GENERIC

OCCUPATIONAL EXPOSURE SCENARIO ADDENDUM TO CSR

(CSR Sections 9 & 10, excluding company specific occupational exposure scenarios)

Final Report

(for registration)

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9 Exposure assessment (and related risk characterisation)

9.0 Introduction and methodology

The current document describes the methodology used for the exposure assessment included in the relevant occupational exposure scenario (ES) for the manufacture and use of the Precious Metals (PM) Refinables as required under the REACH regulation (Regulation (EC) No 1907/2006). The ES was developed according to the REACH Regulation and the relevant REACH Guidance documents as appropriate (Source: European Chemicals Agency, http://echa.europa.eu/):

- "R.12 – Use descriptor system" guidance (version 2, March 2010, ECHA-2010-G-05-EN) for the description of the covered uses and processes.
- "R.13 – Risk management measures" guidance (version 1.2, October 2012, ECHA-12-G-19-EN) for the description and implementation of risk management measures.
- "R.14 – Occupational Exposure Assessment" (version 2.1, November 2012, ECHA-2010-G-09-EN) for the actual occupational exposure assessment.

Since ES have been developed on a company-specific basis, these ES are not included in this document. Instead company-specific ES are attached to IULCID by the individual registrant.

9.0.1 Environmental exposure assessment and risk characterisation

Please refer to the methodology part of the environmental exposure assessment in Section 13 of IUCLID.

9.0.2 Occupational exposure assessment and risk characterisation for workers

Generally, according to the REACH Guidance R.14, different assessment approaches may be used for occupational exposure. Preference should be given to monitoring data obtained under the same operational conditions (OC) and with the same risk management measures (RMM) in place when compared to the OC and RMM described in the ES. If such data are not available, analogous data can be used given that OC and RMM are similar to an extent justifying such read-across. If monitoring data are not available, occupational exposure can be assessed by the aid of exposure assessment tools. By definition an ES has to describe under which OC and RMM the substance can be handled safely. This is demonstrated if the estimated exposure level is below the respective derived no-effect level(s) (DNEL(s)), which is expressed by a risk characterisation ratio (RCR = Exposure/DNEL) below 1.

For the assessment of occupational exposure, different health endpoints are relevant. In general, occupational exposure via the inhalation route and the dermal route are considered relevant. Exposure via these routes may result in systemic or local effects in humans and these may occur after short-term (acute) exposure or long-term exposure. Depending on the type of effect, either quantitative or qualitative exposure assessments are required. Guidance is provided in R.14 on how to assess acute exposures based on monitoring data or modelled data. In addition, there is guidance available on how to undertake a qualitative human health assessment (Practical Guide 15, November 2012, ECHA-12-B-49-EN, Source: European Chemicals Agency, http://echa.europa.eu/).

If systemic effects are relevant for inhalation and the dermal route of exposure, RCRs have to be summed up and safe use is demonstrated if the sum is below 1.

9.0.2.1 UVCB implications on risk assessment

The PM Refinables are so-called UVCB substances (Substance of Unknown or Variable composition, Complex reaction products or Biological materials) for which explicit guidance on how to conduct a risk assessment under REACH is not yet available. UVCB substances are characterised by a high variability in content of individual constituents, whereas the constituents as such (or at least their elemental composition) are known. It is noted that the content range of individual constituents could even include zero as lower limit. Such variation in composition requires specific adoptions of the standard exposure assessment as required under REACH. The approach followed for the occupational exposure assessment and risk characterisation for workers of the substance is therefore described in this subsection.

9.0.2.1.1 UVCB hazard assessment

With the mentioned variability in composition of the UVCB in mind, it is evident that also the toxicological profile of an UVCB will vary accordingly. By acknowledging that toxicity of an inorganic UVCB is determined by its constituents and, at the same time, individual constituents vary considerably, any re-calculation of known constituent-specific (hazard) threshold values according to their content appear inappropriate. As a worst-case assumption, such constituent-specific threshold values are therefore used in the hazard assessment without modification. As a further consequence, the hazard assessment will not conclude on a single threshold value for a specific combination of route and exposure duration (e.g. “chronic inhalation”) but instead has to consider all threshold values for each of the individual constituents for which an hazard is identified for human health.

It is noted that for most of the relevant constituents, toxicity data in the form of DNELs (and the required contextual information) is available from associated REACH registration files. This is however not the case for each constituent. For the sake of brevity, any surrogate threshold values are also referred to as DNELs in this document. Please refer to Chapter 5 of the CSR for further information on relevant DNELs or alternatively relevant surrogate values.

9.0.2.1.2 UVCB exposure assessment

As a consequence of the hazard assessment summarised above, the exposure assessment has therefore to consider all constituents identified in the hazard assessment as being hazardous for human health. Such an exposure assessment easily becomes very complex when additionally considering individual company settings in terms of the specific (still variable) composition of the UVCB substance, prevailing operational conditions and implemented risk management measures. A table summarising all derived (inhalation) exposure estimates for the individual constituents is therefore provided in Appendix 1 and is further referred to in this document as generic exposure assessment table (GEA).

Since the UVCB substance is exclusively manufactured for its direct use in further refining, exclusively workers operating in industrial settings are potentially being exposed to the UVCB substance. As part of good occupational hygiene practice in the metals’ industry and additionally as a requirement from parallel legislation on the protection of workers’ health, the identified hazardous constituents are in most cases monitored on a regular basis in the relevant workplaces. Such monitoring is normally only conducted for inhalation exposure and dermal exposure is commonly assessed by the aid of exposure modelling tools. Additionally, bio-monitoring has often to be conducted for specific constituents, which is particular relevant if workers are exposed to lead or lead compounds.

When analysing inhalation monitoring data, obtained in workplaces, in which the UVCB substance is manufactured or handled, the following aspects are to be considered:

1. The impact of varying content of any constituent in the substance on exposure levels to that constituent is automatically reflected. The impact of varying process conditions and risk management measures are also directly reflected in any sample.
2. The contribution of other substances (including UVCB substances) handled in parallel and having the same constituent(s) as the UVCB substance under investigation to overall exposure, is also automatically reflected in the sample.
3. Exposure levels are monitored by sampling of the airborne dust in the workers' breathing zone. The sampled dust is subsequently analysed for individual elements. Further chemical speciation of these elements is normally not conducted and in most cases also not possible.

The first point is the main reason why monitoring data are commonly the preferred basis for occupational exposure assessments as the introduction of uncertainty when assuming the impact of variation in composition, process conditions and risk management measures on exposure levels is omitted.

The contribution of other substances to workers' exposure to an individual constituent as listed under the second point is normally not to be addressed under REACH since substance-specific assessments are required under the REACH regulation. By the inclusion of such contribution from other substances, the assessment for the substance is therefore intrinsically conservative (i.e. precautionary) with respect to legal REACH requirements. As being anyway good occupational hygiene practice, the exposure assessment is however based on these "aggregated exposure levels" and could be seen as an "intrinsic combined exposure assessment" to an individual constituent.

The third point is of high relevance if the hazard profile of a constituent varies with its chemical speciation. In such cases, the worst-case chemical species (i.e. the most hazardous) is therefore always assumed as a precautionary measure unless this species can be excluded based on plausibility considerations.

In summary, the current exposure assessment to the substance therefore:

- reflects current good industrial hygiene practice in terms of monitoring,
- reflects variations in composition of the UVCB substance during its use,
- covers all constituents classified for human health,
- in fact, represents a "combined exposure assessment" to individual constituents, and
- is pre-cautionary to protect workers' health even in unrealistic worst-case conditions.

Definition: Workplace composition profile

As already indicated above, the exposure assessment for the PM Refinables is in large part based on monitoring data obtained in workplaces, which are characterised by their combined exposure settings. In addition, the concerned inorganic UVCB substances consist of many constituents of which most have hazardous properties to human health. The proposed constituent-based approach (please refer to Chapter 9.0.2.1.1 above), recognises these settings by simultaneously conducting risk assessments for all classified constituents on a workplace-by-workplace basis, instead of conducting a substance-specific assessment, which is non-compliant with industry practice. The constituent-based approach is however "data-hungry" by nature: the guidance requires a minimum number of data points for individual assessments[1]. These requirements can in most cases only be met if monitoring data were pooled for multiple companies. Such pooling

[1] Please compare with Table R.14-2 in ECHA R.14 guidance.

however requires that also the processed materials in the associated workplace are similar enough in terms of the overall handled amount of a specific constituent (potentially being emitted from other substances than the substance to be actually assessed). Companies therefore provided an indication of the approximate amount of specific constituents present in the processed materials in relation to the overall mass of materials being processed in the individual workplaces. It is noted that the term “processed materials” may thereby also include non-REACH substances such as waste and by-products as well as already registered substances if relevant for the workplaces in which monitoring data were obtained.

Relevant species to be considered in the assessment of occupational exposure

Depending on the composition of the handled materials and operational conditions such as process temperature, different species (i.e. constituents) may be relevant in a process and at a workplace. The risk assessment should cover all relevant species either on a worst-case basis or in a refined assessment if knowledge on the relevant species is available. Considering common inorganic substances, two types of hazard assessments may be generically distinguished:

1. Hazard assessment based on metal content
2. Hazard assessment not exclusively based on metal content

The consequences for the UVCB risk assessment arising from the individual types are summarised below:

Hazard assessment of species that is exclusively based on metal content

For many constituents, the toxicological properties of the metal (ion) have been assessed to be the toxicological determinant of the constituent in the individual REACH dossier of that constituent. In these cases, DNELs that could be found in the registration dossiers for different (inorganic) compounds (i.e. chemical species in this context) of a specific element are therefore calculated based on the weight percentage of the respective element in the compound. As will be explained in more detail below (Section 9.0.2.3.3), in the metals’ sector inhalation monitoring data are normally obtained sampling airborne dust on filters. The sample is subsequently analysed for contents of individual elements – further chemical speciation is normally not possible. For a standard exposure assessment to a given species of that element, the analysed mass of the specific element therefore has to be re-calculated based on the weight percentage of the element in that species.

Consequently, when re-calculating both the DNEL as well as the exposure level based on the weight percentage of the metal in the substance the corresponding RCRs would be constant regardless of the species to be assessed. For such metals, the actual species for which the exposure assessment should be conducted is only of little relevance. Since the metal itself would have the lowest DNEL for all species, the metal is reported by default in the ES below. The following list includes the metals: As, Cd, Co, Hg, Ni, Pb and Sb.

Hazard assessment of species that is not exclusively based on metal content

For some metal species, the hazard assessment may have to account for toxicological properties which are not exclusively related to the respective metal. Consequently, DNELs are likely to different also when considering the metal content. In such cases, it is important to conduct an assessment to the relevant species. In this assessment these species were either selected based on consideration of the handled material and process conditions or on a worst-case basis if the mentioned information was not available. However, when considering the metals to which this applies, it becomes obvious that the potentially relevant inorganic species could always be separated in two distinct groups although the grouping criteria may vary from metal to metal. One

group always represent the worst case species which should be considered by default, whereas the other group (typically associated with less hazard potential and higher DNELs) is only considered if content and process information justifies such a selection.

A survey was conducted amongst all registrants in order to determine the correct species to be considered in the risk assessment. Such information was obtained at the workplace level and was used in the specific assessments below. Thus, each contributing ES for workers will include a generic section for the assessed workplace indicating the content (weight percentage) and chemical species considered in the exposure assessment and risk characterisation.

An overview of the considered DNELs is given in the table below:

Table 1: DNELs relevant for the workplace-specific risk assessment

Ele-ment	Chemical Species	Inhalation DNELs				Dermal DNELs				Eye	Ref.
		ISL	ISA	ILL	ILA	DSL	DSA	DLL	DLA		
Ag	Ag	100 µg/m³	NHI	NHI	NHI	NHI	NHI	NHI	NHI	NHI	RR
	$AgNO_3$	10 µg/m³	NHI	NHI	NHI	NHI	NHI	NHI	QA	medium	RR/ SV9
Al	$AlCl_3$	SV0	SV0	SV0	SV0	QA	NHI	NHI	QA	medium	SV0
As	As_2O_3	4 µg/m³	NHI	QA	QA	0.085 mg/kg bw.	NHI	QA	QA	medium	RR
Au	[AuCl4]-	QA	NHI	NHI	NHI	NHI	NHI	QA	NHI	NHI	SV1
B	Borate	SV0	QA*	SV0	SV0	SV0	QA*	QA*	QA*	low	SV0
Ba	Ba soluble	500 µg/m³	NHI	500 µg/m³	NHI	NHI	NHI	NHI	NHI	low	SV2
Ca	CaO	NHI	NHI	1000 µg/m³	4000 µg/m³	NHI	NHI	NHI	QA	medium	SV10
Cd	Cd	4 µg/m³	NHI	NHI	NHI	QA*	QA*	QA*	QA*	NHI	RR
Co	Co	NHI	NHI	SV0	QA	NHI	NHI	QA	NHI	NHI	SV0
Cr	CrO_3	NHI	NHI	SV0	SV0	NHI	NHI	NHI	NHI	NHI	SV0
Cs	CsCl	SV0	NHI	NHI	NHI	SV0	NHI	NHI	NHI	NHI	SV0
Cu	Cu_2O	1000 µg/m³	NHI	1000 µg/m³	NHI	NHI	NHI	NHI	NHI	low	SV3
	$CuSO_4$	1000 µg/m³	4000 µg/m³	1000 µg/m³	4000 µg/m³	NHI	NHI	NHI	NHI	NHI	SV3
Hg	Hg	20 µg/m³	NHI	QA*	QA*	NHI	NHI	NHI	NHI	NHI	SV4
Li	Li	SV0	NHI	QA	QA	SV0	NHI	QA	QA	medium	SV0
	LiCl	SV0	SV0	QA	QA	SV0	SV0	QA	QA	low	SV0
Mn	MnO_2	SV0	QA	NHI	NHI	SV0	NHI	NHI	NHI	NHI	SV0
Mo	MoO_3	11170 µg/m³	NHI	2000 µg/m³	NHI	NHI	NHI	NHI	NHI	low	SV4
Ni	Ni	50 µg/m³	680000 µg/m³	50 µg/m³	4000 µg/m³	NHI	NHI	70 µg/cm²	NHI	NHI	RR
	$NiSO_4$	50 µg/m³	16000 µg/m³	50 µg/m³	700 µg/m³	NHI	NHI	0.44 µg/cm²	NHI	NHI	RR
	NiO	50 µg/m³	520000 µg/m³	50 µg/m³	3900 µg/m³	NHI	NHI	24 µg/cm²	NHI	NHI	RR
	NiS/Ni_3S_2	50 µg/m³	16800 µg/m³	50 µg/m³	470 µg/m³	NHI	NHI	4.8 µg/cm²	NHI	NHI	RR
Pb	Pb	40 µg/dL**	NHI	NHI	NHI	40 µg/dL**	NHI	NHI	NHI	NHI	RR
Pd	soluble	20 µg/m³	NHI	NHI	NHI	0.6 mg/kg bw.	NHI	NHI	NHI	NHI	SV6
Pt	soluble	300 µg/m³	NHI	QA	NHI	0.1 mg/kg bw.	NHI	NHI	NHI	NHI	SV6
Sb	Sb_2O_3	NHI	NHI	500 µg/m³	NHI	234.7 mg/kg bw.	NHI	NHI	NHI	NHI	RR
Se	Se	50 µg/m³	NHI	QA	NHI	7 mg/kg bw.	QA	QA	NHI	NHI	RR
	$ZnSeO_3$	SV0	SV0	NHI	NHI	NHI	NHI	NHI	NHI	NHI	SV0
Si	SiO_2 cryst. respirable	NHI	NHI	49 µg/m³	NHI	NHI	NHI	NHI	NHI	NHI	SV7
Te	Te	100 µg/m³	QA	100 µg/m³	NHI	QA	QA	QA	NHI	NHI	RR SV8

Ele-ment	Chemical Species	Inhalation DNELs				Dermal DNELs				Eye	Ref.
		ISL	ISA	ILL	ILA	DSL	DSA	DLL	DLA		
V	soluble without irrit.	NHI	NHI	SV0	NHI	NHI	NHI	NHI	NHI	NHI	SV0
	soluble with irrit.	NHI	NHI	SV0	NHI	NHI	NHI	NHI	QA	medium hazard	SV0
	slightly soluble/ insoluble	SV0	NHI	NHI	NHI	NHI	NHI	NHI	NHI	NHI	SV0

Explanation of abbreviations: DLA = dermal, local, acute; DLL = dermal, local, long-term; DNEL = derived no-effect level; DSA = dermal, systemic, acute; DSL = dermal, systemic, long-term; ILA = inhalation, local, acute; ILL = inhalation, local, long-term; ISA = inhalation, systemic, acute; ISL = inhalation, systemic, long-term; NHI = no hazard identified for humans; QA = qualitative assessment; SV = surrogate value (for further information on each SV, please see below)
* Exposure based waiving as indicated in the REACH registration dossier is addressed with a qualitative assessment (including quantification of exposure)
** Internal reference value
RR = Data access to IUCLID section 7 of REACH registration dossier via LoA
SV0 = ECHA dissemination website; no official data access yet, value currently deleted for copyright issues
SV1 = MAK: Gold und seine anorganischen Verbindungen
SV2 = Commission Directive 91/322/EEC, May 29th, 1991
SV3 = Former MAK value; values for acute inhalation DNEL: extrapolation from long term value multiplied with 4
SV4 = GESTIS DNEL database
SV6 = Anonymous (2013): Tentative DNELs for Platinum and Palladium, bibra toxicology advice & consulting, October 2013, for the sake of this assessment, a dermal absorption factor of 1 % for palladium substances was assumed.
SV7 = Anonymous (2003): Recommendation from the Scientific Committee on occupational exposure limits for silica, crystalline (respirable dust), SCOEL/SUM/94, November 2003.
SV8 = Anonymous (2011): Code pf practice for the Safety, Health and Welfare at Work (Chemical Agents) Regulations 2001, (S.I. 619 of 2001), Irish Health and Safety Authority.
SV9 = Qualitative assessment for local acute effects on the skin and the eyes are triggered by the corrosivity of the substance.
SV10 = Anonymous (2008): Recommendation from the Scientific Committee on occupational exposure limits for calcium oxide (CaO) and calcium hydroxide (Ca(OH)2, SCOEL/SUM/137, February 2008.

9.0.2.1.3 Risk characterisation for UVCB

Modification of both, the hazard and exposure assessment as described above, is to be reflected with an adapted risk assessment. Several DNELs are to be compared with multiple exposure estimates resulting in a generic risk characterisation for all combinations of exposure settings and (classified) constituents that is annexed to this document. Depending on initial exposure estimates for specific exposure settings, the use of respiratory protective equipment (RPE) has to be taken into account in the exposure assessment. It has to be guaranteed that RPE is assigned appropriately to protect workers' health, e.g. by showing that exposure levels are below the relevant DNELs in consideration of PPE. However, exemptions from this approach are substances for which an exposure assessment is based on internal exposure levels, such as lead. The uncertainty of the exposure assessment is less compared to substances for which internal exposure levels are not available. In addition, internal exposure levels already take any PPE as worn by the worker under surveillance into account.

Appropriate PPE was selected for each workplace following the procedure listed below:

1. Derivation of exposure estimates for each relevant species in the given workplace.
2. Calculation of associated RCR.
3. Determine required protection factors[2] by considering the highest RCR.
4. Either use determined protection factors or those of PPE that is intrinsically considered in blood lead levels (please see above) whatever is the higher.

Risk characterisation for combined effects of UVCB constituents

The proposed risk assessment approach for inorganic UVCB substances is based on the hazard and exposure assessment of its individual constituents, for which the risk assessment is conducted separately. These separate risk assessments do however not include a combined risk assessment

[2] Protection factors were selected based on EN 529:2005 for RPE or set to 100 for gloves, respectively.

for the various constituents which may in conjunction form antagonistic, additive or even synergistic effects. One has to answer the question how different UVCB constituents act together when humans or the local environment are exposed to several constituents in parallel and how to consider this in the risk assessment of the UVCB.

It is worth noting that how to address co-exposure from several chemicals, the potentially associated combined effects -and the resulting risk- ("combined toxicity") is not a metal-specific issue but generic to all chemicals. Approaches are currently under discussion in several regulatory bodies like, for example, the WHO, EPA and NIOSH as well as in EU Scientific Committees. The methods currently proposed to assess mixtures can take account of additive actions, such as dose/concentration addition or response/effect addition. With these methods, effects of chemical mixtures composed of either dissimilarly or similarly acting substances can be predicted. Interactions between substances are, however, generally more difficult to assess and require expert judgment on a case-by-case basis.

In the EU, the risk assessment on the combined effects of chemicals is currently not commonly carried out and not required by REACH for standard substances. In addition, clear guidelines on how to derive an overall estimation of the risk in case of combined exposure/combined effects are not yet available. Simply adding RCRs is not considered appropriate to derive realistic estimates and is likely to derive over precautionary solutions in terms of risk management. This generic issue, which will require a generic solution, is further complicated by the limited amount of literature data on combined toxicity of metals and metal compounds and the huge number of possible permutations of combinations of metals. It is known that effects of metals may be additive, less-than-additive, or more-than-additive but further research is needed to at least cover the spectrum of the main constituents in the inorganic UVCBs.

In the absence of a clear framework for consideration of risk from co-exposure to multiple chemicals, and until more metal data have become available, it is proposed by EUROMETAUX, the registrants of inorganic UVCBs and their respective consultants to apply the approach described below -as a *temporary* solution- and to update their dossiers as soon as more evidence has become available. This will allow at least the key information on risk management measures to be brought forward in the supply chain without delay and to already distinguish areas of concern from obvious low risk situations. This strategy has been taken up as short-, medium and long-term actions on the combined toxicity issue which have been proposed to ECHA in the "roadmap" sent early February 2014 in follow-up of the January 22 meeting:

<u>On a short-term basis (by the submission end of April)</u>

- Registrants include considerations/information on combined toxicity on their UVCB constituents in their dossiers where/when available.
- If information on combined toxicity is not available, the registrant includes in his dossier this 'placeholder' document, which summarises both the current thinking and includes references to on-going scientific research/ approaches under development in the metals sector.

<u>On a medium- and long -term basis</u>

- Further improve dossiers with information on combined toxicity as becoming available from scientific progress.
- Develop a paper on tiered approach for the environment combined effects that can be consistently referred to in the different dossiers.
- Research on combined toxicity to improve combined toxicity knowledge for further updates/validation of the methodology e.g. by means of a literature review on existing (metal)

studies (e.g. epidemiological studies and environmental studies) in order to better understand the magnitude of the issues (if any) in the metal sector and identify/clarify research gaps.

It is also recommended to the registrants to carefully follow up both the progress made by EU authorities and by the metal scientists on the issue and *to assess on a regular basis whether the registration dossiers shall not be further adapted in line with the state of the art*.

It is expected that more data on mechanisms of action and interactions shall become available in the coming years due to the regulatory focus on combined toxicity as well as from regular literature screening. However, at this stage no specific metal research programmes can be referred here. Recently a metals 'health initiative' has been launched (the HeTAP panel), that aims at supporting an advisory panel consisting of experts from academia, institutes etc. and industry experts, that will reflect on scientific issues of common interest to the mining and metals industry and provide scientific advice. Combined toxicity is one of the identified major issues on the agenda.

Tier 0

As a Tier 0, *by default,* it is proposed to add the RCRs of the different constituents and to compare the sum to 1 as a default approach for each type of DNEL. This is done as a first filter, to analyse whether there is actually a concern.

Tier 1

A refinement is proposed below based on the knowledge of the mechanism of action and/or information on the target organ of the constituents:

- If information is available showing that two or more constituents of the UVCB have the same mode of action, the corresponding constituent-specific RCRs are to be added and this "combined RCR" is to be used to implement risk management measures.
- If no information is available on the mechanism of action but that the target organs of the UVCB constituents are known (by endpoint) it is proposed to work as follows:
- For repeated dose, systemic effects, if two or more constituents have a same target organ, RCRs shall be added. Otherwise no combined toxicity is assumed.
- For repeated dose, local effects, if two or more constituents have a same target organ, RCRs shall be added. Otherwise no combined toxicity is assumed.
- For acute, systemic effects: add RCRs (if thresholds available).
- For acute, local effects: add RCRs (if thresholds available) or address via RMMs if peak exposures can be expected
- For reproductive effects, RCRs shall be added.
- Mutagenicity: as for the individual constituents, only a qualitative Risk Assessment is possible.
- Carcinogenicity: at this stage it is proposed to use the lowest DNEL/DMEL as driving RMMs/exposure route (assuming that for two carcinogens with the same target organs, same exposure route, protecting against the most hazardous one will protect against the others).

A refinement may also be based on the knowledge of the workplace exposure patterns:

- In the calculation of the RCR for the risk assessment an individual UVCB constituent, 90th percentiles are used by default as suggested by the R.14 guidance for standard substances. However, if RCRs are to be summed up for individual constituents, such summation could easily lead to an unrealistic overestimation of risk as worst case estimates of exposure would be combined. Thus, for the assessment of combined effects, the contribution to risk of individual constituent should be calculated on the basis of estimates of typical exposure. It is noted that such a refinement is only justified if no (significant) positive correlation was

discovered between individual constituents. Consequently, any such analysis requires comprehensive monitoring databases including information on contextual information such as the content of the specific constituents in the materials handled/processed during actual generation of the monitoring data. In addition to the purely exposure-based argumentation, it is important to note that the hazard assessments of the individual constituents already represent worst case assessments which would lead to an unrealistic assessment if the resulting RCRs would simply be summed up. In the absence of a straight forward solution to compensate on the hazard side, a combined effects assessment refined with estimates of typical exposure levels remains as a practical solution for the conduct of a realistic risk assessment of combined effects.

Work on these two possible Tier 1 refinements has been launched (e.g. collecting the list of target organs in the multi-metallic database, check of exposure datasets…) and is already partly included in this CSR: combined effects assessments (CEA) are included in the risk characterisation tables of the company specific exposure scenarios. These CEA are based on typical exposure levels for which separate RCRs are given.

9.0.2.2 Assignment of activity classes and generic exposure assessment

Although the refinables' sector is a very complex industry sector, there are some processes generally required to refine precious metals that are (with respect to occupational exposure assessment) very similar between all companies. It is therefore assumed, that the development of activity classes describing common tasks/operations in industry represents a simplification of relevant processes but still provides an adequate level of detail to reflect actual working practice. Therefore, a list of common workplaces (activity classes, ACs) was developed for all reported activities/processes during handling of refinables. Information provided together with measured data (contextual information), i.e. information on tasks that were conducted by the worker during the measurement and information on assigned workplaces for these measurements according to occupational exposure questionnaires that were circulated was used as a basis for the definition of these activity classes. Each inhalation exposure monitoring measurement was subsequently assigned to one of the activity classes. By also assigning workplaces to the activity classes as nominated in the occupational exposure questionnaires, (see Figure 1 below) it is possible to derive exposure estimates on a task/operation basis by considering the relevant species information (see Section 9.0.2.1.2).

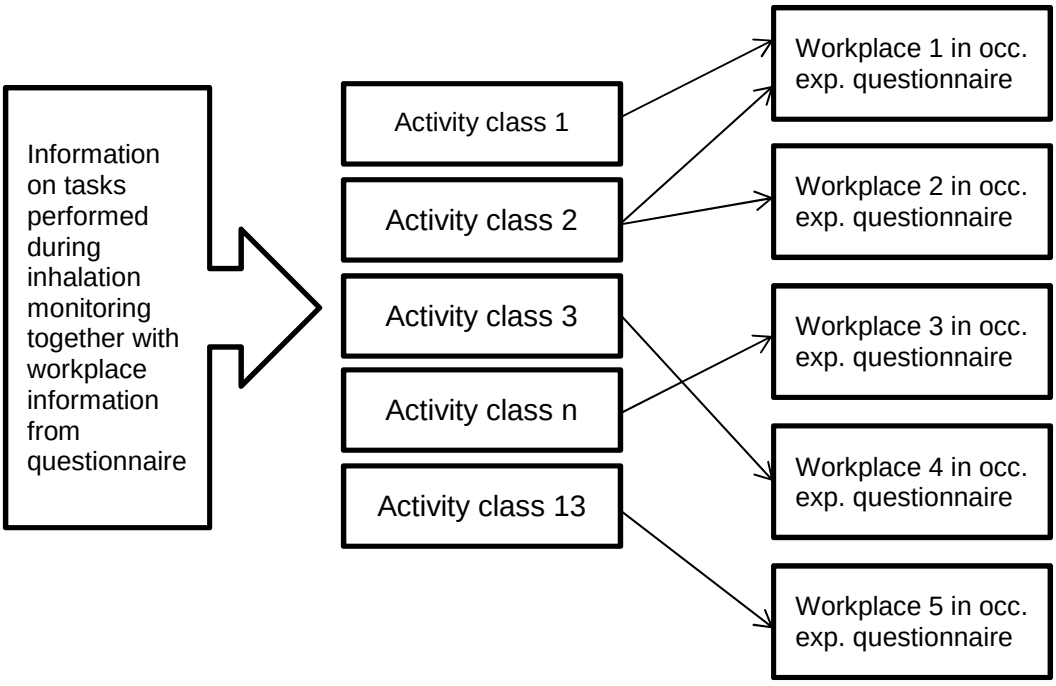

Figure 1: Development of activity classes and their assignment to nominated workplaces

For the development of these ACs, not only performed tasks (as indicated during the submission of measurements and as indicated in the occ. exp. questionnaire) were taken into account, but also information on the physical forms handled materials and information on exposure modifying parameters such as enclosure of processes and separation of workers (see Table 2 below).

Table 2: Overview of activity classes

AC	Short description of AC	Covered tasks	Covered PROCs	Modifier	Physical appearance
AC1	handling of dusty materials	transfer operations, cold furnace loading, packaging, mixing	26	ambient temperature, semi-automated/remote controlled	solid (dusty) materials
AC2	handling of materials with varying dustiness	transfer, cold furnace loading, packaging, mixing	5, 8b, 9, 21, 26,	ambient temperature, semi-automated/remote controlled	various
AC3	handling of very low to low dusty materials	storage, transfer/handling of containers, handling of damp materials (incl. filter cakes) and massive objects	8b, 9, 21	ambient temperature	very low dusty
AC4	completely closed process (rigorous containment)	no manual interventions, only supervision	1	completely enclosed	various
AC5	smelting, no separation of workers	smelting, tapping, chlorination	22, 23	worker involved in manual interventions	molten (sublimation not excluded)
AC6	smelting, separation of workers	smelting, tapping, chlorination	22	no manual interventions, closed furnace and/or control room	molten (sublimation not excluded)
AC7	melting, open processes	melting, casting, cooling, pyrorefining, calcination, granulation	23	open processes including casting	molten
AC8	roasting processes	roasting	22	closed furnaces	metal oxide fumes, solids
AC9	drying processes	drying, slightly elevated temperature	3	liquid/damp materials used as input, damp/dried materials as output, only limited manual intervention required	solid
AC10	hydrometallurgical processes	reduction, precipitation, dissolution, filtration, cementation, separation, leaching, electrolysis, electrorefining, floatation, extraction, mixing	1, 2, 3, 4, 8b, 9, 27b	automated or only handling of liquids	liquid (aqueous solutions)
AC11	obsolete	-	24	-	-
AC12	mechanical operations	crushing, milling, knock-out (booth), scraping, sawing	26	potentially high energy input	generated abrasive dust
AC13	obsolete	-	-	-	-
AC14	cleaning & maintenance	cleaning, maintenance, recovery of bricks/crucibles from furnace linings	0 (26 used as surrogate)	either wet suppression or exhaustion by hoovering devices	various
AC15	sampling & evaluation	including small scale milling and melting	15	small scale operations with effective (partly mobile) extraction devices	various

The above described approach facilitates grouping of data from different data submitters for similar tasks and enables analysis of these data on a task-specific basis. Since inhalation monitoring data were also assigned to workplaces of data-submitting companies, further information such as operational conditions (OCs) and risk management measures (RMMs) are available for these data and consequently also for activity classes. Considering data submissions from different companies with potentially different sets of OCs and RMMs, a specific AC may be sub-divided on the basis of these different conditions.

For the ES, the following format has therefore been applied: workplaces as being defined by companies are seen as contributing ES to which multiple ACs may be assigned. Depending on the OCs and RMMs which are specific to the workplace and depending on the OCs and RMMs which are specific to the AC, exposure estimates are to be derived. Each nominated AC thereby represents an own sub-scenario and sub-assessment. Sections 9.0.2.3.3 and 9.0.2.4.1 below describe how these estimates were derived for inhalation and dermal exposure, respectively.

9.0.2.3 Exposure assessment based on monitoring data

9.0.2.3.1 Dermal exposure data

Dermal exposure data representing actual workplace measurements were not provided. Dermal exposure is therefore assessed with the exposure assessment tool MEASE (please refer to Section 9.0.2.4.1 for further details).

9.0.2.3.2 Oral exposure data

For workers, oral exposure is assumed to be sufficiently controlled by strict occupational hygiene practices (e.g. not eating and smoking in the workplace, wash hands before eating, etc.) and is therefore not considered in the assessment of workplace exposure.

9.0.2.3.3 Inhalation exposure data

All data that have been entered into the inhalation exposure data base had to fulfil strict quality criteria to be used for the exposure assessment outlined in this document. A detailed description of the quality criteria applied to the measured inhalation exposure data can be found in several risk assessment reports as conducted under 793/93/EEC (e.g. the RA of diantimony trioxide). For the sake of brevity, only the most important qualifiers are listed below:

- In general, only personal measurements of inhalation exposure data have been used.
- Depending on the exposure duration, these values have to be either full-shift-representative (at minimum of 120 minutes measurement duration) or must have been obtained during the entire task duration.
- The measured fraction must be “inhalable” according to EN 481.
- All measurements have to be assigned to a specific workplace, process or task. Operational conditions prevailing and risk management measures implemented during monitoring need to be reported.
- Additional information such as measurement date, sampling equipment and method of analysis has to be provided for individual data sets.

Data not meeting the above mentioned criteria are normally used as supportive information for the derived exposure levels. However, given the complexity of this UVCB risk assessment this was omitted for the sake of brevity.

Analysis of air monitoring data

Whenever measured data are used in exposure assessments below they have been checked for their quality by applying the quality criteria as outlined above. According to REACH Guidance R.14, the percentile to reflect the exposure level for workers has to be determined according to the specificity of the data to the ES to be assessed and the variability of the data (Table 14-2) as reflected by the geometric standard deviation (GSD). Given the large number of total data points as well as the detailed information on OCs and RMMs the approach as suggested in the guidance was however slightly adopted as described below.

As already mentioned above, depending on the OCs and RMMs which are specific to the workplace and depending on the OCs and RMMs which are specific to the AC, exposure estimates are to be derived. Each nominated AC thereby represents an own sub-scenario requiring and sub-assessments for all constituents relevant at the associated workplace considering the mentioned OCs and RMMs as stratifying variables.

For the derivation of exposure estimates, data analyses were performed with the programme R[3]. In an effort to minimise the geometric standard deviation (GSD), indicating variability and specificity of data to an ES, grouping was conducted. Merely on a semi-quantitative basis, more advanced statistical methods such ANOVA and procedures for multiple comparisons of means (Tukey test) were used to further identify significant exposure modifiers, i.e. to identify grouping variables.

For the resulting data sets for individual ES, reasonable worst case (RWC) estimates of inhalation exposure levels were derived according to a procedure adopted from R.14. Table 3 below indicates which statistical parameters were to be used as RWC estimate. It is noted that data sets with low numbers of data points (n < 6) were also used although the guidance suggest n = 6 data points as a minimum number for the following reasoning:

1. The low number of data points is a reflection of the efficient sub-grouping, i.e. assignment to highly specific ES.
2. When grouping based on the basis of the content of an individual constituent in the handled material, the statistical power for specific groups increased.

Table 3: Derivation of exposure estimates for a given number of data points and geometric standard deviation

		Number of data points						
		1	<6	<12	12	<20	<50	≥50
Geometric standard deviation	-	F	-	-	-	-	-	-
	>3.5	-	E	D	C	B	B	B
	2-3.5	-	D	C	B	B	B	A
	<2	-	C	B	B	B	A	A

Source: Adopted from ECHA R.14 guidance, Table R.14-2.

Legend: F = maximum value x 2
E = maximum value x 1.5
D = maximum value
C = 95th percentile value
B = 90th percentile value
A = 75th percentile value

[3] R Core Team (2012). R: A language and environment for statistical computing. R Foundation for Statistical computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

An analysis of all inhalation monitoring data that were submitted to EBRC and that fulfilled the requirements with regard to quality and applicability is provided in Appendix 1. Please note that these data apply to all PM Refinables that are subject to standard registration under REACH. A subset of the data is used in the corresponding company-specific exposure assessment and risk characterisation (Section 9.1 and Section 10.1) below.

It has to be noted that all inhalation monitoring data described above were measured outside any RPE. If applicable, such equipment was taken into account by dividing the calculated exposure level by the so-called assigned protection factor (APF) as reported in the exposure scenario below. These APFs have been set according to BS EN 529:2005 and can also be consulted in the glossary of MEASE (available on http://www.ebrc.de/mease.html).

In case of RCRs above a value of 0.85[4], the use of RPE with a certain assigned protection factor (APF) was taken into account for inhalation exposure monitoring data. This approach was different in case of availability of bio-monitoring data for the same AC (see Chapter 9.0.2.3.4): In this case, RPE as worn by workers that were monitored has to be taken into account as minimum level of RPE for this AC. Higher APFs are however possible to reduce the inhalation exposure level to a value below the DNEL. The use of PPE with higher protection factors compared to the pre-scribed minimum protection factor is not required but also not prohibited.

Assessment of peak exposures

According to R14 guidance, peak exposures can be extrapolated from full-shift exposure levels. For such an extrapolation the variability and the selected percentile for the full-sift estimate are to be considered. For the sake of this risk assessment, peak exposures were derived according to the following table:

Table 4: Derivation of peak exposure estimates based on full-shift estimates

Full shift estimate based on	**75th percentile**	**90th percentile**
Peak (short term) exposure duration	15 min	15 min
Peak exposure based on	95th percentile	95th percentile
GSD = 1 - 2	3	2.2
GSD = 2 – 4	3	2
GSD = 4 – 6	4	1.5
GSD = 6 – 8	5	1.4
GSD > 8 *	6	1.4

Source: Adopted from ECHA R.14 guidance, Table R.14-18.

Assessment of typical exposure levels

For the combined effects assessment, typical exposure levels (i.e. median values) from the available data sets are used for risk characterisation. Further details and justification can be found in Chapter 9.0.2.1.3.

Analogous data (data extrapolation for inhalation exposure assessment)

For sub-scenarios for which monitoring data were not available, exposure levels have been extrapolated from similar (monitored) exposure situations. Three types of extrapolation may be distinguished:

[4] For the combined effects assessment a RCR threshold of 1 was considered.

1. Data are available for the constituent to be assessed and for the AC, but specific OCs or RMMs are not covered in the available data sets.
2. Data are available for the AC but not specifically available for the constituents to be assessed.
3. Data are available for the constituent to be assessed but not specifically available for the AC.

In addition, any combination of the types listed above may apply. Extrapolation was conducted by using extrapolation factors. The following extrapolation factors (EF) were considered depending on the type of data gap:

Extrapolation to different RMMs

Many assessment tools for occupational exposure assume some kind of linear relationship between an initial exposure estimate and resulting exposure when considering efficiencies of RMMs. Thus, when extrapolating, one would have to consider the associated efficiencies of RMMs applying to the actually monitored exposure situation and those of RMMs relevant for the exposure situation to which the exposure level is to be extrapolated. However, only RMMs for which significant impact on exposure levels was found during data analysis were accounted for during extrapolation. Default RMM efficiencies were taken from a publication by Fransman et al. (2008) and are summarised for the relevant RMMs below:

For the existence of a local exhaust ventilation (LEV), the following extrapolation factors were used:

Table 5: Extrapolation factors for different types of LEV

Type of LEV	Efficiency	EF	Example
1 (no LEV)	0%	1.00	Extrapolation from LEV Type 4 to LEV Type 2 would be done by using an EF_{LEV} of 0.22/0.16 = 1.375.
2 (generic LEV)	78%	0.22	
3 (exterior LEV)	78%	0.22	
4 (integrated LEV)	84%	0.16	

For enclosing the emission source, the following extrapolation factors were used:

Table 6: Extrapolation factors for different levels of enclosure

Level of enclosure	Efficiency	EF	Example
1 (no enclosure)	0%	1.00	Extrapolation from enclosure level 3 to enclosure level 1 would be done by using an EF_{Enc} of 1.00/0.26 = 3.846.
2 (partly enclosed)	50%	0.50	
3 (fully enclosed)	74%	0.26	

For suppression measures, the following extrapolation factors were used:

Table 7: Extrapolation factors for different levels of suppression

Level of suppression	Efficiency	EF	Example
1 (not implemented)	0%	1.00	Extrapolation from suppression level 4 to suppression level 2 would be done by using an EF_{Sup} of 0.12/0.07 = 1.714.
2 (generic suppression technique)	88%	0.12	
3 (wet suppression)	89%	0.11	
4 (capture sprays)	93%	0.07	

Separation of workers is not yet considered during extrapolation. However, it is noted that the existence of control rooms was considered for the assignment of activity classes. However, in

particular for transfer activities, further investigations into this may be useful once further monitoring will become available.

Extrapolation to different OCs

The actual concentration of the individual constituent to be assessed in the overall handled materials is not covered by the definition of the specific activity classes. Thus, the following extrapolation factors were considered relevant:

Table 8: Extrapolation factors for different concentration ranges

Concentration category	Concentration range	EF (= typical concentration)	Example
4	0.001% - 0.01%	0.0055	Extrapolation from concentration category 6 to concentration category 8 would be done by using an EF_{Cont} of 7.5/0.55 = 13.636.
5	0.01% - 0.1%	0.055	
6	0.1% - 1%	0.55	
7	1% - 5%	3	
8	5% - 10%	7.5	
9	10% - 25%	17.5	
10	25% - 50%	37.5	
11	50% - 100%	75	

Extrapolation to different constituent

Extrapolation from one constituent to another was conducted by carefully considering the associated substance-intrinsic emission potential of the extrapolation source and the extrapolation target. This is in particular relevant for processes conducted at elevated temperatures. For these processes, extrapolation was considered justified only if the associated melting points of the substances are at a similar level. Potential sublimation and degradation points were also considered for these processes. For processes at ambient temperature, the substance-intrinsic emission potential is characterised by the physical form/dustiness of a substance. To account for the remaining uncertainties an extrapolation factor of EF_{Metal} = 1.25 was applied in each case.

Extrapolation to different AC

Extrapolation between similar ACs was also conducted. Although this was only considered justified if the anticipated activity-intrinsic emission potential of the extrapolation target is less or at the same level when compared to the extrapolation source, an extrapolation factor EF_{AC} = 1.5 was applied in each case.

Overall extrapolation factor

Any combination of the above extrapolation factors could have been used in the exposure assessment, so that the resulting total extrapolation factor is defined as follows:

$EF_{tot} = EF_{LEV} \times EF_{Enc} \times EF_{Sup} \times EF_{Cont} \times EF_{Metal} \times EF_{AC}$

Estimation of peak inhalation exposure levels

As summarised above, inhalation monitoring data were made available as full-shift representative (i.e. having sampling durations of at least 120 minutes). Thus, when comparing to acute effect levels, additional exposure estimates have to be derived for peak exposure levels. The R.14 guidance gives advice on how to extrapolate from full-sift exposure estimates to peak exposure

levels. The following table is adopted from that guidance in a way that only exposure duration of 15 minutes and 95th percentiles for peak exposure estimates are considered relevant.

Table 9: Extrapolation factors from full-shift to peak exposure levels

GSD	Full-shift estimate based on		Example
	75th percentile	90th percentile	
1 - 2	3	2.2	Extrapolation from a full-shift level (P90) of 100 µg/m³ based on data with a GSD of 2.5 to a peak exposure estimate would be done by using a factor of 2 resulting in a peak exposure estimate of 200 µg/m³.
2 – 4	3	2.0	
4 – 6	4	1.5	
6 – 8	5	1.4	
> 8	6	1.4	

It is noted that extrapolation factors for full-shift exposure estimates based on higher percentiles than the 90th would be extrapolated by using the factors as given for the 90th percentile on a conservative basis.

Given the enclosed nature of processes related to AC4, peak exposures are not expected for this activity class. Thus, an extrapolation factor of 1 is considered appropriate in these cases.

9.0.2.3.4 Bio-monitoring data (blood lead data)

As a standard procedure in the EU for workers exposed to lead, bio-monitoring in the form of blood measurements is legally required. Thus, such data exist to a large extent at the company level (given that specific medical confidentiality requirements are met). It should be noted that depending on national legislation and/or company-specific policies, blood lead levels of individual workers are to be repeatedly determined in particular, if significantly elevated blood lead levels have been observed. Thus, additional monitoring of the same worker is also common practice. Consequently, any database consisting of individual measurements could be biased by high exposed workers simply by their over-representation in the database. Thus, in analogy to the EU risk assessment report on lead (ILA Europe, 2009), repeated measurements of a specific worker have been consolidated into a single median value on an annual basis.

It is noted that bio-monitoring data already reflect uptake through all routes of exposure and all sources of lead present in the workplace atmosphere. The uncertainty of the assessment of internal exposure (that is after uptake) is less compared to substances for which exclusively external exposure levels are available. In addition, internal exposure levels already take any PPE as worn by the worker under surveillance into account. Thus, the information on worn PPE of workers for whom bio-monitoring data are available is crucial and has to be considered and reported in the corresponding exposure assessment based on such data. Given that the risk assessment concludes on acceptable risks, the respective PPE has to be considered as a mandatory risk management measure for the scenario to be assessed.

Thus, in the context of this project, when determining the required PPE for specific exposure scenarios, the mentioned PPE as imposed by the blood-lead assessment has to be seen as the minimum requirement. Depending on the level of inhalation exposure levels estimated for other constituents in the same exposure setting, even stricter PPE may have to be pre-scribed to lower such external exposure levels below the relevant DNEL. It is recognised that such stricter PPE is likely to also influence blood-lead levels in future measurements.

However, due to the nature of the conducted processes and industrial practice in the refinables' sector, blood lead data cannot easily be assigned to workplaces and activity classes. This is mainly

due to the fact that workers are commonly deployed in several workplaces in their working time, so that neither information on lead content nor on implemented (i.e. localised) controls could be assigned to workplaces and activity classes. The risk assessment below is therefore conducted on an industry wide scale and is assessed to be representative for the involved European companies (7 of the involved companies submitted blood lead data which were used in the risk assessment).

The table below includes RWC estimates of blood lead values for individual companies. The analysis was conducted on 1,861 annual median values out of a total of 1,978[5] single blood lead measurements (please see above for details on annual median values). Statistical analyses show that there was no influence on internal blood lead values from process temperature and enclosure of processes. However, the lead content in the handled materials had an impact on internal lead exposure levels. Thus, available blood lead values were evaluated based on the lead content in the handled materials. It was identified that blood lead levels from workers handling materials with lead content of less than 1 % at the workplace were significantly lower compared to blood lead levels from workers handling materials with lead content higher than 1 %. In addition, for completely closed processes with no potential for exposure (AC4 and AC6), internal blood lead values from the male general population in Germany[6] are used for the exposure and risk assessment (referred to as BIO1 below). An overview of the blood lead values used (referred to as BIO1-BIO3 below) and an analysis of the provided blood lead data (referred to as BIO2 and BIO3) is provided in the following table.

Table 10: Estimates for blood lead levels and reference value for the male general population (values provided in µg/dL)

Reference in exposure and risk assessment	Lead content in handled materials	Counts	Min	Median	75th percentile	90th percentile	95th percentile	Max	GSD
BIO1	lead not handled	-	-	4.5	-	-	9.0	-	-
BIO2	<1 %	549	0.9	4.8	7.2	10.3	12.7	32.0	1.9
BIO3	>1 %	1312	0.9	13.0	18.2	23.6	26.7	41.2	2.0

As can be seen above all RWC estimates (90th percentile values) are well below the current DNEL of 40 µg/dL. Only one maximum value is slightly above this threshold (41.2 µg/dL). Thus, current occupational hygiene practice appears to be adequate with respect to risks related to lead exposure. The reasonable worst-case values and the median values as provided above are taken forward to risk characterisation for the assessment of exposure to lead.

9.0.2.4 Exposure assessment based on modelled data

In cases where neither measured data were made available to EBRC nor an assessment based on monitoring data (incl. analogous data) could be established, occupational exposure was assessed with the aid of a modelling tool. At the first tier screening level, the MEASE tool (http://www.ebrc.de/mease.html) was used according to the ECHA Guidance (R.14). If exposure levels were modelled, all parameters needed to run the tool are provided in the ES. Exposure

[5] One blood lead value of 1,015 µg/dL was excluded from the analysis as sampling artefact.
[6] Arbeitsmedizinische Leitlinie der Deutschen Gesellschaft für Arbeitsmedizin und Umweltmedizin e.V. (DGAUM), available on http://www.awmf.org/uploads/tx_szleitlinien/002-001l_S1_Arbeit_unter_Einwirkung_von_Blei.pdf

estimates were derived based on realistic worst-case combinations of PROCs and physical forms that were assigned to specific activity classes.

9.0.2.4.1 Assessment of inhalation exposure

As explained above, the inhalation exposure assessment is generally based on monitoring data. However, for AC4, monitoring data were not available to a sufficient extent so that MEASE was used to derive inhalation exposure estimates for this specific activity class. Since this activity class is related to completely enclosed processes, additional uncertainties are not expected by using modelled data in this specific situation.

In MEASE, the worst case initial exposure estimate for solid substances (assuming high dustiness) is 10 µg/m³. This initial exposure assessment is then further refined by taking the workplace-specific composition profile into account on constituent-by-constituent basis. The possible exposure estimates are displayed in the table below:

Table 11: Overview of inhalation exposure estimates for AC4

Concentration range	Inhalation exposure estimate
≤100%	10 µg/m³
5% - ≤25%	6 µg/m³
1% - <5%	2 µg/m³
<1%	1 µg/m³

9.0.2.4.2 Assessment of dermal exposure

Dermal exposure data representing actual workplace measurements were not provided. Thus, for the assessment of dermal exposure that is required for long-term systemic or long-term local effects (peak dermal exposure levels are excluded by good occupational hygiene practices and any such assessments are therefore conducted on a qualitative basis), the first tier exposure assessment tool MEASE (version 1.02.01, available on www.ebrc.de/mease) is used. For dermal exposure, MEASE is based on the classification system of the broadly used EASE system. The resulting exposure estimates are based on measured data for several metals. For the assessment of dermal exposure with MEASE, different model parameters have to be selected under pattern of use, pattern of exposure control and contact level to describe the operational conditions at a workplace that are relevant for the dermal exposure assessment. An overview on these operational conditions and the parameters to be selected is provided in the table below.

Table 12: Overview and explanation on operational conditions and parameters to be selected for the dermal exposure assessment

Operational conditions used for dermal exposure assessment	**Model parameters**
Pattern of use	Wide dispersive use: wide dispersive use refers to those activities which deliver uncontrolled exposure not only to the immediate process worker but to other workers and sometimes the general public. Typical activities falling into this category are painting/spraying of paints. Non-dispersive use: non-dispersive use refers to processes in which substances are used in a way that only certain groups of workers, with the knowledge of the processes, come into contact with these chemicals. Procedures are normally worked out to achieve adequate control of exposure commensurate with the risk. This category is intended to cover most occupational use not specifically assignable to other categories. Inclusion into/onto matrix: use consisting of inclusion into or onto matrices means all processes where chemicals are incorporated into products or articles from which release into the environment is minimised. Closed system without breaches: a process should be assigned to this category if the substance remains within a reactor or is transferred from vessel to vessel through closed piping systems.
Pattern of exp. control	Direct handling: in the absence of any other control procedures it is assumed that the worker handles the substance directly (including the use of tools such as shovels, forceps which do not significantly separate the worker from the emission source). Non direct handling: if the level of control is full containment, or the worker is separated from the substance by means of space or time, or by using some other procedural controls, this option should be chosen.
Contact level	Extensive: extensive exposure is assumed to be greater than 10 events per day arising from work in which the hands are used as part of the process, for example, transfer of 'wet' objects from a bath to a draining rack. Intermittent: intermittent exposure is assumed to be 2 to 10 events per day involving exposure as part of a process; for example, material transfer by a device which involves e.g. weighing. Incidental: incidental exposure is assumed to be one event per day and would typically involve splashes or spills which arise from the way in which the process is carried out, for example, during mixing of paint. None: dermal exposure is unlikely to occur.

The PM Refinables are intermediates that are exclusively used in industrial settings. Thus, for all applicable processes and handling steps, exclusively non-dispersive uses are relevant when considering operational conditions (to be selected under “Pattern of use” in MEASE). Only cleaning and maintenance operations may represent an exception to this. However, in this sector even cleaning and maintenance operations are conducted with great care in order to not risk losing any of the dust originating from materials which are potentially of very high economic value. For some processes, even closed systems without breaches could be considered relevant due to closed reactors/vessels and transfer operations through closed piping systems. However, since this may not always be the case, non-dispersive uses were considered relevant for all activities classes as defined above. Parameters to be selected for the other operational conditions that are relevant for the assessment of dermal exposure may differ between activity classes and company-specific settings. For some ACs, the “pattern of exposure control” is already defined by the AC itself: for example, AC6 is defined by no manual interventions, clearly indicating that exclusively “non-direct handling” is relevant for this AC. However, this is not possible for each and every AC, since for example processes that are grouped under AC12 (mechanical operations) may be conducted either with manual intervention of workers (corresponding to the parameter “direct handling”) or may be conducted in enclosed systems, thus making direct handling impossible. Due to the high level of automation and very valuable materials that are handled at the workplaces in the precious metals industry, the contact level can in most cases be described as either “intermittent” or even

less. In the exposure scenarios below, only abbreviated codes are used to describe the selected parameters for relevant operational conditions for the assessment of dermal exposure according to the table below.

Table 13: Overview and explanation of abbreviations used for the dermal exposure assessment

Order of abbreviated parameters in the assessments	**Abbreviation of parameters used**
1st letter reflects the "pattern of use"	W=wide dispersive use, N=non-dispersive use, I=inclusion into matrix, C=closed system without breaches
2nd letter reflects the "pattern of exposure control"	D=direct handling, N=non-direct handling
3rd letter reflects the "contact level"	E=extensive, M=intermittent, I=incidental, N=none

Dermal exposure estimates are provided for the dermal loading in µg/cm²/day for a specific exposed skin area in cm² in MEASE. For comparison of these values with (systemic) dermal DNELs that are provided in µg/kg bw/d, a standard body weight of 70 kg was taken into account in the dermal exposure assessments. Relevant factors that may additionally be taken into account for the assessment of dermal exposure are:

- dermal absorption rates,
- exposure duration,
- concentration of the substance in a preparation, and
- the use of protective gloves.

Dermal absorption of metals and inorganic substances is generally very low. However, since information if dermal absorption was already considered in the derivation of DNELs is not available for each of the substances and constituents, dermal absorption values were not taken into account in the assessment of dermal exposure below. Although exposure duration may be reduced for some ACs and a reduced exposure duration may be reported in the ES below (i.e. to less than 480 minutes/shift), this is also not taken into account in the assessment of dermal exposure below.

Information on concentration ranges of the different constituents present at a workplace was gathered and used in the assessments of dermal exposure below. Exposure levels were reduced according to the following principle as provided in MEASE.

Table 14: Overview of exposure modifiers for the dermal exposure assessment in consideration of concentration of constituents at a workplace

Content in preparation	**Exposure modifier**
>25 %	100 %
5-25 %	60 %
1-5 %	20 %
<1 %	10 %

The following PROCs and parameters were taken into consideration for the derivation of initial dermal exposure estimates.

Table 15: Parameters considered for initial dermal exposure estimation

AC	relevant PROCs*	Parameters used for initial exposure estimate
1	**26**	NDM
2	5, 8b, 9, **21, 26**	NDM
3	8b, 9, **21**	NDM
4	**1**	NNN
5	**22, 23**	NDM
6	**22**	NDM
7	**23**	NDM
8	**22**	NDM
9	**3**	NDM
10	1, 2, 3, 4, **8b, 9**, 27b	NDM
12	**24**	NDM
14	0 (**26** was used as worst-case)	NDE
15	**15**	NDM

*The PROC(s) leading to the maximum dermal exposure estimate is provided in bold text.

Where applicable, AC-specific and company-specific information such as separation of workers during tasks (either according to company-specific information or due to AC characteristics, e.g. for AC6), resulting in “non-direct handling” for the assessment of dermal exposure were taken into account in a next step. In addition, concentration ranges as provided by the companies and the use of protective gloves were considered in the assessment.

The use of appropriate protective gloves is considered in every dermal exposure assessment. The reason for this is as follows: A variety of processes may result in potential injuries of the hands, either because of substance-intrinsic properties of handled/processed substances (e.g. irritating or sensitizing properties) or process-intrinsic properties (e.g. processes conducted under high temperature or processes that may lead to mechanical injuries). Thus, properly designed and selected dermal protection should be worn continuously throughout the facilities unless any dermal exposure is impossible. Efficiency of 99 % is considered for the use of appropriate protective gloves in the dermal exposure assessments below.

Assessment of typical dermal exposure

For the assessment of combined effects, typical dermal exposure values were to be derived (please see Chapter 9.0.2.1.3). Since the tool used for dermal exposure assessment does only provide estimates of reasonable worst case exposures, the tool output was further processed as follows: MEASE outputs represent upper range limits of so-called exposure bands reported in the HERAG factsheet on dermal exposure and absorption[7]. Since lower range limits are also reported in this factsheet, it was possible to derive a typical estimate by taking the average of the upper and lower range limit.

[7] HERAG fact sheet, Assessment of occupational dermal exposure and chemical absorption for metals and inorganic metal compounds, Final version, EBRC Consulting GmbH, August 2007

9.0.2.5 Qualitative exposure assessments

Qualitative exposure assessments may be required in some cases, either because exposure cannot be assessed on a quantitative basis or because a reference value to compare estimated exposure with is not available. The latter is often relevant for substances leading to acute effects in humans, e.g. because of their corrosive nature.

9.0.2.5.1 Assessment of eye exposure

Eye exposure may occur during many different processes. A variety of these processes may result in potential injuries of the eyes, either because of substance-intrinsic properties of handled/processed substances (e.g. irritating or sensitizing properties) or process-intrinsic properties (e.g. processes that may lead to mechanical injuries). Thus, appropriate eye protection should be worn continuously throughout the facilities unless this is either impractical or any eye injury is impossible.

9.0.2.6 Generation of occupational exposure scenarios

It is noted that Section 1 - 8 of the CSRs for the PM Refinables are substance-specific by their nature (as required under the REACH regulation), providing the required information for each of the substances separately. In contrast, the occupational exposure scenarios (ES) are generated on a company-specific basis not only taking all handled PM Refinables into account but also all other relevant substances handled in parallel in a specific workplace. Thus, the occupational ES, potentially include confidential information such as composition information or specific information on process conditions. In order to protect such information, the occupational ES (Sections 9.1.X of the CSR) are provided to the individual companies and should be attached to the IUCLID dossier by each co-registrant separately. The current methodology part is however generic for all companies and is therefore included in Section 13 of IUCLID for all registrants.

9.0.2.7 Uncertainty analyses

This analysis represents a first attempt to assess uncertainty associated with the risk assessment reported in this document. It is therefore meant to be constantly improved upon request by regulators or when additional information becomes available. Different types of uncertainty may therefore be distinguished. Uncertainty in this risk assessment may be related to:

1. the conducted hazard and exposure assessment and resulting risk characterisation conducted as for any other (standard) substance,
2. the variability and missing knowledge of the composition of the UVCB to be assessed and/or
3. the specific approach followed in this risk assessment for inorganic UVCBs.

These three types are separately addressed below.

9.0.2.7.1 Uncertainty related to the conducted hazard and exposure assessment and resulting risk characterisation conducted as for any other (standard) substance

Within the settings as given for the risk assessment approach for inorganic UVCBs (iUVCBs) as explained above, neither the hazard nor the exposure assessment introduces additional uncertainties at the constituent level.

The hazard assessment for an individual constituent was applied without any modification from existing REACH dossiers and can thus be assumed to be conducted according to applicable

guidance (i.e. by taking into account relevant assessment factors to address uncertainty). The identification of the relevant speciation of the constituent was either based on knowledge or was considered at a worst case basis (i.e. by assuming the lowest DNEL for each type of DNEL). In addition to risk assessments for standard substances, the selection of the species relevant for risk assessment was conducted at the workplace level and thus representing the highest protection level achievable for workers.

The scope of the exposure assessment (EA) is completely determined by the identified constituents in the hazard assessment as described above. For inhalation exposure the EA is based on monitoring data obtained in the workplaces to be actually assessed. However, the inhalation EA does not distinguish between different chemical species but instead always considers the sampled mass (from elemental analysis) as being reflective for the identified worst-case species. Furthermore, contribution to collected (elemental) masses from other substances being handled in parallel is intrinsically included in dust samples. For REACH purposes, such contribution is normally not to be taken into account but was included in the current EA and thus represents an additional level of conservatism with respect to legal requirements.

In the absence of sufficient dermal exposure data, the dermal exposure assessment was conducted with the occupational exposure tool MEASE. As MEASE being a first tier (screening) tool, any derived exposure estimates may be considered as sufficiently precautionary.

For lead, the exposure assessment is based on bio-monitoring which is known to considerably reduce uncertainties in risk assessments related to uptake and actual internal exposure.

9.0.2.7.2 Uncertainty related to the variability of / missing knowledge on the composition of the UVCB to be assessed

The uncertainty of this type may be further distinguished into uncertainty related to variability of composition and unknown chemical speciation of individual constituents in the iUVCB or as emitted into or present in the workplace.

Uncertainty in considering the correct chemical speciation may be assumed to be exclusively related to the hazard assessment. As already explained above, such uncertainties are being addressed by assuming the worst case (i.e. most hazardous) chemical species and are therefore assumed to be adequately covered. Since the chemical species to be considered in exposure assessment is dictated by the hazard assessment, additional uncertainties are not to be expected.

On the other hand, uncertainty resulting from the variability in concentration of the individual constituents in the iUVCB could be assumed to only affect the EA, whereas the hazard assessment does not consider/use composition/concentration information at all (i.e. DNELs are used from the original dossiers without modification). An uncertainty analysis of the EA is restricted to the question of whether it is applicable to the concentration range one constituent could have.

In the precious metals industry, it needs to be considered that this concentration range is however, not determined by a single iUVCB but by multiple substances being processed in parallel all of which potentially containing the constituent to be assessed and thus contributing to exposure. At first glance this may appear even worse but it in fact leads to less variability since processes are designed to operate within specific concentration ranges so that materials need to be selected and mixed to fulfil these specifications. GSDs of data sets pooled for workplaces and constituents (see Appendix 1) although suggest low variability at the workplace level. These considerations together with the high number of observations and guidance-conform data analysis suggest that the presented EA is indeed representative and capable of covering the variability in composition of the iUVCB in the precious metals industry.

9.0.2.7.3 Uncertainty related to the specific approach followed in this risk assessment for inorganic UVCBs

In addition to the already addressed uncertainties which are common to all risk assessments and those uncertainties which are unavoidable due to the variability and unknowns of the iUVCBs, the followed hazard assessment approach for the iUVCBs introduces additional uncertainties. These "approach-dependent" uncertainties are two-fold:

1. In the hazard assessment, DNEL values for individual constituents are taken over without further modification. In general this is assumed representing a worst case hazard assessment for the iUVCB as it assumes that the constituent is present to 100 % in the iUVCB. However, specific considerations may have been taken into account in the DNEL derivation for the specific constituents that are not evident from the information available to the iUVCB assessors. Such considerations may concern the physical appearance of the substance: for example, a specific DNEL may have been derived by taking into account that the substance is only placed on the market and used as coarse powder. Such coarse powders may be anticipated to only deposit in small amounts in human lungs. If in that example the iUVCB to be assessed is handled as fine powder, then the hazard assessment may not be completely applicable. However, since the hazard assessment of the constituent has to cover its entire life cycle, one has to compare the life cycle of the iUVCB and that of the constituent for differences in considered physical forms as well.
2. In standard risk assessments under REACH, either already available toxicity data would be used or if such data were not available, toxicity data would be generated in laboratory testing. For the iUVCBs, toxicity data are not available and could not be generated for reasons already outlined in Chapters above. Although an alternative solution does not exist, additional uncertainties may be introduced by following the constituent-specific approach. These uncertainties are related to interactions between specific constituents which are not addressed in the constituent-specific dossiers.

Whereas uncertainties related to combined effects are already discussed above, the comparison of physical appearances and potential life cycle modifications of that are assessed below.

As stated above, the exposure assessment of the iUVCBs is workplace-specific. At the concerned workplaces, dust is the predominant physical form leading to exposure. Thus, the comparison of physical forms should check whether dust and/or powders were considered in the derivation of DNELs of the individual constituents. The following information was extracted from publicity available information:

Table 16: Physical forms of test material which has been used in DNEL derivation

Element	Chemical species	Physical form of test material
Ag	Ag	powder (compact)
	AgNO3	crystalline
Al	AlCl3	fine powder
As	As2O3	powder
Au	[AuCl4]-	not relevant
B	Borate	crystalline
Ba	Ba soluble	crystalline
Ca	CaO	powder
Cd	Cd	powder (cast)
Co	Co	compact particulates
Cr	CrO3	Deliquescent crystals, flakes or powder

Element	Chemical species	Physical form of test material
Cs	CsCl	crystalline
Cu	Cu2O	powder
	CuSO4	powder (crystalline)
Hg	Hg	liquid
Li	Li	compact
Mn	MnO2	powder
Mo	MoO3	powder (compact: wires, rods, sheets, etc.)
Ni	Ni	hard metal powder
	NiSO4	crystalline
	NiO	granular
	NiS	powder
	Ni3S2	powder
P	P2O5	powder
Pb	Pb	powder
Pd	Pd soluble	powder
Pt	soluble	powder
Sb	Sb2O3	crystalline
Se	Se	powder
	ZnSeO3	powder
Te	Te	powder
V	soluble without irrit.	granules (powder)
	soluble with irrit.	powder, flakes, crystalline

As appears from the table above, in almost all of registration files of the individual constituents powders have been considered as a potential physical form. Thus, the appearance of dust may safely be considered in the respective hazard assessments.

In addition to the above considerations of the physical form as tested/being placed on the market, the physical appearance may be changed in the processes conducted at the downstream user level. Under REACH, these processes are commonly described with so-called process categories (PROCs). In the risk characterisation for workers below, the following PROCs have been taken into account: 1, 2, 3, 4, 5, 8b, 9, 15, 21, 22, 23, 24, 26 and 27b. Although further interpretation of these PROCs has been shown difficult in various situations, the following groups may still be built from the mentioned list of PROCs:

- Process-specific PROCs 1-4 are more process oriented and present descending level of enclosure,
- Mixing PROC 5 may be related to increased emission potential but is not considered to significantly modify inhalability of the material,
- Transfer PROCs 8b, 9, 15, 21, 26 may considered as processes of low abrasive potential (such as transfer processes) with PROC 26 being associated with highest emission potential,
- Hot metallurgical PROCs 22, 23 and 27b of which PROC 27b is considered to most likely modify the physical form of the processed material and
- High kinetic energy PROC 24 is considered having considerable potential for modifying the physical form of the handled material.

On a worst case basis, the above given list of PROCs could therefore be reduce to PROCs 4, 5, 24, 26 and 27b. When comparing with publicity available information the following table can be deduced:

Table 17: PROCs covered in registration dossiers

Route	Species	PROC 4	PROC 5	PROC 24	PROC 26	PROC 27b
Ag	Ag	yes	yes	yes	yes	yes
	AgNO3	yes	yes	no	yes	yes
Al	AlCl3	yes	yes	yes	yes	no
As	As2O3	yes	no	no	yes	no
B	Borate	yes	yes	yes	yes	no
Ba	Ba soluble	yes	yes	no	no	no
Ca	CaO	yes	yes	yes	yes	yes
Cd	Cd	yes	yes	yes	yes	yes
Co	Co	yes	yes	yes	yes	yes
Cs	CsCl	no	no	no	no	no
Cu	Cu2O	yes	yes	no	no	no
	CuSO4	yes	yes	yes	yes	no
Hg	Hg	yes	yes	yes	no	no
Li	Li	yes	yes	no	no	yes
Mn	MnO2	yes	yes	yes	yes	no
Mo	MoO3	yes	yes	yes	yes	yes
Ni	Ni	yes	yes	yes	yes	yes
	NiSO4	yes	yes	yes	yes	no
	NiO	yes	yes	yes	yes	no
	NiS	yes	no	no	yes	no
	Ni3S2	yes	no	no	no	no
P	P2O5	yes	yes	no	no	no
Pb	Pb	yes	yes	yes	yes	yes
Sb	Sb2O3	yes	yes	yes	yes	no
Se	Se	yes	no	no	yes	yes
	ZnSeO3	no	no	no	no	no
Te	Te	yes	yes	no	yes	yes
V	soluble without irrit.	yes	yes	yes	yes	yes
	soluble with irrit.	yes	yes	yes	yes	yes

It can be seen that most PROCs are already covered on a worst case basis, so that significant impact from life-cycle modifications on the hazard potential of the individual constituents is currently not anticipated.

9.0.3 Man via the environment

For metals, the assessment of exposure of man via the environment is predominantly determined by the respective metal ion. The concentration thereof in environmental media is in most cases determined by monitoring data. Intrinsic to such monitoring data is that they cover potential exposure of the general population resulting from all emissions (including historical emissions) and natural background. Indirect exposure is generally assessed on a local and on a regional spatial scale. In this context, local and regional environments are not to be considered as actual sites or

regions, but instead as standardised environments as defined in the relevant ECHA guidance “R.16 – Environmental Exposure Estimation”.

9.0.3.1 Specific considerations for the regional assessment of inorganic UVCBs in secondary metal production

The life-cycle of the UVCB is limited to the intermediate use relevant only at a small number of sites throughout the EU. There are neither wide dispersive uses nor any downstream uses leading to a significant contribution to regional emissions. The regional assessment is usually based on monitoring data. Thus, exposure of the general population via the environment is already covered in a precautionary way by the respective chemical safety assessments of the metal concerned since monitoring data cover all emission sources.

9.0.3.2 Specific considerations for the local assessment of inorganic UVCBs in secondary metal production

On the local scale, the contribution of specific sites has to be calculated or measured. Such an assessment is in principle covered by the respective metal dossiers, given that air and water emissions are included in all local sources data. This needs to be checked on a case by case basis and thus requires broader data access to the respective registration dossiers.

9.1 Exposure scenario for the manufacture and use

9.1.1 Environmental contributing scenario

Please refer to the environmental contributing scenario for the relevant environmental exposure assessment.

9.1.2 Occupational contributing scenario

Please refer to the company-specific occupational contributing scenarios for the relevant occupational exposure assessment.

10 Risk characterisation related to combined exposure

10.1 Human health

10.1.1 Workers

For simultaneous exposure to the same constituent at a workplace via different exposure routes (i.e. inhalation and dermal), please refer to the risk characterisation ratios (RCRs) as provided in the occupational exposure scenarios reported in Chapter 9 for systemic effects. The sum of the RCRs for systemic effects via inhalation and dermal exposure was controlled to a level below 1 and safe use was demonstrated for simultaneous exposure via these routes in all cases.

For aggregated exposure resulting from the applicability of more than just a single contributing worker scenario in a single work shift, it is noted that all exposure levels were derived for a full-shift exposure time and a safe use was demonstrated for each of these contributing scenarios. Thus, by demonstrating a safe use for individual contributing scenarios it is assured that a combination of activities within a single shift, could not exceed the highest calculated RCR of any of the individual activities in that shift.

For different constituents, current recommendations propose to follow the dose/concentration addition approach in case of unknown modes of action of different constituents. In case of independent modes of action, the assessment of individual constituents is considered to be sufficient also bearing in mind that the followed approach already represents a conservative approach by taking exposures from different substances (including waste and other substances than the UVCB intermediates, please refer to Chapter 9.0.2.1) into account. In addition, information on combined toxicity of different substances is currently not available. However, a first attempt to address combined effects is already included in Section 9 of the CSR.

The contribution of other substances to workers' exposure to an individual constituent is normally not to be addressed under REACH since substance-specific assessments are required under the REACH regulation. By the inclusion of such contribution from other substances, the assessment for the substance is therefore intrinsically conservative (i.e. precautionary) with respect to legal REACH requirements. As being anyway good occupational hygiene practice, the exposure assessment is however based on these "aggregated exposure levels" and could be seen as an "intrinsic combined exposure assessment" to an individual constituent.

For workers who are members of other populations to be protected in this chemical safety assessment (i.e. general population), a specific combined exposure assessment is not required as workers represent a less vulnerable population in comparison to subpopulations e.g. children which may be considered in assessments for the general population. Any RCR from these subpopulations could safely be assumed to be in fact significantly lower if re-calculated for workers. In a combined assessment of exposures one would also avoid adding the worst case RCR for workers with the worst case RCR of another population as this would lead to an unrealistic scenario. Instead lowered RCRs would be taken which would in combination most likely not identify an unacceptable risk.

Appendix 1: Generic exposure assessment table

Est#	Metal	AC	Content	LEV	Enc	Sup	N	MIN	P50	P75	P90	P95	MAX	GSD	N.Cat	GSD.Cat	RWC.Cat	RWC
1	Ag	1	6	2	2	1	12	0.4	0.9	1.8	8.2	11.1	14.0	3.5	4	3	B	8.2
2	Ag	2	7	4	2	1	1	14.0	14.0	14.0	14.0	14.0	14.0	NA	1	1	F	28.0
3	Ag	2	9	4	3	1	1	2.0	2.0	2.0	2.0	2.0	2.0	NA	1	1	F	4.0
4	Ag	2	10	4	2	2	1	39.7	39.7	39.7	39.7	39.7	39.7	NA	1	1	F	79.3
5	Ag	2	11	4	1	1	6	15.0	50.5	72.5	81.7	83.0	84.3	2.1	3	3	C	83.0
6	Ag	3	6	4	2	1	58	0.4	0.4	0.5	0.9	1.2	10.0	1.7	7	4	A	0.5
7	Ag	3	10	1	2	3	6	1.0	2.0	2.8	4.0	4.5	5.0	1.9	3	4	B	4.0
8	Ag	3	11	1	2	1	27	0.4	1.3	3.7	15.7	19.1	25.1	3.7	6	2	B	15.7
9	Ag	3	11	2	2	3	1	2.8	2.8	2.8	2.8	2.8	2.8	NA	1	1	F	5.6
10	Ag	5	6	2	2	1	35	0.4	0.4	0.9	1.2	4.1	5.9	2.1	6	3	B	1.2
11	Ag	5	11	2	2	1	63	1.3	16.7	29.2	44.4	62.4	272.0	2.9	7	3	A	29.2
12	Ag	5	11	3	1	2	4	2.0	11.0	12.0	13.8	14.4	15.0	2.5	2	3	D	15.0
13	Ag	6	6	2	2	1	35	0.4	0.4	0.7	1.0	1.2	1.4	1.5	6	4	A	0.7
14	Ag	6	11	2	2	2	4	13.3	19.1	23.2	26.2	27.1	28.1	1.4	2	4	C	27.1
15	Ag	6	11	3	2	2	3	2.0	2.0	4.5	6.0	6.5	7.0	2.1	2	3	D	7.0
16	Ag	7	10	4	2	1	5	1.0	1.0	1.0	14.8	19.4	24.0	4.1	2	2	E	36.0
17	Ag	7	11	2	2	2	5	3.2	17.6	45.5	88.5	102.8	117.1	4.1	2	2	E	175.7
18	Ag	7	11	4	2	3	1	30.0	30.0	30.0	30.0	30.0	30.0	NA	1	1	F	60.0
19	Ag	9	10	2	2	2	6	16.6	23.3	64.9	95.9	104.9	113.9	2.3	3	3	C	104.9
20	Ag	10	6	2	2	1	8	0.4	0.4	0.8	2.1	2.3	2.6	2.2	3	3	C	2.3
21	Ag	10	9	4	3	1	14	1.0	1.0	2.8	7.1	57.0	148.0	4.1	5	2	B	7.1
22	Ag	10	10	1	2	1	33	0.3	0.9	4.7	11.2	14.9	19.3	4.1	6	2	B	11.2
23	Ag	10	11	1	2	2	3	2.1	2.7	7.6	10.5	11.4	12.4	2.6	2	3	D	12.4
24	Ag	12	9	2	2	1	7	2.0	53.0	206.0	372.4	398.2	424.0	7.4	3	2	D	424.0
25	Ag	12	10	4	2	1	4	2.9	5.3	6.0	6.0	6.0	6.0	1.4	2	4	C	6.0
26	Ag	14	7	1	1	1	37	0.4	0.4	1.0	2.2	4.3	11.7	2.4	6	3	B	2.2
27	Ag	14	10	3	2	1	5	2.9	3.0	6.0	8.5	9.3	10.1	1.8	2	4	C	9.3
28	Ag	14	11	1	1	1	7	1.0	5.0	23.2	64.5	91.0	117.4	5.6	3	2	D	117.4
29	Ag	15	10	2	2	1	5	1.0	1.0	2.0	4.4	5.2	6.0	2.2	2	3	D	6.0
30	As	1	7	2	2	1	12	1.8	1.9	4.8	11.6	33.0	58.4	2.9	4	3	B	11.6
31	As	2	6	4	2	1	1	0.4	0.4	0.4	0.4	0.4	0.4	NA	1	1	F	0.8
32	As	2	7	1	1	1	4	1.0	4.3	6.0	7.6	8.2	8.7	2.5	2	3	D	8.7
33	As	2	7	4	3	1	1	1.0	1.0	1.0	1.0	1.0	1.0	NA	1	1	F	2.0
34	As	3	7	1	2	1	89	0.4	1.8	1.8	2.0	2.9	4.1	1.3	7	4	A	1.8
35	As	5	2	3	1	2	4	1.0	1.0	1.5	2.4	2.7	3.0	1.7	2	4	C	2.7
36	As	5	2	4	2	1	4	5.0	30.0	51.0	74.4	82.2	90.0	3.4	2	3	D	90.0
37	As	5	5	2	2	1	52	1.8	2.7	5.8	7.0	12.4	27.3	2.0	7	3	A	5.8
38	As	5	6	3	2	2	4	0.9	1.3	1.7	2.4	2.6	2.8	1.6	2	4	C	2.6
39	As	5	7	2	2	1	36	1.0	1.8	2.0	4.6	5.9	8.0	1.6	6	4	A	2.0
40	As	6	2	2	2	2	4	0.4	1.8	2.4	3.2	3.5	3.8	2.6	2	3	D	3.8
41	As	6	6	3	2	2	3	1.0	1.0	3.0	4.2	4.6	5.0	2.5	2	3	D	5.0
42	As	6	7	2	2	1	35	1.8	1.8	1.8	2.4	4.3	6.6	1.4	6	4	A	1.8
43	As	7	2	2	2	1	7	0.4	1.0	1.6	2.4	2.6	2.7	1.9	3	4	B	2.4
44	As	7	7	4	2	1	2	1.0	1.5	1.8	1.9	2.0	2.0	1.6	2	4	C	2.0
45	As	9	6	2	2	2	3	0.8	1.5	1.9	2.1	2.1	2.2	1.7	2	4	C	2.1
46	As	10	2	1	2	2	2	1.1	1.7	2.0	2.2	2.2	2.3	1.7	2	4	C	2.2
47	As	10	6	1	2	1	29	1.4	1.5	1.8	1.8	1.8	1.8	1.1	6	4	A	1.8
48	As	10	7	1	2	1	10	1.0	1.8	1.8	2.1	3.7	5.2	1.6	3	4	B	2.1
49	As	10	7	4	3	1	14	1.0	1.0	1.0	1.0	2.8	6.0	1.6	5	4	B	1.0
50	As	12	2	4	2	1	2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2	4	C	1.0
51	As	12	7	2	2	1	6	1.0	10.5	19.0	34.0	41.5	49.0	5.5	3	2	D	49.0
52	As	12	7	4	2	1	2	3.4	4.3	4.7	4.9	5.0	5.1	1.3	2	4	C	5.0
53	As	14	2	1	2	2	2	2.3	4.3	5.3	5.9	6.1	6.3	2.0	2	3	D	6.3
54	As	14	7	1	2	1	46	1.0	1.8	2.6	12.1	25.8	45.0	2.4	6	3	B	12.1
55	As	15	2	4	2	1	1	1.0	1.0	1.0	1.0	1.0	1.0	NA	1	1	F	2.0
56	As	15	7	2	2	1	5	0.6	1.0	1.1	1.9	2.2	2.5	1.7	2	4	C	2.2

Est#	Metal	AC	Content	LEV	Enc	Sup	N	MIN	P50	P75	P90	P95	MAX	GSD	N.Cat	GSD.Cat	RWC.Cat	RWC
57	Au	1	5	2	2	1	12	12.1	13.9	13.9	13.9	13.9	13.9	1.0	4	4	B	13.9
58	Au	3	11	1	2	1	80	12.1	13.9	13.9	13.9	14.0	23.3	1.1	7	4	A	13.9
59	Au	5	7	2	2	1	83	13.0	13.9	13.9	13.9	14.0	14.4	1.0	7	4	A	13.9
60	Au	6	5	2	2	1	31	13.6	13.9	13.9	13.9	13.9	13.9	1.0	6	4	A	13.9
61	Au	10	5	2	2	1	8	13.7	13.9	13.9	13.9	13.9	13.9	1.0	3	4	B	13.9
62	Au	14	5	1	1	1	32	12.1	13.9	13.9	13.9	13.9	13.9	1.0	6	4	A	13.9
63	Bi	10	6	1	2	1	29	10.7	11.5	13.9	13.9	13.9	13.9	1.1	6	4	A	13.9
64	Cd	1	7	2	2	1	12	0.3	1.8	4.5	16.2	55.2	101.7	5.7	4	2	C	55.2
65	Cd	2	6	4	1	1	3	0.1	0.2	0.3	0.4	0.5	0.5	2.5	2	3	D	0.5
66	Cd	3	2	1	2	2	2	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2	4	C	0.0
67	Cd	3	4	1	2	1	22	0.3	0.3	0.3	0.3	0.3	0.3	1.0	6	4	A	0.3
68	Cd	3	7	2	2	1	58	0.3	0.3	0.4	1.2	1.5	2.5	1.8	7	4	A	0.4
69	Cd	5	2	3	2	2	4	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2	4	C	0.0
70	Cd	5	5	2	2	1	52	0.3	0.3	0.4	0.7	1.1	1.8	1.6	7	4	A	0.4
71	Cd	5	7	2	2	1	35	0.3	0.3	1.0	2.9	4.4	4.8	2.7	6	3	B	2.9
72	Cd	6	2	2	2	2	4	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2	4	C	0.0
73	Cd	6	7	2	2	1	35	0.3	0.4	0.6	1.1	1.9	2.6	1.9	6	4	A	0.6
74	Cd	7	2	2	2	2	3	0.0	0.0	0.1	0.1	0.1	0.1	2.0	2	3	D	0.1
75	Cd	7	6	4	2	3	1	1.0	1.0	1.0	1.0	1.0	1.0	NA	1	1	F	2.0
76	Cd	9	2	2	2	2	3	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2	4	C	0.0
77	Cd	10	2	1	2	2	2	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2	4	C	0.0
78	Cd	10	7	2	2	1	8	0.4	0.7	1.7	4.8	6.7	8.5	3.0	3	3	C	6.7
79	Cd	14	7	1	1	1	41	0.3	0.6	1.1	1.7	2.1	3.0	2.2	6	3	B	1.7
80	Cd	15	6	4	2	1	2	0.0	0.2	0.2	0.3	0.3	0.3	4.2	2	2	E	0.5
81	Co	1	6	2	2	1	12	0.2	0.3	0.3	0.3	0.3	0.4	1.1	4	4	B	0.3
82	Co	2	6	2	2	1	1	1.0	1.0	1.0	1.0	1.0	1.0	NA	1	1	F	1.9
83	Co	3	4	1	2	1	22	0.3	0.3	0.3	0.3	0.3	0.3	1.0	6	4	A	0.3
84	Co	3	6	1	2	1	58	0.2	0.3	0.3	0.3	0.3	0.5	1.1	7	4	A	0.3
85	Co	5	2	4	2	1	4	5.0	19.5	27.3	29.5	30.3	31.0	2.3	2	3	D	31.0
86	Co	5	5	2	2	1	52	0.3	0.3	0.3	0.3	0.3	2.0	1.3	7	4	A	0.3
87	Co	5	6	2	2	1	35	0.3	0.3	0.3	0.3	0.3	0.3	1.0	6	4	A	0.3
88	Co	6	6	2	2	1	35	0.3	0.3	0.3	0.3	0.3	0.3	1.0	6	4	A	0.3
89	Co	7	6	4	2	3	1	1.0	1.0	1.0	1.0	1.0	1.0	NA	1	1	F	2.0
90	Co	10	6	2	2	1	8	0.3	0.3	0.3	0.3	0.3	0.3	1.0	3	4	B	0.3
91	Co	14	6	1	1	1	2	2.1	9.0	12.5	14.6	15.3	16.0	4.3	2	2	E	24.0
92	Co	14	6	1	1	1	37	0.2	0.3	0.3	0.5	0.9	3.0	1.6	6	4	A	0.3
93	Cr	2	6	4	2	1	1	1.7	1.7	1.7	1.7	1.7	1.7	NA	1	1	F	3.4
94	Cr	2	7	1	1	1	2	6.0	8.4	9.6	10.3	10.6	10.8	1.5	2	4	C	10.6
95	Cr	7	7	4	2	3	1	3.0	3.0	3.0	3.0	3.0	3.0	NA	1	1	F	6.0
96	Cr	14	7	1	1	1	1	18.0	18.0	18.0	18.0	18.0	18.0	NA	1	1	F	36.0
97	Cr	14	7	4	2	1	1	2.0	2.0	2.0	2.0	2.0	2.0	NA	1	1	F	4.0
98	Cr	15	7	4	2	1	1	2.2	2.2	2.2	2.2	2.2	2.2	NA	1	1	F	4.4
99	Cu	1	8	2	2	1	12	2.8	8.4	22.7	59.9	80.0	102.0	3.3	4	3	B	59.9
100	Cu	2	8	2	2	1	2	15.5	25.3	30.1	33.1	34.0	35.0	1.8	2	4	C	34.0
101	Cu	2	10	1	1	1	2	60.0	85.6	98.4	106.1	108.6	111.2	1.5	2	4	C	108.6
102	Cu	3	6	1	2	1	25	2.8	2.8	3.0	9.3	9.7	11.7	1.6	6	4	A	3.0
103	Cu	3	8	2	2	1	12	2.8	5.4	9.0	15.3	16.0	16.1	1.9	4	4	B	15.3
104	Cu	3	8	4	2	3	46	2.7	2.8	7.5	12.4	16.5	24.2	1.9	6	4	A	7.5
105	Cu	5	2	4	2	1	4	5.0	76.0	95.0	104.0	107.0	110.0	4.2	2	2	E	165.0
106	Cu	5	6	2	2	1	52	2.8	9.8	19.6	32.4	47.7	89.9	2.6	7	3	A	19.6
107	Cu	5	8	2	2	1	39	2.7	3.8	8.6	20.7	54.5	80.4	2.6	6	3	B	20.7
108	Cu	6	2	2	2	2	4	1.2	2.3	3.0	3.6	3.8	4.0	1.7	2	4	C	3.8
109	Cu	6	8	2	2	1	35	2.7	3.7	6.9	11.6	17.9	26.2	1.9	6	4	A	6.9
110	Cu	7	2	2	2	2	1	11.5	11.5	11.5	11.5	11.5	11.5	NA	1	1	F	23.0
111	Cu	7	6	2	2	2	2	2.2	3.1	3.5	3.7	3.8	3.9	1.5	2	4	C	3.8
112	Cu	9	6	2	2	2	3	1.8	2.1	4.4	5.8	6.2	6.7	2.1	2	3	D	6.7
113	Cu	10	7	1	2	1	30	2.2	4.0	9.8	30.6	60.1	83.2	2.8	6	3	B	30.6
114	Cu	10	8	2	2	1	8	2.7	2.8	4.4	17.1	28.8	40.5	2.6	3	3	C	28.8
115	Cu	10	9	4	2	2	1	3.8	3.8	3.8	3.8	3.8	3.8	NA	1	1	F	7.6
116	Cu	12	9	4	2	1	2	180.0	200.0	210.0	216.0	218.0	220.0	1.2	2	4	C	218.0
117	Cu	14	10	1	1	1	45	2.7	8.3	21.5	129.7	250.0	400.0	4.5	6	2	B	129.7

Est#	Metal	AC	Content	LEV	Enc	Sup	N	MIN	P50	P75	P90	P95	MAX	GSD	N.Cat	GSD.Cat	RWC.Cat	RWC
118	Cu	15	9	4	2	1	1	6.8	6.8	6.8	6.8	6.8	6.8	NA	1	1	F	13.6
119	Fe	1	8	2	2	1	12	1.5	6.7	14.4	44.5	50.8	54.6	3.4	4	3	B	44.5
120	Fe	2	11	1	1	1	2	270.0	325.0	352.5	369.0	374.5	380.0	1.3	2	4	C	374.5
121	Fe	3	6	1	2	1	22	1.0	3.6	6.6	8.8	16.6	36.1	2.5	6	3	B	8.8
122	Fe	3	8	2	2	1	12	0.4	5.2	9.6	10.4	109.3	230.0	4.9	4	2	C	109.3
123	Fe	3	8	4	2	3	46	0.4	2.5	4.7	7.4	12.1	21.4	2.4	6	3	B	7.4
124	Fe	5	8	2	2	1	87	0.8	13.7	43.5	84.2	124.5	280.0	4.0	7	2	B	84.2
125	Fe	6	8	2	2	1	35	0.7	5.9	11.4	21.4	33.0	49.2	3.1	6	3	B	21.4
126	Fe	7	11	4	2	3	1	310.0	310.0	310.0	310.0	310.0	310.0	NA	1	1	F	620.0
127	Fe	10	6	1	2	1	29	1.0	2.9	4.2	8.3	10.0	10.9	1.9	6	4	A	4.2
128	Fe	10	8	2	2	1	8	0.7	1.9	2.8	5.6	7.2	8.7	2.3	3	3	C	7.2
129	Fe	14	7	2	2	1	1	160.0	160.0	160.0	160.0	160.0	160.0	NA	1	1	F	320.0
130	Fe	14	11	1	1	1	42	0.4	9.3	25.0	59.5	108.9	270.0	4.8	6	2	B	59.5
131	Hg	1	5	2	2	1	12	2.4	2.8	2.8	2.8	5.5	8.9	1.4	4	4	B	2.8
132	Hg	3	5	1	2	1	80	2.4	2.8	2.8	2.8	2.8	4.7	1.1	7	4	A	2.8
133	Hg	5	-	2	2	1	87	2.6	2.8	2.8	2.8	2.8	2.9	1.0	7	4	A	2.8
134	Hg	6	5	2	2	1	35	2.7	2.8	2.8	2.8	2.8	2.8	1.0	6	4	A	2.8
135	Hg	10	5	2	2	1	8	2.7	2.8	2.8	2.8	2.8	2.8	1.0	3	4	B	2.8
136	Hg	14	5	2	2	1	36	2.4	2.8	2.8	2.8	2.8	2.8	1.0	6	4	A	2.8
137	Ni	1	7	2	2	1	12	2.4	2.8	2.8	2.8	3.8	5.0	1.2	4	4	B	2.8
138	Ni	2	6	4	2	1	1	5.6	5.6	5.6	5.6	5.6	5.6	NA	1	1	F	11.2
139	Ni	2	8	2	2	3	1	5.1	5.1	5.1	5.1	5.1	5.1	NA	1	1	F	10.2
140	Ni	2	9	1	1	1	3	19.0	60.0	64.6	67.3	68.2	69.1	2.0	2	3	D	69.1
141	Ni	2	9	4	3	1	1	6.0	6.0	6.0	6.0	6.0	6.0	NA	1	1	F	12.0
142	Ni	3	7	1	2	1	83	1.4	2.8	2.8	2.8	2.8	5.2	1.2	7	4	A	2.8
143	Ni	5	2	4	2	1	4	14.0	108.0	192.5	287.0	318.5	350.0	3.9	2	2	E	525.0
144	Ni	5	8	2	2	1	92	1.4	2.8	2.8	2.8	3.5	21.9	1.4	7	4	A	2.8
145	Ni	6	2	2	2	2	4	1.4	1.4	1.4	1.4	1.4	1.4	1.0	2	4	C	1.4
146	Ni	6	7	2	2	1	35	2.7	2.8	2.8	2.8	2.8	2.8	1.0	6	4	A	2.8
147	Ni	7	2	2	2	2	3	1.4	1.4	1.4	1.4	1.4	1.4	1.0	2	4	C	1.4
148	Ni	7	9	4	2	1	6	1.0	1.0	4.8	9.0	10.5	12.0	3.1	3	3	C	10.5
149	Ni	9	6	2	2	2	3	1.4	1.4	1.4	1.4	1.4	1.4	1.0	2	4	C	1.4
150	Ni	10	2	1	2	2	2	1.4	1.4	1.4	1.4	1.4	1.4	1.0	2	4	C	1.4
151	Ni	10	7	1	2	1	37	2.2	2.8	2.8	3.3	3.8	4.3	1.2	6	4	A	2.8
152	Ni	10	9	4	3	1	14	1.0	1.0	1.0	4.5	15.5	33.0	2.8	5	3	B	4.5
153	Ni	12	9	2	2	1	6	1.0	17.0	52.8	70.0	74.5	79.0	5.6	3	2	D	79.0
154	Ni	12	9	4	2	1	3	0.8	1.0	1.0	1.0	1.0	1.0	1.1	2	4	C	1.0
155	Ni	14	2	1	1	1	2	1.4	1.4	1.4	1.4	1.4	1.4	1.0	2	4	C	1.4
156	Ni	14	9	1	1	1	43	2.4	2.8	3.6	50.5	60.0	220.0	3.4	6	3	B	50.5
157	Ni	15	8	4	3	3	1	0.2	0.2	0.2	0.2	0.2	0.2	NA	1	1	F	0.4
158	Ni	15	9	2	2	1	6	1.0	1.3	4.7	10.4	12.7	15.0	3.2	3	3	C	12.7
159	Pb	1	8	2	2	1	12	8.3	23.5	59.7	131.6	166.3	200.0	3.0	4	3	B	131.6
160	Pb	2	5	2	2	3	1	0.7	0.7	0.7	0.7	0.7	0.7	NA	1	1	F	1.4
161	Pb	2	6	4	2	1	1	2.5	2.5	2.5	2.5	2.5	2.5	NA	1	1	F	4.9
162	Pb	2	9	1	1	1	4	6.0	32.4	35.3	38.1	39.1	40.0	2.4	2	3	D	40.0
163	Pb	3	6	1	2	1	25	2.8	2.8	8.3	8.4	8.4	12.3	1.7	6	4	A	8.3
164	Pb	3	8	1	2	3	6	1.0	2.0	2.8	4.5	5.3	6.0	1.8	3	4	B	4.5
165	Pb	3	8	2	2	1	12	8.3	17.7	28.5	45.0	46.1	46.9	1.9	4	4	B	45.0
166	Pb	3	8	4	2	3	46	2.7	8.3	11.8	17.3	23.3	35.2	2.0	6	4	A	11.8
167	Pb	5	4	3	1	2	4	2.0	31.5	81.0	142.2	162.6	183.0	6.7	2	2	E	274.5
168	Pb	5	5	2	2	2	2	1.3	7.6	10.8	12.6	13.3	13.9	5.3	2	2	E	20.9
169	Pb	5	8	2	2	1	87	2.8	25.1	83.1	193.1	252.3	904.0	4.3	7	2	B	193.1
170	Pb	5	10	3	2	2	5	7.0	23.4	38.5	46.4	49.1	51.7	2.5	2	3	D	51.7
171	Pb	5	11	4	3	1	3	25.0	26.0	32.5	36.4	37.7	39.0	1.3	2	4	C	37.7
172	Pb	6	2	2	2	2	4	3.1	4.9	7.4	10.2	11.1	12.0	1.8	2	4	C	11.1
173	Pb	6	8	2	2	1	38	2.8	6.0	11.0	24.1	32.2	100.7	2.4	6	3	B	24.1
174	Pb	7	11	2	2	1	10	1.0	8.1	21.5	25.6	33.9	42.3	4.3	3	2	D	42.3
175	Pb	9	10	2	2	2	6	18.1	24.4	58.4	98.1	112.4	126.7	2.2	3	3	C	112.4
176	Pb	10	6	1	2	1	31	2.8	6.9	8.3	8.3	10.5	19.3	1.4	6	4	A	8.3
177	Pb	10	8	1	2	1	10	2.8	5.5	13.3	20.6	36.8	52.9	2.5	3	3	C	36.8
178	Pb	10	8	4	3	1	8	1.0	1.0	1.5	3.0	3.0	3.0	1.7	3	4	B	3.0

Est#	Metal	AC	Content	LEV	Enc	Sup	N	MIN	P50	P75	P90	P95	MAX	GSD	N.Cat	GSD.Cat	RWC.Cat	RWC
179	Pb	10	11	4	3	1	6	1.0	2.0	3.0	40.5	59.3	78.0	5.4	3	2	D	78.0
180	Pb	12	8	2	2	1	7	1.0	8.0	70.5	131.0	155.0	179.0	8.0	3	2	D	179.0
181	Pb	12	8	4	2	1	2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2	4	C	1.0
182	Pb	12	9	4	2	1	2	30.0	55.0	67.5	75.0	77.5	80.0	2.0	2	3	D	80.0
183	Pb	14	8	1	1	1	40	2.8	12.0	24.8	43.6	67.6	127.8	2.5	6	3	B	43.6
184	Pb	14	9	1	1	1	7	15.0	150.0	420.0	522.0	576.0	630.0	3.8	3	2	D	630.0
185	Pb	15	9	2	2	1	6	1.0	1.4	10.2	18.0	20.5	23.0	4.2	3	2	D	23.0
186	Pd	1	5	2	2	1	12	8.5	9.7	9.7	9.7	9.7	9.7	1.0	4	4	B	9.7
187	Pd	2	6	4	2	2	2	0.1	0.1	0.1	0.1	0.1	0.1	1.0	2	4	C	0.1
188	Pd	2	7	4	2	2	1	0.5	0.5	0.5	0.5	0.5	0.5	NA	1	1	F	1.0
189	Pd	2	8	2	2	3	2	4.4	22.8	31.9	37.4	39.3	41.1	4.8	2	2	E	61.7
190	Pd	2	11	1	1	1	5	0.1	9.5	35.0	37.0	37.7	38.4	11.9	2	2	E	57.6
191	Pd	3	8	2	2	1	59	0.1	9.7	9.7	9.7	10.5	16.3	1.8	7	4	A	9.7
192	Pd	3	11	1	2	1	22	9.7	9.7	17.2	25.0	82.6	364.0	2.4	6	3	B	25.0
193	Pd	5	5	2	2	1	35	9.6	9.7	9.7	9.7	9.7	9.7	1.0	6	4	A	9.7
194	Pd	5	7	2	2	1	52	9.1	9.7	9.7	9.8	9.9	10.0	1.0	7	4	A	9.7
195	Pd	5	8	4	3	1	1	3.0	3.0	3.0	3.0	3.0	3.0	NA	1	1	F	6.0
196	Pd	6	10	1	1	1	38	0.2	9.7	9.7	9.7	9.7	9.7	2.7	6	3	B	9.7
197	Pd	7	11	4	2	1	6	1.0	4.5	6.5	8.0	8.5	9.0	2.2	3	3	C	8.5
198	Pd	10	5	2	2	1	8	9.6	9.7	9.7	9.7	9.7	9.7	1.0	3	4	B	9.7
199	Pd	10	8	2	2	1	7	0.6	1.0	2.0	3.2	4.1	5.0	2.1	3	3	D	4.1
200	Pd	12	10	2	2	1	6	1.0	3.0	21.8	156.0	220.0	284.0	9.2	3	2	D	284.0
201	Pd	12	11	4	2	1	5	1.0	4.2	13.0	14.8	15.4	16.0	3.8	2	2	E	24.0
202	Pd	14	11	1	1	1	45	1.0	9.7	9.7	10.6	11.0	85.0	2.0	6	4	A	9.7
203	Pd	15	11	2	2	1	8	0.3	1.6	2.4	5.1	7.6	10.0	3.2	3	3	C	7.6
204	Pt	1	5	2	2	1	12	7.3	8.3	8.3	8.3	8.3	8.3	1.0	4	4	B	8.3
205	Pt	2	6	4	2	2	3	0.1	0.1	0.8	1.2	1.3	1.4	4.2	2	2	E	2.2
206	Pt	2	8	2	2	1	5	0.4	1.0	4.0	19.4	24.5	29.6	6.4	2	2	E	44.4
207	Pt	2	11	1	1	1	8	0.2	3.0	7.5	9.0	10.1	11.2	4.2	3	2	D	11.2
208	Pt	3	5	2	2	1	58	7.3	8.3	8.3	8.3	9.2	14.0	1.1	7	4	A	8.3
209	Pt	3	8	2	2	3	1	0.2	0.2	0.2	0.2	0.2	0.2	NA	1	1	F	0.4
210	Pt	3	11	1	2	1	22	8.3	8.4	10.3	30.4	74.1	253.0	2.4	6	3	B	30.4
211	Pt	5	7	2	2	1	87	7.8	8.3	8.3	8.4	8.4	8.6	1.0	7	4	A	8.3
212	Pt	5	8	4	3	1	3	4.0	4.0	6.0	7.2	7.6	8.0	1.5	2	4	C	7.6
213	Pt	6	5	2	2	1	35	8.2	8.3	8.3	8.3	8.3	8.3	1.0	6	4	A	8.3
214	Pt	6	10	2	1	1	8	0.0	0.1	0.1	0.2	0.3	0.3	2.8	3	3	C	0.3
215	Pt	7	11	4	2	1	6	1.0	8.5	10.5	16.0	18.5	21.0	2.8	3	3	C	18.5
216	Pt	10	10	2	2	1	26	0.1	3.0	8.3	8.3	8.3	29.0	4.0	6	2	B	8.3
217	Pt	12	10	2	2	1	7	1.0	30.0	37.5	80.6	110.3	140.0	5.8	3	2	D	140.0
218	Pt	12	11	4	2	1	6	0.3	1.9	5.8	10.9	12.9	15.0	4.5	3	2	D	15.0
219	Pt	14	11	1	1	1	46	0.1	8.3	8.3	8.3	8.3	8.6	2.4	6	3	B	8.3
220	Pt	15	11	2	2	1	13	0.1	0.2	2.0	5.0	5.4	6.0	5.4	5	2	B	5.0
221	Rh	1	5	2	2	1	12	4.9	5.6	5.6	5.6	5.6	5.6	1.0	4	4	B	5.6
222	Rh	2	7	2	2	3	3	0.1	0.3	7.0	11.0	12.4	13.7	13.2	2	2	E	20.6
223	Rh	2	8	4	2	1	2	0.4	0.7	0.8	0.9	1.0	1.0	2.0	2	4	C	1.0
224	Rh	2	10	1	1	1	2	1.0	3.2	4.2	4.9	5.1	5.3	3.3	2	3	D	5.3
225	Rh	2	10	2	2	1	1	1.0	1.0	1.0	1.0	1.0	1.0	NA	1	1	F	2.0
226	Rh	2	11	4	2	1	1	0.2	0.2	0.2	0.2	0.2	0.2	NA	1	1	F	0.4
227	Rh	3	5	2	2	1	58	4.9	5.5	5.6	5.6	6.1	9.3	1.1	7	4	A	5.6
228	Rh	3	7	2	2	3	2	0.0	0.6	0.8	1.0	1.0	1.1	17.0	2	2	E	1.7
229	Rh	3	11	1	2	1	22	5.5	5.6	5.6	5.6	22.1	25.2	1.5	6	4	A	5.6
230	Rh	5	7	2	2	1	90	1.0	5.6	5.6	5.6	5.7	13.0	1.2	7	4	A	5.6
231	Rh	6	5	2	2	1	35	5.5	5.6	5.6	5.6	5.6	5.6	1.0	6	4	A	5.6
232	Rh	6	10	1	2	1	38	0.0	5.6	5.6	5.6	5.6	5.6	3.4	6	3	B	5.6
233	Rh	7	11	4	2	1	6	1.0	1.0	1.8	2.5	2.8	3.0	1.6	3	4	B	2.5
234	Rh	10	8	2	2	1	24	0.1	1.0	5.6	5.6	5.6	12.0	3.1	6	3	B	5.6
235	Rh	12	8	2	2	1	7	1.0	6.0	29.5	50.4	55.2	60.0	5.4	3	2	D	60.0
236	Rh	12	11	4	2	1	4	1.0	1.4	1.8	1.9	1.9	1.9	1.4	2	4	C	1.9
237	Rh	14	11	1	1	1	44	0.6	5.5	5.6	5.6	5.6	6.0	1.8	6	4	A	5.6
238	Rh	15	11	2	2	1	8	0.1	1.0	1.0	1.1	1.3	1.4	3.0	3	3	C	1.3
239	Ru	2	9	4	3	1	1	5.0	5.0	5.0	5.0	5.0	5.0	NA	1	1	F	10.0

Est#	Metal	AC	Content	LEV	Enc	Sup	N	MIN	P50	P75	P90	P95	MAX	GSD	N.Cat	GSD.Cat	RWC.Cat	RWC
240	Ru	5	8	4	3	1	3	1.0	3.0	7.0	9.4	10.2	11.0	3.3	2	3	D	11.0
241	Ru	7	8	4	2	1	5	1.0	1.0	1.0	1.6	1.8	2.0	1.4	2	4	C	1.8
242	Ru	10	9	4	3	1	14	1.0	1.0	1.0	1.0	19.9	55.0	2.9	5	3	B	1.0
243	Ru	12	8	4	2	1	2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2	4	C	1.0
244	Ru	12	9	2	2	1	7	1.0	2.0	13.5	55.6	79.3	103.0	6.2	3	2	D	103.0
245	Ru	15	9	2	2	1	3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2	4	C	1.0
246	Sb	1	7	2	2	1	12	2.4	2.8	2.8	2.8	8.4	15.2	1.6	4	4	B	2.8
247	Sb	3	7	1	2	1	80	2.4	2.8	2.8	2.8	2.9	4.7	1.1	7	4	A	2.8
248	Sb	5	7	2	2	1	87	2.6	2.8	2.8	3.7	5.7	11.2	1.3	7	4	A	2.8
249	Sb	6	7	2	2	1	35	2.7	2.8	2.8	2.8	2.8	2.8	1.0	6	4	A	2.8
250	Sb	10	7	1	2	1	37	2.1	2.7	2.8	2.8	2.8	2.9	1.1	6	4	A	2.8
251	Se	1	7	2	2	1	12	2.4	2.8	3.8	10.1	28.8	51.2	2.5	4	3	B	10.1
252	Se	2	5	2	2	3	1	0.9	0.9	0.9	0.9	0.9	0.9	NA	1	1	F	1.8
253	Se	2	7	1	1	1	3	7.4	13.4	13.7	13.9	13.9	14.0	1.4	2	4	C	13.9
254	Se	3	7	1	1	1	91	1.0	2.8	2.8	3.0	3.3	4.7	1.2	7	4	A	2.8
255	Se	5	2	2	2	2	2	3.3	3.3	3.3	3.3	3.3	3.3	1.0	2	4	C	3.3
256	Se	5	5	2	2	1	52	2.6	4.0	9.8	22.9	56.0	126.4	2.7	7	3	A	9.8
257	Se	5	5	3	1	2	4	1.0	21.5	36.3	36.7	36.9	37.0	5.5	2	2	E	55.5
258	Se	5	7	2	2	1	41	2.7	2.8	3.3	6.8	16.4	31.3	1.8	6	4	A	3.3
259	Se	6	7	2	2	1	39	2.7	2.8	3.0	4.1	10.4	41.4	1.7	6	4	A	3.0
260	Se	6	8	3	2	2	3	2.0	5.0	8.5	10.6	11.3	12.0	2.4	2	3	D	12.0
261	Se	7	2	2	2	2	5	3.3	3.3	3.3	3.3	3.3	3.3	1.0	2	4	C	3.3
262	Se	7	6	4	2	3	1	7.0	7.0	7.0	7.0	7.0	7.0	NA	1	1	F	14.0
263	Se	9	7	2	2	2	6	3.3	3.9	6.6	14.4	17.9	21.4	2.1	3	3	C	17.9
264	Se	10	5	1	2	1	32	2.1	2.4	2.8	2.8	3.3	3.3	1.1	6	4	A	2.8
265	Se	10	6	4	2	2	2	3.3	3.3	3.3	3.3	3.3	3.3	1.0	2	4	C	3.3
266	Se	10	7	1	2	3	2	4.0	8.0	10.0	11.2	11.6	12.0	2.2	2	3	D	12.0
267	Se	10	7	2	2	1	8	2.7	2.8	2.8	2.8	2.8	2.9	1.0	3	4	B	2.8
268	Se	12	6	4	2	1	1	2.8	2.8	2.8	2.8	2.8	2.8	NA	1	1	F	5.5
269	Se	14	8	1	1	1	49	2.0	2.8	4.4	18.4	29.2	72.3	2.3	6	3	B	18.4
270	Se	15	6	4	2	1	2	2.0	3.7	4.5	5.1	5.2	5.4	2.0	2	3	D	5.4
271	Sn	1	7	2	2	1	12	1.2	1.4	1.5	9.4	23.4	39.5	2.9	4	3	B	9.4
272	Sn	3	7	1	2	1	80	1.2	1.4	1.4	1.4	2.1	12.5	1.3	7	4	A	1.4
273	Sn	5	7	2	2	1	87	1.3	1.4	1.4	1.4	1.6	1.9	1.1	7	4	A	1.4
274	Sn	6	7	2	2	1	35	1.4	1.4	1.4	1.4	1.4	2.8	1.1	6	4	A	1.4
275	Sn	10	7	1	2	1	37	1.1	1.4	1.4	1.4	1.4	1.4	1.1	6	4	A	1.4
276	Sn	14	7	1	1	1	36	1.2	1.4	1.4	5.0	5.6	6.3	1.6	6	4	A	1.4
277	Te	1	7	2	2	1	12	2.4	2.8	2.8	5.7	13.4	22.3	1.9	4	4	B	5.7
278	Te	2	9	1	1	1	2	5.8	7.4	8.2	8.7	8.8	9.0	1.4	2	4	C	8.8
279	Te	2	9	4	3	1	1	1.0	1.0	1.0	1.0	1.0	1.0	NA	1	1	F	2.0
280	Te	3	7	1	2	1	80	2.4	2.8	2.8	2.8	2.8	4.7	1.1	7	4	A	2.8
281	Te	5	5	2	2	1	52	2.8	15.5	26.9	48.2	69.2	86.0	2.5	7	3	A	26.9
282	Te	5	7	2	2	1	38	1.0	2.8	2.8	6.5	15.3	18.3	1.7	6	4	A	2.8
283	Te	6	7	2	2	1	35	2.7	2.8	2.8	2.8	3.6	6.9	1.2	6	4	A	2.8
284	Te	7	2	4	2	1	4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2	4	C	1.0
285	Te	7	7	4	2	1	2	2.0	4.5	5.8	6.5	6.8	7.0	2.4	2	3	D	7.0
286	Te	10	5	1	2	1	29	2.1	2.3	2.8	2.8	2.8	2.8	1.1	6	4	A	2.8
287	Te	10	9	2	2	1	22	1.0	2.4	2.8	3.0	3.0	13.0	2.0	6	4	A	2.8
288	Te	12	2	4	2	1	2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2	4	C	1.0
289	Te	12	8	4	2	1	2	5.9	22.9	31.5	36.6	38.3	40.0	3.9	2	2	E	60.0
290	Te	12	9	2	2	1	7	2.0	6.0	56.0	147.8	193.4	239.0	6.4	3	2	D	239.0
291	Te	14	9	1	1	1	44	2.0	2.8	2.8	12.8	19.4	76.4	2.1	6	3	B	12.8
292	Te	15	9	2	2	1	4	1.0	1.0	1.4	2.1	2.4	2.6	1.6	2	4	C	2.4
293	Zn	1	7	2	2	1	12	1.4	2.6	9.4	33.2	58.4	87.0	4.1	4	2	C	58.4
294	Zn	2	5	2	2	3	1	0.5	0.5	0.5	0.5	0.5	0.5	NA	1	1	F	1.0
295	Zn	2	8	1	1	1	1	17.5	17.5	17.5	17.5	17.5	17.5	NA	1	1	F	35.0
296	Zn	3	7	1	2	1	80	1.3	1.4	1.8	3.7	5.5	9.5	1.6	7	4	A	1.8
297	Zn	5	7	2	2	1	1	1.4	1.4	1.4	1.4	1.4	1.4	NA	1	1	F	2.8
298	Zn	6	7	2	2	1	35	1.4	1.4	2.8	6.2	7.3	27.6	2.1	6	3	B	6.2
299	Zn	10	7	1	2	1	37	1.1	2.2	2.3	3.0	6.9	158.7	2.3	6	3	B	3.0
300	Zn	14	7	1	1	1	36	1.4	1.4	4.6	7.8	13.7	22.2	2.3	6	3	B	7.8

Est# = assessment number; AC = activity class; Content = content range during measurements; LEV = localised controls; Enc = enclosure; Sup = suppression; N = number of data points; MIN = minimum value; P50 = typical value (median value); P75 = 75th percentile value; P90 = 90th percentile value; P95 = 95th percentile value; MAX = maximum value; GSD = geometric standard deviation; N.Cat = category for number of observations; GSD.Cat = category for GSD; RWC.Cat = category for reasonable worst case; RWC = estimate for reasonable worst case; NA = not available

