acetate)

1.1.2. Physico-chemical properties

Physico-chemical properties of cobalt dichloride, cobalt sulphate, cobalt dinitrate, cobalt carbonate and cobalt di(acetate) are summarised in Table 1-2 below and were extracted from the ECHA information database on chemicals as well as from the ECHA SVHC support documents.[8]

[8] ECHA (2010a): Support document for identification of cobalt (II) sulphate as a Substance of Very High Concern because of its CMR properties, Adopted on 2 December 2010; https://echa.europa.eu/documents/10162/5fa87d07-2872-4502-b07c-4186797aa442, last viewed 04.06.2018.

Table 1-2: Overview of physico-chemical properties of cobalt dichloride, cobalt sulphate, cobalt dinitrate, cobalt carbonate, cobalt di(acetate)

Property	Cobalt dichloride	Cobalt sulphate	Cobalt dinitrate	Cobalt carbonate	Cobalt di(acetate)
Physical state at 20°C and 101.3 k Pa	Solid (crystals)	Solid (crystals)	Pale-red powder	Red crystalline powder	Light-pink crystals
Melting/freezing point	736 °C 724 °C (ECHA 2011)	700 °C 735°C (ECHA 2010)	100-105 °C	No data	No data for anhydrous form, loses four H2O at 140°C for tetrahydrate form
Boiling point	1.049 °C	No data	74 °C	No data	No data
Vapour pressure	40 mmHg at 770°C	No data	No data	No data	No data
Water solubility	585.8 g/l at 20 °C	376.7 g/l at 20°C soluble 362 g/l at 20 ℃ 830 g/l at 100 ℃ (SVHC support document)	1338 g/l at 0°C soluble 2170 g/l at 80°C	Insoluble in water 0.18 g/100 g water	Readily soluble Soluble in water * The water solubility of cobalt(II) diacetate in the form of a numerical value or range is not available
Partition coefficient n-octanol/ water (log POW)	Not appropriate, inorganic substance	Not relevant	Not relevant	Not relevant	Not relevant
Dissociation constant	No data	No data	No data	No data	No data
Relative density	3.36 g/cm³ at 20 °C	3.71 g/cm³ at 20 °C	No data	No data	No data
Specific gravity	No data	No data	No data	No data	No data

Source: ECHA database on chemicals; ECHA (2010a,b,c,d and 2011)

ECHA (2011): Support document for identification of cobalt dichloride as a Substance of Very High Concern because of its CMR properties, 20 June 2011;https://echa.europa.eu/documents/10162/7d541979-6f03-421b-91bb-039bfb326de1, last viewed 04.06.2018.

ECHA (2010b): Support document for identification of cobalt dinitrate as a Substance of Very High concern because of its CMR properties, Adopted on 2 December 2010; https://echa.europa.eu/documents/10162/a6ff4bdb-6aa3-48ff-b9b4-6f086d8f35fa, last viewed 22.02.2019.

ECHA (2010c): Support document for identification of cobalt carbonate as a Substance of Very High concern because of its CMR properties, Adopted 2 December 2010; https://echa.europa.eu/documents/10162/efdc02e9-f1e6-47c7-872b-7d6285457495, last viewed 22.02.2019.

ECHA (2010d): Support document for identification of cobald di(acetate) as a Substance of Very High concern because of its CMR properties, Adopted 2 December 2010; https://echa.europa.eu/documents/10162/f68e76b3-751d-48b4-a225-4a23c0ee6249, last viewed 22.02.2019.

1.2. Classification and labelling status

The Classification, Labelling and Packaging (CLP) regulation[9] ensures that the hazards presented by chemicals are clearly communicated to workers and consumers in the European Union through classification and labelling of chemicals. Annex VI of the CLP regulation No 1272/2008 lists substances where a harmonised classification exists based on e.g. human health concerns.

Annex VI of the CLP regulation is constantly adapted by engagement of Member State Competent Authorities and ECHA where new information becomes available, where existing data are re-evaluated or due to new scientific or technical developments or changes in the classification criteria. [10]

For an explanation on the human and environmental hazards, see section 2.4 and 4.

1.2.1. Classification in Annex VI Regulation No 1272/2008

The five cobalt salts all have the same classification under the CLP regulation (Regulation (EC) No 1272/2008 on Classification, Labelling and Packaging) with the following entries:[11]

- Acute Tox. 4 (Acute toxicity) - H302 (Harmful if swallowed);
- Skin Sens. 1 (Sensitisation of the skin) - H317 (May cause an allergic skin reaction);
- Resp. Sens. 1 (Sensitisation of the respiratory tract) - H334 (May cause allergy or asthma symptoms or breathing difficulties if inhaled;
- Muta. 2 (Germ cell mutagenicity) - H341 (Suspected of causing genetic defects);
- Carc. 1B (Carcinogenicity) - H350i (May cause cancer by inhalation);
- Repr. 1B (Reproductive Toxicity) - H360F (May damage fertility);
- Aquatic Acute 1 (Hazardous to the aquatic environment) - H400 (Very toxic to aquatic life); and
- Aquatic Chronic 1 (Hazardous to the aquatic environment) - H410 (Very toxic to aquatic life with long lasting effects).

The harmonised classification according to Table 3.1 of Annex VI Regulation No 1272/2008, for the five cobalt salts is presented in Table 1-3.

[9] Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006 (REACH).

[10] For further information, see https://echa.europa.eu/regulations/clp/harmonised-classification-and-labelling, last viewed 19.04.2018

[11] https://echa.europa.eu/de/information-on-chemicals/annex-vi-to-clp, last viewed 19.04.2018

Table 1-3: Classification according to part 3 of Annex VI, Table 3.1 (list of harmonised classification and labelling of hazardous substances) of Regulation (EC) No 1272/2008 for the five cobalt salts

Index No.	International Chemical ID	EC No.	CAS No.	Classification		Labelling			Spec. Conc. Limits, M-factors
				Hazard Class and Category Code(s)	Hazard statement code	Pictogram Signal Word Code(s)	Hazard statement code(s)	Suppl. Hazard statement code(s)	
027-004-00-5	cobalt dichloride	231-589-4	7646-79-9	Carc. 1B Muta. 2 Repr. 1B Acute Tox. 4 Resp. Sens. 1 Skin Sens. 1 Aquatic Acute 1 Aquatic Chronic 1	H350i H341 H360F H302 H334 H317 H400 H410	GHS08 GHS07 GHS09 Dgr	H350i H341 H360F H302 H334 H317 H410	No data	Carc. 1B; H350i: C ≥ 0,01 % M=10
027-005-00-0	cobalt sulphate	233-334-2	10124-43-3						
027-006-00-6	cobalt di(acetate)	200-755-8	71-48-7						
027-009-00-2	cobalt dinitrate	233-402-1	10141-05-6						
027-010-00-8	cobalt carbonate	208-169-4	513-79-1						

Source: Annex VI Regulation No 1272/2008; https://echa.europa.eu/de/information-on-chemicals/annex-vi-to-clp, last viewed 15.04.2019

To summarize, it is understood based on the harmonised classification that all five cobalt salts are considered as CMR substances. This means that exposure to these substances could lead to severe impacts on human health and/or the health of other species, e.g., cancer, genetic defects and/or impacts on the reproductive system and organs. Given other hazards that have been classified, relevant pathways for such impacts include exposure through the respiratory system and through inhalation, through contact with skin and through oral exposure. The five cobalt compounds have further been classified for aquatic toxicity, meaning that exposure of aquatic organisms is also of potential concern.

1.2.2. Self-classification(s)

Manufacturers, importers or downstream users have to (self-)classify and label hazardous substances and mixtures to ensure a high level of protection of human health and the environment. If a harmonised classification is available, it should be applied by all manufacturers, importers or downstream users of such substances and of mixtures containing such substances.

However, mostly, suppliers decide independently as to the classification of a substance or mixture, which is then referred to as self-classification. Therefore, self-classification might indicate an e.g.

additional hazard which is so far not reflected by the harmonised classification. The ECHA database C&L inventory contains classification and labelling information on notified and registered substances received from manufacturers and importers. The substance specific entries compiles all hazards notified in self-classification.[12]

To summarize the various self-classifications, basically the same types of hazards are addressed as by the harmonised classification. Though in some cases the level of hazard may differ or certain hazard types have been omitted and given that the harmonised classification is assumed to have a higher scrutiny the differences in the self-classification compared to the harmonised classification are not further considered. To conclude on the classification, the five cobalt salts are recognised CMR substances thus relevant for human health.

1.3. Legal status and use restrictions

1.3.1. Regulation of the substance under REACH

The five cobalt salts, cobalt dichloride, cobalt sulphate, cobalt dinitrate, cobalt carbonate and cobalt di(acetate) are all recognised as substances of very high concern and were all included in the REACH Candidate list in 2008 because of being carcinogenic and toxic for reproduction (Articles 57a and 57c).

On 20 December 2011, ECHA prioritised the five cobalt salts for inclusion in Annex XIV to the REACH Regulation.[13] In December 2012, the Commission requested ECHA[14] to investigate the uses of the five cobalt salts because at least one of the uses of the cobalt salts (e.g. surface treatment) was considered to pose a risk to human health that is not adequately controlled and might need to be addressed. The inclusion into Annex XIV of REACH was postponed until this investigation was to be completed.

Based on the outcomes of its investigation, compiled in a 2017[15] report, ECHA came to the conclusion that there is a need for a proposal for restriction of the five soluble cobalt salts. ECHA

[12] ECHA CL Inventory: Entry for cobalt dichloride; https://echa.europa.eu/de/information-on-chemicals/cl-inventory-database/-/discli/details/119523, last viewed 04 June 2018

ECHA CL Inventory: Entry for cobalt sulphate; https://echa.europa.eu/de/information-on-chemicals/cl-inventory-database/-/discli/details/79319, last viewed 04 June 2018

ECHA CL Inventory: Entry for cobalt di(acetate); https://echa.europa.eu/information-on-chemicals/cl-inventory-database/-/discli/details/126330, last viewed 18.02.2019

ECHA CL Inventory: Entry for cobalt dinitrate; https://echa.europa.eu/information-on-chemicals/cl-inventory-database/-/discli/details/242, last viewed 18.02.2019

ECHA CL Inventory: Entry for cobalt carbonate; https://echa.europa.eu/information-on-chemicals/cl-inventory-database/-/discli/details/72255, last viewed 18.02.2019

[13] ECHA (2011): Third Annex XIV recommendation - 20 December 2011; http://www.echa.europa.eu/documents/10162/13640/3rd_a_xiv_recommendation_20dec2011_en.pdf, last viewed 19.04.2018

[14] Recitals (11) and (12) of Commission Regulation (EU) No 348/2013 of 17 April 2013 amending Annex XIV to Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH): http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0348&qid=1493704087781&from=en, last viewed 04.06.2018

[15] ECHA (2017a): Study report on the conditions of use of five cobalt salts, Final report, May 2017, https://echa.europa.eu/documents/10162/13641/cobalts_salts_study_report_en.pdf/42f0947f-e7fe-7b14-fc97-cfda0c068e9d, last viewed 04.06.2018

committed to make a proposal for a restriction of the substance and to submit a REACH Annex XV dossier for a restriction in 07/2018.[16]

Thus, for this restriction proposal under REACH, the five soluble cobalt salts are assessed as a group of substances.

The restriction proposal by ECHA has been posted in December 2018.[17] It is proposed that the cobalt salts cannot be manufactured, placed on the market or used unless a reference exposure value of 0.01 µg Co/m^3 ambient air is used by manufacturers and downstream users; they are required to implement a monitoring programme to demonstrate that all occupational exposures to the cobalt salts are below the reference exposure value of 0.01 µg Co/m^3.

The wording of the proposed restriction is shown in the following figure. The proposed restriction aims at reducing workers exposure levels and reducing the cancer risk and number of cancer cases resulting from occupational exposure to the cobalt salts.

As a number of national occupational exposure limits exists in the EU, the restriction proposal is further aimed at harmonizing EU-wide a high level of protection of human health across and besides minimizing the potential of market distortion.

The six-month public consultation under REACH ended on 19.06.2019. The comments submitted during the consultation as well as all ECHA documents (Information note on restriction report, restriction report and restriction report annexes) can be found on the ECHA webpage on submitted restrictions under consideration at: https://echa.europa.eu/restrictions-under-consideration/-/substance-rev/21805/term.

[16] ECHA (2017b): Risk Management Option Analysis Conclusion Document, Substance Name: Soluble cobalt salts; 19/5/2017; https://echa.europa.eu/documents/10162/c362c44b-9470-a290-5ed7-c6c7a84989ae, last viewed 19.04.2018

[17] ECHA (2018a): Annex XV Restriction Report, Proposal For A Restriction, Substance Names: cobalt sulphate cobalt dinitrate cobalt dichloride cobalt carbonate cobalt di(acetate); https://echa.europa.eu/documents/10162/0015c4ff-3036-9206-26ba-c6ff7ddf18e6, last viewed 18.02.2019

Figure 1-1: Proposed restriction according to Annex XV Restriction Report - Five cobalt salts

Column 1 Designation of the substance, of the group of substances or of the mixture	Column 2 Conditions of restriction
Cobalt sulphate CAS no 10124-43-3 EC no 233-334-2 Cobalt dichloride CAS no 7646-79-9 EC no 231-589-4 Cobalt dinitrate CAS no 10141-05-6 EC no 233-402-1 Cobalt carbonate CAS no 513-79-1 EC no 208-169-4 Cobalt di(acetate) CAS no 71-48-7 EC no 200-755-8	1) Shall not be manufactured, placed on the market or used as substances on their own or in mixtures in a concentration equal to or above 0.01% by weight, unless: a) if required by article 14 of REACH, registrants have carried out in their Chemical Safety Assessment an assessment according to paragraph 6.5 of Annex I of REACH and have used a reference exposure value of 0.01 µg Co/m³ to demonstrate that all occupational exposures to the cobalt salts are below this reference level, and b) if required by article 37(4) of REACH, downstream users have carried out in their Downstream users Chemical Safety Assessment an assessment according to paragraph 6.5 of Annex I of REACH and have used a reference exposure value of 0.01 µg Co/m³ to demonstrate all occupational exposures to the cobalt salts are below this reference level, and c) the supplier has provided the recipient of the substance on their own or in mixtures in a concentration equal to or above 0.01% by weight with a Safety Data Sheet and exposure scenarios (where relevant) according to article 31 of REACH that includes the operational conditions and risk management measures to control occupational exposure to the cobalt salts below a reference exposure value of 0.01 µg Co/m³. The Safety Data Sheet shall state the reference exposure value under Section 8.1 Control parameters. d) the manufacturers and downstream users have implemented a monitoring programme to ensure that all occupational exposures to the cobalt salts are below a reference exposure value of 0.01 µg Co/m³ .[3] 2) Paragraph 1 above shall not apply to the extent that the cobalt salts specified in column 1 are used as an additive in feedingstuffs within the scope of Regulation (EC) no 1831/2003 on additives for use in animal nutrition.

Source: ECHA (2018a)

It is expected that the outcome of the restriction proposal may have consequences as to the use of all cobalt salts and on surface treatment with cobalt in general. Should a restriction under the RoHS directive be recommended, the conditions of the restriction are to be evaluated in order to avoid double regulation and/or discrepancies. It is concluded that the REACH restriction process also applies to the manufacturing processes of EEE. Thus risks arising at that stage are considered to be covered by the REACH Restriction, affording a high level of protection.

1.3.2. Other legislative measures

Cobalt and its compounds are subject to the other legal restrictions as follows:

- The IED Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control) sets emission limit values for cobalt and its compounds at industrial sites.[18]
- In the Water Framework Directive 2006/11/EC on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community, cobalt is listed as a substance for which water pollution has to be reduced; therefore Member States are required to establish environmental quality standards for this purpose.
- Maximum air emission limit values for the incineration of waste are established in Directive 2000/76/EEC on the incineration of waste.[19]

Cobalt is listed on the 2017 list of Critical Raw Materials for the EU (COM(2017) 490 final)[20]. Materials appearing on this list have been identified as critical for the EU because possible risks of supply shortage (scarcity) and their impacts on the economy are higher than those of most of the other raw materials. Additional aspects (e.g. environmental, social) are not mentioned in the communication.

1.3.3. Non-governmental initiatives

The International Chemical Secretariat (ChemSec) has developed and regularly updates the so called SIN List, which identifies potential substances of concern. The purpose of this list is to put pressure on legislators to assess and where relevant address substances identified therein in the future in respect to relevant chemical legislation.[21] Chemsec applies a number of categories for adding substances to the SIN List, including substances that can cause cancer, alter DNA or damage reproductive systems (CMR properties); substances that do not easily break down and accumulate in the food chain (PBT/vPvB substances); and substances of equivalent concern that give rise to an equivalent level of concern in terms of potential damage to health and environment (such as substances with endocrine disrupting properties).

All five cobalt salts[22] have been listed in the SIN List for the reason that they are *"classified CMR according to Annex VI of Regulation 1272/2008"*. Thus, the SIN List does not address further hazards then those already recognised by the harmonised classification.

[18] Average emission limit values (mg/Nm^3) for the following heavy metals over a sampling period of a minimum of 30 minutes and a maximum of 8 hours for Cobalt and its compounds, expressed as cobalt (Co): 0,5 mg/Nm^3

[19] All average values over the sample period of a minimum of 30 minutes and a maximum of 8 hours: total 0,5 mg/m^3 and total 1 mg/m^3 for Cobalt and its compounds, expressed as cobalt (Co)

[20] EU COM (2017): Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the 2017 list of Critical Raw Materials for the EU, Brussels, 13.9.2017, COM(2017) 490 final, available under: http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM:2017:0490:FIN, last viewed 19.04.2018

[21] http://chemsec.org/business-tool/sin-list/about-the-sin-list/, last viewed 24.07.2018

[22] https://sinlist.chemsec.org/search/search?query=cobalt, last viewed 20.02.2019

2. USE IN ELECTRICAL AND ELECTRONIC EQUIPMENT

All five cobalt salts (cobalt dichloride and cobalt sulphate, cobalt dinitrate, cobalt carbonate and cobalt diacetate) are used in surface treatment processes. The EEE specific uses in surface treatment processes are **electroplating** and **metal passivation**.

- In relation to **electroplating**, in the ECHA background documents of 2011[23] technical or decorative or magnetic plating is mentioned.

  According to the preliminary investigation regarding the conditions of use of the five soluble cobalt salts, ECHA (2013)[24] stated that the cobalt salts are used in **metal alloy plating processes**: *"The main process reported is gold-cobalt alloy electroplating, although other processes, such as zinc-cobalt, nickel-cobalt, nickel-cobalt-copper, tin-cobalt, etc., have also been identified. Cobalt sulphate appears to be the preferred cobalt salt for gold-cobalt electroplating, together with cobalt carbonate in very small amounts. Cobalt sulphate is also reportedly used in a large number of other cobalt alloy electroplating applications, while cobalt dichloride appears to be used for tin-cobalt and zinc-cobalt coatings specifically. Although no information has been provided regarding the interchangeability of the cobalt salts in electroplating applications, it might be inferred that, similar to the passivation processes, the choice of cobalt salt can affect the characteristics of the final coating. Specific surface characteristics such as ductility, grain size, etc. are referred to in the information supplied, which appear to be cobalt salt-specific."*

  According to ECHA (2018b)[25], *"metallic alloy coatings produced by electroplating are used for example in the jewellery and the watchmaking industry."*

- In **metal passivation**, an anti-corrosion layer/coating is achieved. According to Association of Equipment Manufacturers AEM:[26] *"some formulations also contain cobalt chloride (to give harder coatings)."*

  According to ECHA (2013), cobalt dichloride, cobalt sulphate, cobalt dinitrate and cobalt diacetate are used in the generation of **conversion layers in passivation** processes: *"Cobalt dinitrate appears to be the most commonly used cobalt salt for this application, accounting for more than half of the total use of cobalt salts in passivation. According to the information supplied in the consultation, each cobalt salt provides specific characteristics to the protective coating (colour, optical appearance, thermal and corrosion resistance, etc.) and can influence the speed of the passivation process. However, due to the limited information available, it is not possible to draw a firm conclusion as to whether the cobalt salts will be readily interchangeable from a technical or economic perspective in passivation applications."*

[23] Op. cit. ECHA (2011 a and b)

[24] Op. cit. ECHA (2017a); from page 41 on as last part the following report is included: ECHA (2013): A preliminary investigation into the conditions of use of five cobalt salts final report July 2013, public version.

[25] ECHA (2018b): Restriction report Annexes; Annex XV Restriction Report, Proposal For A Restriction, Substance Names: cobalt sulphate cobalt dinitrate cobalt dichloride cobalt carbonate cobalt di(acetate); https://echa.europa.eu/restrictions-under-consideration/-/substance-rev/21805/term, last viewed 18.02.2019

[26] AEM Association of Equipment Manufacturers (2018): Contribution submitted on 15.06.2018 during the stakeholder consultation conducted from 20 April 2018 to 15 June 2018 by Oeko-Institut in the course of the study to support the review of the list of restricted substances and to assess a new exemption request under RoHS 2 (Pack 15); http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_15/1st_Consultation_Contributions/Contribution_AEM_Cobalt_chloride_sulphate_20180615_RoHS.PDF, last viewed 16.07.2018

The Cobalt Institute[27] explains the processes in the course of this substance assessment at hand as follows; it should be noted that the statement focuses on cobalt dichloride and cobalt sulphate as the contribution had been submitted before the scope of this substance assessment was amended to the five cobalt salts:

> *"In these reaction processes the cobalt dichloride and/ or cobalt sulphate are combined with other metal salts and chemical constituents to prepare the formulation solutions (i.e. proprietary made-to-order mixtures). In solution the metal salts will dissolve and dissociate into their cationic and anionic components. Through the electrochemical deposition process or the passivation process, the cobalt ion is deposited onto the surface layers of the treated article; for example, in the form of metallic cobalt, as an alloyed metal layer, or as a metal oxide/hydroxide complex, or another cobalt-containing compound. The form and composition of the deposited layer will depend on the chemical constituents and technological processes selected by the DU* [downstream user] *company to achieve the required physical-chemical properties and technical functionality that has been specified by the end-user for the intended application."*

Thus, the cobalt salts are not present in the EEE, but transformed into a reaction product which is cobalt metal or a cobalt-containing compound (alloy) or e.g. in metal passivation apparently cobalt oxides. According to the ECHA background documents for e.g. cobalt dichloride and cobalt sulphate from 2011, the alloys could contain nickel, tungsten, iron, molybdenum, chromium, zinc, precious metals, etc.[28]

2.1. Function of the substance

As regards the function of the cobalt compounds in EEE, though the compounds are understood not to remain in the final product, their use affects the functional properties of the resulting plating layer, as also reflected in the following information:

- In relation to **electroplating**, ECHA (2018b) summarises that cobalt salts are used in metal or metal alloy plating (mainly gold-cobalt and tin-cobalt plating) for increased hardness and wear resistance and/or for metal colouring.

  In the ECHA background documents of 2011[29] technical or decorative or magnetic plating is mentioned: *"The function of the substance is to affect physical properties of surfaces, e.g. smoothness, hardness, brightness, ductility, resistance, porosity or the production of record and compact discs."*

  According to ECHA (2018b), *"one company […] estimates that around 45% of the components cobalt-coated by galvanising companies in Germany are used in the automotive sector. Cobalt*

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[27] Cobalt Institute (2018): Contribution submitted on 15.06.2018 during the stakeholder consultation conducted from 20 April 2018 to 15 June 2018 by Oeko-Institut in the course of the study to support the review of the list of restricted substances and to assess a new exemption request under RoHS 2 (Pack 15); http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_15/1st_Consultation_Contributions/Contribution_Cobalt_Institute_Co_response_RoHS_15062018_CoCl2andCoSO4.pdf, last viewed 16.07.2018

[28] ECHA (2011a): Background document for cobalt dichloride; 20 December 2011; http://www.echa.europa.eu/documents/10162/a002b713-7e1a-46ba-ba54-13763c18fd82, last viewed 19.04.2018

ECHA (2011b): Background document for cobalt(II) sulphate, 20 December 2011; http://www.echa.europa.eu/documents/10162/ef958831-f28c-47f1-b159-ab4a32b53b2f, last viewed 19.04.2018

Both documents were developed in the context of ECHA's third Recommendation for the inclusion of substances in REACH Annex XIV.

[29] Op. cit. ECHA (2011 a and b)

salts also have important applications in the aerospace and defence sectors as well as in window construction".

- In **metal passivation**, an anti-corrosion conversion layer is achieved. According to ECHA (2018b) mainly used *"for improving the corrosion resistance of zinc plated metal, hence leading to longer service life and operating time of metal components."*

  According to the Association of Equipment Manufacturers AEM,[30] *"some formulations also contain cobalt chloride (to give harder coatings)."*

To summarise, the five cobalt salts are applied as process chemicals and do not remain in the final layer but rather react. The reaction product is cobalt metal, a cobalt-containing alloy or cobalt oxides.

It can be understood that cobalt / cobalt containing alloys or cobalt oxides provide properties such as resistance to wear and electricity, high temperature and corrosion. The exact properties can be understood to be a result of the compounds used in the various plating/passivation processes. ECHA (2013) states the function is a result of the process and thus understood to be (partly) affected by the specific cobalt compounds used even if it is no longer available in the coating in this previous form. It is further understood that detailed information for specific cobalt salts is not available. Interchangeability may be possible between cobalt salts in some cases, but it is not clear for which cobalt salt and whether this would have additional impacts on the process (amounts of used) or its outcomes (e.g. additional properties, plating thickness, etc.).

2.2. Types of applications / types of materials

The Cobalt Development Institute (CDI) stated in 2014[31] that "*in general Co is used in*

- *semi-conductors,*
- *component lead frames,*
- *contacts and connectors,*
- *printed circuit boards,*
- *processors and chipsets, and*
- *hard-disk drives.*

However it is not known to the CDI yet which, and how much of each of the three cobalt substances [Cobalt dichloride, Cobalt sulphate, Cobalt metal] *are used in each of these applications.*"

On their website, the Cobalt Institute refers to EEE applications that contain cobalt as follows:

[30] AEM Association of Equipment Manufacturers (2018): Contribution submitted on 15.06.2018 during the stakeholder consultation conducted from 20 April 2018 to 15 June 2018 by Oeko-Institut in the course of the study to support the review of the list of restricted substances and to assess a new exemption request under RoHS 2 (Pack 15); http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_15/1st_Consultation_Contributions/Contribution_AEM_Cobalt_chloride_sulphate_20180615_RoHS.PDF, last viewed 16.07.2018

[31] Cobalt Development Institute (2014): Contribution submitted on 04.04.2014; http://rohs.exemptions.oeko.info/index.php?id=213, last viewed 19.04.2018

Integrated circuits[32]

- **Contacts:** *"The connections between different components of an integrated circuit (IC) are called contacts. Within these connections copper is generally used. The thickness and length of the connection causes gate resistance. Silicides such as CoSi2 can be used to reduce this resistance. The use of a cobalt silicide has the advantage of low resistance, good process compatibility (high duration of high temperatures) and little electro-migration (displacement of a substance by the electric current)."*
- **Metal leads**: *"Cobalt is also used in metal leads (a length of wire or a metal pad that comes from a device). Gold is commonly used for marking mechanical electrical contacts. By co-depositing the gold with 15% cobalt, the wear-resistance properties of the metal lead are greatly increased. When an electrical current passes through the IC cycling occurs, the friction produced can cause the IC to fail, the addition of cobalt prevents this."*
- **Packages**: *"Lastly, cobalt is used in the packaging of ICs. Cobalt can be used in printing circuit board materials (PCB). PCBs usually consist of an insulating support surrounded by layers of electrically resistive materials which are attached to highly conductive materials. Cobalt antimony, cobalt boron, cobalt geranium, cobalt indium, cobalt-molybdenum, cobalt phosphorous, cobalt rhenium, cobalt ruthenium, cobalt tungsten and cobalt vanadium can all be used as resistive materials."*

Semi-conductors[33]

"Cobalt is used in three main parts within a semi-conductor:

- *The trend of increasing power by increasing the electric current in copper metal wiring is leading to electro-migration (e.g. 'leaking') of the copper. Cobalt is currently the material being extensively researched for its ability to provide a* ***barrier to prevent the electro-migration of copper.***
- ***Magnet tunnel junction transistors.***
- ***Cobalt-silicon-germanium nanowires*** *can be used in optical electrical devices. Cobalt improves the contact interface and allows for a tuneable bandgap."*

Magnetic recording[34]

"Cobalt is an essential metal in data recording devices such as hard disk drives [...]. Cobalt is often found in the medium used in magnetic recording devices, usually in the form of iron-cobalt. When in contact with an electro-magnet field the metallic grains can be polarised in one direction. Eventually the medium will migrate back to the previous chaotic state however."

According to MedTech Europe,[35] also flow cytometer parts may contain cobalt sulphate. However, so far it was not specified whether cobalt sulphate is used as a material constituent, as an additive, as an intermediate or a reactant, etc. and what concentration of cobalt sulphate remains in the final

[32] https://www.cobaltinstitute.org/integrated-circuits.html, last viewed 20.07.2018

[33] https://www.cobaltinstitute.org/semi-conductors.html, last viewed 20.07.2018

[34] https://www.cobaltinstitute.org/magnetic-recording.html, last viewed 20.07.2018

[35] MedTech Europe (2018): Contribution submitted on 15.06.2018 during the stakeholder consultation conducted from 20 April 2018 to 15 June 2018 by Oeko-Institut in the course of the study to support the review of the list of restricted substances and to assess a new exemption request under RoHS 2 (Pack 15); http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_15/1st_Consultation_Contributions/Contribution_MedTech_Europe_7_substance_contribution20180613_FINAL.PDF, last viewed 16.07.2018

product; neither the function of cobalt sulphate in the flow cytometer parts nor quantities in which cobalt sulphate is applied in flow cytometer parts were specified by MedTech Europe. [36]

2.3. Quantities of the substance used

For quantities of cobalt salts used in surface treatment relevant for EEE, the Cobalt Institute[37] refers to recent information provided in the ECHA Call for Evidence (CfE)[38] in 2017 on the soluble cobalt salts. The Cobalt Institute[39] estimates the volumes as follows:

"Based on the survey results, less than 500 tonnes of cobalt salts were estimated to be used per year in the EU28 in the surface treatment sector, and survey responses indicated that this was primarily used for plating applications. […] The Secretariat notes that this volume (<500 tpa) is being used in the surface treatment sector, and the EEE-related applications represent a portion of this total volume."

Estimations as presented in ECHA (2013)[40] are based on the following information: *"The most comprehensive information regarding the volumes used in this sector has been provided by the Central Association of Surface Treatment Professionals Germany (ZVO). The volumes reported relate only to the German market and represent around 40 per cent of the total European market (ZVO). Based on these figures, the total volumes of cobalt salts used in the European surface treatment sector have been estimated and compared with the information made available by the Commission in its request to ECHA."*

[36] MedTech Europe (2018): Information provided on request by Nathalie Buijs, MedTech Europe on 08.08.2018.

[37] Op. cit. Cobalt Institute (2018)

[38] https://echa.europa.eu/de/previous-calls-for-comments-and-evidence/-/substance-rev/17030/term, last viewed 16.07.2018

It should be noted here that contributions submitted during a call for evidence are not published by ECHA.

[39] Op. cit. Cobalt Institute (2018)

[40] Op. cit. ECHA (2017); from page 41 on as last part the following report is included: ECHA (2013): A preliminary investigation into the conditions of use of five cobalt salts final report July 2013, public version.

Figure 2-1: Reported and estimated volumes of cobalt salts used in surface treatment in 2012 (tonnes/year); the amounts of cobalt sulphate and cobalt dichloride are marked in yellow.

Cobalt salt	Reported by industry*	Estimate for EU	Initial estimate **
Cobalt sulphate	100	250	115
Cobalt dichloride	80	200	40
Cobalt dinitrate	245	613	100
Cobalt carbonate	<0.1	<0.25	3
Cobalt diacetate	25	63	30
Other	-	-	-
Total	**450**	**1126**	**288**

* Information corresponding to the German market (approximately 40% of the European market).
** Information provided by the Commission in its request to ECHA

Source: ECHA (2013): A preliminary investigation into the conditions of use of five cobalt salts final report July 2013, public version in ECHA (2017a)

To conclude, the estimates on the amounts of the five soluble cobalt salts in surface treatment ranged between 1,126 tonnes per year (ECHA 2013)[41] and 500 tonnes per year (Cobalt Institute 2017). The latest specifications of ECHA (2018b) agreed to a *"total volume of cobalt salts used in the surface treatment sector in the EU (2011-2013) was 500 tonnes, representing 1.5% of the total usage of cobalt salts in the EU."*

Information as to amounts of the cobalt salts used in the manufacture of imported EEE articles is currently not available.

Questions for stakeholders participating in the stakeholder consultation:

In light of the extension of the scope of this assessment to the five cobalt salts, information on the applications and quantities are requested:

Is the list of the following applications exhaustive, if not, please provide information on the specific application:

- *Contacts,*
- *Metal leads / component lead frames,*
- *Printed circuit boards / packages,*
- *Semi-conductors,*
- *Magnetic recording / hard-disk drives.*

Please provide information on the quantities of the five cobalt salts used for these applications in the EU as well as quantities on imported articles manufactured outside of the EU.

[41] Op. cit. ECHA (2017); from page 40 on as last part the following report is included: ECHA (2013): A preliminary investigation into the conditions of use of the five cobalt salts final report July 2013, public version.

2.4. Potential for impacts of the substance on the environment and on health during the use of EEE

Seeing as the cobalt salts are understood not to be present in EEE, impacts would not be expected in relation to these substances in the use phase of such EEE. It is, however, noted that the application of these substances in plating processes applied in the manufacture of EEE components results in the presence of cobalt metal or cobalt alloys or cobalt oxide in EEE. Potential impacts on health and or the environment during the use phase of such equipment arising from other cobalt compounds than the five cobalt salts are considered being beyond the scope of this assessment.

3. HUMAN HEALTH HAZARD PROFILE

According to an ECHA report,[42] which was prepared to support the assessment of remaining cancer risks related to the industrial use of cobalt salts in the context of chemical risk management procedures under REACH, the divalent cobalt cation (Co^{2+}) moiety is considered to constitute the critical entity of the five cobalt salts and being responsible for systemic toxicity. In consequence, the classification of the five cobalt salts in Annex VI of the CLP regulation is identical.

As for the counter ions of the cobalt salts (i.e. sulphate, nitrate, chloride, acetate, and carbonate), ECHA (2018) summarises that the combination of released ions (i.e. both the cobalt (II) ion and the anion) is expected to be responsible for local toxicity by exposure to lungs or skin.

3.1. Critical endpoints

The cobalt salts are classified for the following human health hazards:

- CMR substances (carcinogenic and toxic for reproduction) and therefore recognised as substances of very high concern. Furthermore, they are recognised as being mutagenic (H341 - Suspected of causing genetic defects).
  The CMR properties are explained in more detail further below.
- They are recognised skin and respiratory sensitizing chemicals: H317 - May cause an allergic skin reaction and H334 - May cause allergy or asthma symptoms or breathing difficulties if inhaled.
- They are recognised as being acute toxic (category 4: H302 - Harmful if swallowed).

In the following, the consideration on carcinogenicity and mutagenicity are summarised from the ECHA report[43] as it is understood to be the most recent compilation on these critical endpoints of the five soluble cobalt salts:

Carcinogenicity

The carcinogenicity classification was allocated because the cobalt salts may cause cancer by inhalation.

According to ECHA (2017), uncertainties existed on the carcinogenic mode of action, whether the cobalt salts exhibit a threshold mode of action regarding their carcinogenicity effects - as claimed in the registration dossiers - or whether they should be considered as non-threshold carcinogens.

An assessment made by DHI[44] concluded that due to a lack of identified thresholds and due to remaining uncertainties regarding the mechanisms involved, the water soluble cobalt salts are considered as genotoxic carcinogens and are to be assessed using a non-threshold approach.[45]

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[42] ECHA project SR 23 (no year): Support to the assessment of remaining cancer risks related to the industrial use of cobalt salts in the context of chemical risk management procedures under REACH, Poul Bo Larsen (DHI), Brian Svend Nielsen (DHI), Mona-Lise Binderup; https://echa.europa.eu/documents/10162/13563/echa_sr23_project_en.pdf, last viewed 16.07.2018

[43] ECHA project SR 23 (no year): Support to the assessment of remaining cancer risks related to the industrial use of cobalt salts in the context of chemical risk management procedures under REACH, Poul Bo Larsen (DHI), Brian Svend Nielsen (DHI), Mona-Lise Binderup; https://echa.europa.eu/documents/10162/13563/echa_sr23_project_en.pdf, last viewed 16.07.2018

[44] Op. cit. ECHA project SR 23 (no year)

According to ECHA (2018), the Risk Assessment Committee RAC agreed in 2016, that the cobalt salts should be considered as genotoxic carcinogens with a non-threshold mode of action and established a dose-response relationship for these substances, which is described below in section 3.2.

Mutagenicity

In vivo data indicate that cobalt salts may induce a variety of genotoxic alterations (DNA damage, gene mutations and chromosomal aberrations) in connection with intraperitoneal administration. Only very limited and non-conclusive human data are available with respect to the assessment of genotoxic effects from cobalt/ cobalt salt exposure.

The assessment made by DHI,[46] concluded that genotoxicity as a mode of action behind lung tumours cannot to be ruled out.

The assessment further stated that *"the underlying mechanisms for the genotoxic and carcinogenic effects of the cobalt salts have not been fully elucidated, but it is a general view that key mechanisms involved are:*

- *oxidative DNA damages due to cobalt(II) induced [*Reactive Oxygen Species*] ROS generation as Co(II) catalyses the generation of reactive oxygen species through a Fenton like mechanism;*
- *cobalt(II) induced impairment of DNA-repair mechanisms due to cobalt (II) binding to DNA-repair enzyme."*

3.2. Existing Guidance values (DNELs, OELs)

ECHA (2018) summarises that a DNEL value of 40 µg Co/m^3 is used by the registrants in their Chemical Safety Assessments for the five cobalt salts. In the restriction proposal, ECHA (2018) criticises that the *"REACH registration dossiers […] presents the cobalt salts as non-genotoxic carcinogens with a threshold mode of action. The registration dossiers have not been updated to take into account the RAC agreement in 2016."* As a result, they do not control or minimise the risks posed by the substances.

Instead in the restriction proposal, a dose-response relationship was derived for the respirable fraction. The exposure level for the surface treatment sector ranges at 4 µg Co/m^3 for passivation and at 7 µg Co/m^3 for plating operations. Based on the dose-response relationship as shown in the following figure and on the exposure levels for the surface treatment processes, individual excess lifetime cancer risk levels were derived which are e.g. among all uses highest (≥10^{-2}) for plating process in surface treatment.

[45] OELs for non-threshold carcinogens are derived using a 'cancer risk level': the number of additional cases of cancer due to exposure to a carcinogenic, according to RIVM, the Dutch National Institute for Public Health and the Environment (2016): Difference in risk assessment of non-threshold carcinogens for workers; https://www.rivm.nl/en/Documents_and_publications/Common_and_Present/Newsmessages/2015/Difference_in_risk_assessment_of_non_threshold_carcinogens_for_workers, last viewed 24.07.2018

[46] Op. cit. ECHA project SR 23 (no year)

Figure 3-1: Dose-response relationship for the respirable fraction for the five cobalt salts

Excess risk (lung cancer, workers) = 1.05(mg Co/m³)$^{-1}$ x exposure level (respirable fraction)

Source: ECHA (2018)

Based on a subsequent impact assessment, the conclusion is drawn in ECHA (2018a) that a reference exposure value of 0.01 µg Co/m^3 would be the most appropriate EU-wide measure to ensure a high level of protection of workers from the risk of developing cancer due to exposure to the cobalt salts.

According to ECHA (2018a), 15 member states have implemented regulatory measures to limit exposure of workers to the cobalt salts, which are shown in the following figure.

Figure 3-2: Existing national OELs for cobalt compounds

Member state	Cobalt sulphate (CAS 10124-43-3) Limit value 8h (mg Co/m³)	Cobalt dichloride (CAS 7646-79-9) Limit value 8h (mg Co/m³)	Cobalt and compounds Limit value 8h (mg Co/m³)	Cobalt and compounds Limit value short term (mg Co/m³)
Austria			0.1	0.4
Belgium			0.02	
Denmark			0.01	0.02
Finland	0.02	0.02	0.02	
Hungary			0.1	0.4
Ireland			0.1	
Latvia			0.5	
Norway			0.02	
Poland			0.02	
Slovakia			0.05	
Spain			0.02	
Sweden	0.02	0.02	0.02	
The Netherlands			0.02	
United Kingdom			0.1	

Source: GESTIS international limit values, http://limitvalue.ifa.dguv.de/WebForm_gw2.aspx, accessed 26/02/2018. Note OELs are not listed for cobalt dinitrate, cobalt carbonate and cobalt di(acetate).

Source: ECHA (2018a)

To conclude on the human health hazard, there are national occupational exposure limits in place in some Member States. The restriction proposal under REACH would provide an EU-wide

harmonised protection level. Thereby, the manufacturing processes of EEE are covered (though only for the EU) and might substantially affect the uses and amounts of cobalt present in EEE.

Regarding the five cobalt salts, the divalent cobalt cation moiety is considered to constitute the critical entity being responsible for the human toxicity. However the five cobalt compounds are converted during manufacture process and the resulting cobalt compounds might have an impact during use and waste phase. As pointed out in the section on the scope, such analysisis beyond the scope of this assessment.

4. ENVIRONMENTAL HAZARD PROFILE

The ECHA reports (2010a-d) supporting the identification of the five cobalt salts as Substances of Very High Concern did not consider environmental fate properties or hazards, since the dossiers were targeted at the identification of the five cobalt salts as CMR substances. There is no other environmental risk assessment available for the five cobalt salts. However, the European harmonised classification points out aquatic toxicity as environmental concern of the five cobalt salts. These substances are attributed the hazard statements H400 and H419 (Aquatic Acute 1and Aquatic Chronic 1).[47]

4.1. Endpoints of concern

The five cobalt salts are toxic to aquatic organisms. The aquatic toxicity is acute and chronic as described by the hazard statements H400 - very toxic to aquatic life and H410 - very toxic to aquatic life with long lasting effects.

As the five cobalt salts are inorganic substances, degradation is not a relevant process. Due to the water solubility, the cobalt ion is the relevant compound in the environment. Therefore, in the following, bioaccumulation and the guidance values refer to cobalt.

4.2. Potential for secondary poisoning and bioaccumulation

Cobalt is considered not to bio-magnify through either freshwater or marine trophic food-webs according to the information of the ECHA database on registered substances:[48]

- In aquatic systems, cobalt accumulates from water to plants;
- In general, cobalt is not largely concentrated from soil into plant or soil into invertebrate or vertebrates.

[47] ECHA (2019) Infocard on Cobalt dichloride https://echa.europa.eu/de/substance-information/-/substanceinfo/100.028.718, last viewed 12.09.2019. (similar hazard statements apply for other cobalt salts too)

[48] ECHA Registered Substance Database: Entry for Cobalt dichloride; https://echa.europa.eu/de/registration-dossier/-/registered-dossier/14346, last viewed 04.06.2018.

ECHA Registered Substance Database: Entry for Cobalt sulphate; https://echa.europa.eu/de/registration-dossier/-/registered-dossier/15094, last viewed 04.06.2018.

ECHA Registered Substance Database: Entry for Cobalt dinitrate; https://echa.europa.eu/registration-dossier/-/registered-dossier/14964; last viewed 18.02.2019.

ECHA Registered Substance Database: Entry for Cobalt carbonate; https://echa.europa.eu/registration-dossier/-/registered-dossier/14925, last viewed 18.02.2019.

ECHA Registered Substance Database: Entry for Cobalt di(acetate); https://echa.europa.eu/registration-dossier/-/registered-dossier/14769, last viewed 18.02.2019.

4.3. Guidance values (PNECs)

The predicted no effect concentration (PNEC) is the concentration below which exposure to a substance is not expected to cause adverse effects on species in the environment.

ECHA's registered substances database[49] provides guidance values on aquatic and terrestrial toxicity for cobalt. It should be noted that this information has been provided by the registrant and has not been subject to scrutiny by e.g. ECHA.

Table 4-1: PNECs values for cobalt

Fact	Compartment	PNEC values for cobalt
Hazard for aquatic organisms	Freshwater	0.6 µg/l
	Marine water	2.36 µg/l
	Sewage treatment plant (STP)	370 µg/l
	Sediment (freshwater)	9.5 mg/kg sediment dw
	Sediment (marine water)	9.5 mg/kg sediment dw
Hazard for terrestrial organism	Soil	10.9 mg/kg soil dw
Hazard for air	Air	No hazard identified
Hazard for predators	Secondary poisoning	No potential for bioaccumulation

Source: ECHA Registered Substance Database: Entries for the five cobalt salts

To conclude on the environmental hazards, the cobalt salts are not expected to remain in the environment but due to e.g. the water solubility, the cobalt ion is the relevant compound in the environment. As the cobalt salts are converted during EEE manufacture, a release of cobalt in the forms of cobalt alloys and cobalt oxide may appear in the waste phase. However this release is not a release of the original cobalt salts that are in the scope of this RoHS assessment.

[49] ECHA Registered Substance Database: Entries of the five cobalt salts

5. WASTE MANAGEMENT OF ELECTRICAL AND ELECTRONIC EQUIPMENT

The five cobalt salts are not present in original form in EEE and would thus also not be found in various EEE waste streams.

Though it is possible that the presence of such transformed cobalt compounds in EEE could have impacts on the environment and or on health, during the use phase or during waste management, such an assessment is beyond the scope of the study at hand.

Therefore this section is not further detailed.

6. EXPOSURE ESTIMATION DURING USE AND DURING WEEE TREATMENT

As the five cobalt salts under consideration in this substance dossier are not present in the final EEE, it is concluded that there is no exposure to either of these substances during WEEE treatment.

7. IMPACT AND RISK EVALUATION

This section will not further be discussed as the available data indicate that the five cobalt salts are not present in EEE.

The restriction process under REACH is considered to sufficiently cover risks in the manufacturing process of EEE; thus for coherence of the legislation, manufacturing is not considered.

8. ALTERNATIVES

No information has been provided on possible alternatives during the first stakeholder consultation on the grounds that cobalt dichloride and cobalt sulphate (as at this time, only these two cobalt compounds were addressed) are not present in EEE and therefore substitution does not need to be discussed.

Information on possible alternatives for cobalt dichloride and cobalt sulphate in the surface treatment processes is scarce. Some information is available as detailed below, but does not indicate substitutes that can be considered to be practical in light of the hazardousness of such substitutes.

8.1. Availability of substitutes / alternative technologies

During ECHA's preliminary investigation into the conditions of use of the five cobalt salts summarised in 2013,[50] industry stated that *"no valid alternatives to the cobalt salts have been identified so far. In fact it is remarked that the use of cobalt salts was developed by the automotive industry as an alternative to the use of chromium VI in passivation processes. No feasible alternatives are expected to be found in the near future."*

In the background document of ECHA in 2011, a cobalt-free passivation for zinc or zinc-alloy plating was mentioned. In the ECHA report in 2013, it was noted that *"one company did suggest that the replacement of cobalt salts with nickel compounds could be a viable option in the longer term, but no further information was provided on this."*

The (reverse) substitution by the following (more) hazardous substances is mentioned:[51]

- Substitution of zinc-cobalt plating by cadmium plating,
- Replacement of Cr(VI) in electroplating by Co(II); and though not mentioned in the ECHA report vice versa.

In the background document of ECHA in 2011,[52] with regards to alternatives, the interchangeability within different cobalt salts was also discussed, which is however considered as a substitution with an equally hazardous substance (see detail below). According to ECHA, industry argued that *"interchangeability between the cobalt salts included in ECHA's recommendation is not expected to occur at large-scale, and that case-by-case evaluation is deemed necessary."* ECHA acknowledged that cobalt dichloride or cobalt sulphate may in some of its uses hardly be replaceable by another cobalt(II) salt but concluded that *"considering scientific knowledge in chemistry and the principal chemical processes taking place it appears very improbable that it would technically not be possible to replace cobalt dichloride [or cobalt sulphate] in at least some of its uses by another cobalt salt or that cobalt dichloride [or cobalt sulphate] could not be used to replace other cobalt salts."* However, taking into account the comparable human health and environmental hazards of the five cobalt salts and the consequence that the five cobalt salts are grouped for a joint restriction proposal, the approach of substitution of one cobalt salt by another or by CR (VI) or cadmium does not seem to comprise a pragmatic solution as it is not expected to lead to environmental and or health benefits.

[50] Op. cit. ECHA (2017); from page 40 on as last part the following report is included: ECHA (2013): A preliminary investigation into the conditions of use of five cobalt salts final report July 2013, public version.

[51] Op. cit. ECHA (2011a and b)

[52] Op. cit. ECHA (2011a and b)

8.2. Hazardous properties of substitutes

The various substitutes indicated above are all considered to have various hazardous properties that render their use as substitutes as problematic:

- Cadmium and hexavalent chromium are themselves restricted by the RoHS Directive and are thus not understood to be practical alternatives.
- Substituting one cobalt salt with another is also not considered to result in a benefit in terms of impacts on health and or environment as explained above. This is further supported by the understanding that a restriction on the use of the five cobalt salts is being considered under REACH (see Section 1.3.1).
- As for substitution with nickel compounds, two nickel compounds that are used in plating processes are being assessed in parallel for restriction under RoHS. Nickel sulphate and nickel sulphamate are both classified with comparable hazards, including among others being classified as CMR substances and as being toxic to the aquatic environment. Nickel and its compounds are furthermore subject to the restriction listed under entry 27 of REACH Annex XVII, which prohibits the use in post assemblies and articles coming into direct and prolonged contact with the skin. In this sense, substitution of the cobalt salts with a nickel compound is also not considered to result in a benefit in terms of impacts on health and or environment.

8.3. Data basis for alternatives and uncertainties

The information specified above regarding alternatives for the cobalt compounds and their hazardousness originates from various documents generated in the context of the REACH and CLP regulations. Such documents are understood to have been subject to scrutiny and to have a relatively high certainty.

9. DESCRIPTION OF SOCIO-ECONOMIC IMPACTS

9.1. Approach and assumptions

The scope of this assessment requires a review of possible socio-economic impacts related to a scenario in which the substances under assessment (five cobalt salts) were to be added to the list of restricted substances specified in Annex II of RoHS 2. This would restrict the presence of these substances in EEE to be placed on the market in the future.

However, as has been specified in the sections above, these compounds are used in plating processes of relevance to the manufacture of EEE, but do not remain in the final products in their compound form. These manufacturing processes are considered to be sufficiently covered by the restriction proposal under REACH affording a high level of protection.

In this sense, it is assumed that a restriction under RoHS of the five cobalt salts would not be effective: RoHS restricts the presence of substances present in EEE placed on the market and thus would not affect substances used in manufacture, assuming these do not remain present in the final product to be placed on the market. Against this background it is generally assumed that:

- Substitution would not take place, seeing as the applications do not contain these substances and would still be allowed on the market;
- The choice of related EEE available to consumers would not be expected to change, nor the properties and characteristics of such EEE;
- The amount of related EEE reaching end-of-life and subject to waste management would not be expected to change as a result of the restriction;
- Potential impacts of substitution on health and or environment during use and or the waste phase would thus not be expected.

9.2. Impact on chemicals industry

As the compounds do not remain present in the final product, it is assumed that manufacture could continue without change. In this sense the chemicals industry would continue manufacture as usual.

9.3. Impact on EEE producers (OEM[53] manufacturers and supply chain)

As the compounds do not remain present in the final product, it is assumed that manufacture, both of OEMs and the supply chain, could continue without change. In this sense EEE producers and their supply chain would continue manufacture as usual.

9.4. Impact on EEE users

As the compounds do not remain present in the final product, it is assumed that manufacture could continue without change and thus also the placing on the market of relevant products.

[53] OEM: Original Equipment Manufacturer

9.5. Impact on waste management

As the compounds do not remain present in the final product, it is assumed that manufacture could continue without change and thus also the placing on the market of relevant products. The same EEE would reach the waste phase and require treatment and in this sense, any possible impacts at this stage related to the use of the five compounds in plating processes would not be expected to differ.

9.6. Impact on administration

As a restriction is not expected to affect EEE placed on the market, such ineffective listing of substances under RoHS should be avoided because compliance with the restriction would require provision of documentation and in some cases testing. This would result in an administrative burden for manufacturers and suppliers, and it can also be expected that a certain administrative burden would fall on regulators in relation to the implementation of the restriction in the RoHS Directive and in national legislation and its enforcement.

9.7. Total socio-economic impact

To summarise, a possible restriction can be expected to result in administrative costs for both, industry (e.g. EEE manufacturers, suppliers) and for regulators (e.g. legislators, market surveillance). However the restriction is not expected to generate benefits for the environment or for health (in the form of prevention of possible impacts tied with the five cobalt salts in general and particularly during the use and waste phase of interest for RoHS 2 Article 6(1)). In terms of total socio-economic impacts this suggests that a restriction of the five substances would not be proportionate, given that its costs are not expected to generate benefits for the environment or for health.

10. RATIONALE FOR INCLUSION OF THE SUBSTANCE IN ANNEX II OF ROHS

The five cobalt salts cobalt sulphate, cobalt dichloride, cobalt dinitrate, cobalt carbonate, and cobalt diacetate are used in metal surface treatment processes, including electroplating and metal passivation. It can be understood that these substances are converted through the surface treatment processes and do not remain in their original form in the final produce, i.e, in relevant EEE and its parts. In the final coating, the cobalt salts are understood to be converted into metallic cobalt, as an alloyed metal layer, or as a metal oxide/hydroxide complex, or as another cobalt-containing compound.

Therefore, it is not recommended to include the five cobalt salts under consideration in this substance assessment to the list of restricted substances under RoHS. The reaction products are coatings or layers of cobalt metal or a cobalt-containing compound (alloy) or cobalt oxide/hydroxide complex. Thus, the cobalt salts are not present in the original form in the final EEE.

11. List of References

11.1. Databases

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ECHA Brief Profile: Entry for Cobalt dinitrate: https://echa.europa.eu/brief-profile/-/briefprofile/100.030.353, last viewed 22.02.2019

ECHA Brief Profile: Entry for Cobalt carbonate: https://echa.europa.eu/brief-profile/-/briefprofile/100.007.428, last viewed 22.02.2019

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ECHA CL Inventory: Entry for cobalt dichloride; https://echa.europa.eu/de/information-on-chemicals/cl-inventory-database/-/discli/details/119523, last viewed 04 June 2018

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11.2. Contributions, documents and reports

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12. Appendix I: Contributions to 1st stakeholder consultation hold from 20 April 2018 to 15 June 2018

The following non-confidential contributions were submitted during the 1st stakeholder consultation (see also: http://rohs.exemptions.oeko.info/index.php?id=296):

> Contribution of **MedTech Europe** submitted on 15.06.2018: PDF

> Contribution of the **JBCE – Japan Business Council in Europe aisbl** submitted on 15.06.2018: PDF

> Contribution of the **Test and Measurement Coalition (TMC)** submitted on 15.06.2018: PDF

> Contribution of **Cobalt Institute** submitted on 15.06.2018: PDF

> Contribution of the **Association of Equipment Manufacturers (AEM)** submitted on 15.06.2018: PDF

> Contribution of the **Japanese electric and electronic (E&E) industrial associations** submitted on 14.06.2018: PDF

> Contribution of the **AeroSpace and Defence Industries Association of Europe (ASD)** submitted on 14.06.2018: PDF