Geological Materials Assessment Methodology

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METHODOLOGY FOR THE ASSESSMENT OF GEOLOGICAL MATERIALS REVISION HISTORY

REVISION DATE	SECTION	TYPE OF CHANGE	AUTHORIZED BY
June 2017	Initial Release		S. Klosterhaus
March 2018	2.3.1	Interpretation of limits of toxic metals to correspond to migration limits according to Toy Directive (DIN EN 71-3:2013-07)	S. Klosterhaus
March 2018	2.3.2	Added that testing must be in compliance with the Toy Directive (DIN EN 71-3:2013-07). Other testing procedures may be accepted at C2CPII's discretion.	S. Klosterhaus
September 2018	1.3	Clarified that some industrial by-products with geological material like composition are also defined as geological materials (e.g. coal fly ash, phosphogypsum, blast furnace slag).	S. Klosterhaus
September 2018	2.3.1	Clarified that if a geological material is a biological nutrient then it must meet the biological nutrient limits.	S. Klosterhaus
September 2018	2.3.1	Clarified that tests measuring total concentration or migration may be used to demonstrate compliance with the limits for banned and other toxic metals.	S. Klosterhaus
September 2018	2.3.1	Added that for food contact substances, food contact limits take precedence if lower.	S. Klosterhaus
September 2018	2.3.1	Added that other test methods and associated limits may be used with pre-approval from C2CPII.	S. Klosterhaus
September 2018	2.3.1	Clarified that testing for radionuclides is only required for indoor use products.	S. Klosterhaus
September 2018	2.3.1	Added an alternative to testing for radionuclides based on literature review and/or provision of historical data.	S. Klosterhaus
September 2018	2.3.2	Added information regarding the use of test method DIN EN 71-3:2013-07. Moved information regarding testing frequency from 2.3.1 to this section and clarified that it applies to all required testing.	S. Klosterhaus

March 2019	2.3.1	Added an exception to the radioactive element testing requirement for several rock types.	S. Klosterhaus
November 2019	1.3 & 2	Added an interpretation regarding the assessment of tar, bitumen, and other complex/variable fossil-derived distillation residues	S. Klosterhaus
October 2020	2.3.1	Clarified when CMRs above detection limits per VOC testing are acceptable.	S. Klosterhaus
October 2020	2.3.1	Clarified activity index differentiation between bulk and superficial materials	S. Klosterhaus

1 OVERVIEW

1.1 PURPOSE AND CONTENT

This document outlines a customized methodology for the Material Health assessment of geological materials in the Cradle to Cradle Certified Product Standard. Geological materials include all materials extracted from earth in rock or sediment form.

1.2 SUPPORTING DOCUMENTS

The following documents are to be used in conjunction with this document:

- Cradle to Cradle Certified™ Product Standard
- Cradle to Cradle Certified™ Material Health Assessment Methodology
- Any additional Cradle to Cradle Certified standard documents and methodology documents posted on the C2CPII website.

1.3 GEOLOGICAL MATERIALS

Geological materials include rocks, clays, sands, limestone, and other industrial minerals. For the purposes of this assessment methodology, geological materials also include industrial by-products such as coal fly ash, tar, bitumen, and other complex/variable fossil-derived distillation residues, blast furnace slag, and phosphogypsum that are used in place of natural geological material due to the similarity in composition. Materials derived from geological inputs, but processed in such a way that their chemical composition is fully defined and not variable, are not considered geological materials for the purpose of the C2C certification program (e.g. industrial glass, precipitated calcium carbonate, and metal alloys). Raw materials derived from rock or sediment can be part of the technical cycle, or they can return to nature as inert materials. They are not typically considered biological nutrients as they tend to be inorganic and inert, and therefore cannot be utilized by living systems. These materials provide valuable physical and chemical properties to products; however, they also provide a unique challenge to Material Health assessments. Geological materials are generally inert, yet some may pose hazards to human or environmental health. As with any Material Health assessment in the Cradle to Cradle Certified program, constituent chemical substances must be identified and evaluated to derive an overall material assessment rating.

1.4 SCOPE OF MATERIAL HEALTH ASSESSMENT FOR GEOLOGICAL MATERIALS

Like the conventional standard methodology, the Material Health evaluation is to be conducted on the chemical substances contained within each homogeneous material in the finished product as it leaves the final manufacturing facility. Geological materials have variable chemical composition and

may contain toxic metals, radioactive substances, or other compounds. To help ensure that these substances, if present, are below levels likely to impact human or environmental health, geological materials must be analyzed according to the methodology outlined in section 2.

2 DERIVING FINAL MATERIAL ASSESSMENT RATINGS

2.1 OVERVIEW

Given the lack of toxicity data and variable composition of geological materials, the conventional Material Health Assessment Methodology as applied in the Cradle to Cradle Certified Products Program would lead to 'Grey' assessments in the majority of cases. In order to not limit the use of geological materials within the Cradle to Cradle Certified program, the following methodology has been developed to assign Material Health assessment ratings to geological materials for the purpose of Cradle to Cradle certification.

2.2 INFORMATION SOURCES

The information sources for the Material Health assessment of geological materials are consistent with those used for a typical Material Health assessment. Please see the Cradle to Cradle Certified Material Assessment Methodology for a detailed description. In addition, research papers, journal articles, and technical specification/data sheets will be helpful in identifying the typical composition of geological materials.

2.3 ASSESSMENT PROCESS

2.3.1 GENERAL REQUIREMENTS

Geological materials must be assessed using the following process:

- Research on the geological material must be conducted to understand the origin, typical composition (if available), and potential presence of toxic metals and other hazardous substances. In this methodology, toxic metals are defined as antimony, arsenic, cadmium, chromium VI, cobalt, lead, mercury, nickel, thallium, tin, uranium, and vanadium.

- The geological materials must be pure and contain no other additives, colorants, or finish (e.g. coating, plating, paint). If additives, colorants, or finishes are present on the geological material then these must be assessed separately following the conventional Material Health Assessment Methodology or material-specific methodology if applicable (e.g. colorants,

polymer, or recycled content assessment methodology). This includes meeting all banned list requirements for technical or biological nutrients as relevant.

- Homogeneous materials subject to review that are or that contain geological materials as defined above, must meet the Banned List limits for geological materials per table 1.[1] The limits refer to the amount of metal or metalloid (in mg) that leaches or migrates from a sample of material (in kg) via an extraction methodology. For the purposes of this assessment methodology, the limits may also be applied to the total amount of each listed metal within the homogeneous material.

Table 1 – Banned List Limits for Geological Materials

Banned List Metal	**Banned if total concentration OR migration exceeds this limit:**
Arsenic	47 ppm or mg/kg
Cadmium	17 ppm or mg/kg
Chromium VI (not total Chromium)	0.2 ppm or mg/kg
Lead	160 ppm or mg/kg
Mercury	94 ppm or mg/kg

Tests that measure total concentration and/or the test method indicated for Category III threshold limits in the Toy Directive (DIN EN 71-3:2013-07) may be used to demonstrate compliance[2]. See testing requirements in Section 2.3.2 for further information. Exception: For food contact materials, including food contact ceramics, the relevant EU migration limits and test methods take precedence if lower than those listed in Table 1 above. Other extraction tests and associated limits[3] may be accepted at the discretion of and with pre-approval from the certification body if appropriate to the product type, use, and end of use.

- In addition to the five Banned List Metals (Table 1), the geological materials must also be tested for the presence of other toxic metals if the assessor has deemed that appropriate

[1] If a geological material is also a biological nutrient (for example, if the material abrades into the environment or is in a wet applied product), then the limits for biological nutrients (BNs), when lower, take precedence. Where the geological limits are lower, those will take precedence. Therefore, for a geological material that is a BN, the following limits apply at the homogeneous material level: arsenic: 10 mg/kg, cadmium: 2 mg/kg, total chromium: 100 mg/kg, chromium VI: 0.2 mg/kg, lead: 90 mg/kg, mercury: 1 mg/kg.

[2] For example, if the total concentration is found to be above the limits indicated, the assessor may then decide to follow up with migration testing. If migration is found to be within the allowable limits noted in Table 1, then the material is in compliance with the geological materials banned list limits. ALTERNATIVELY, the assessor may select one of the suggested methods (total concentration or migration testing) and apply the results to the assessment without being required to conduct a second test.

[3] Pre-requisites for accepting other limits: (1) Limits must have been assigned for at least those metals included in Table 1, and (2) the limits must have been set based on safety consideration relevant to the product's use and end of use as opposed to technical feasibility.

based on research to understand the material composition (see testing requirements in Section 2.3.2). If any toxic metals (antimony, cobalt, nickel, thallium, tin, uranium, and vanadium) are detected at a concentration or migration >100 ppm, the material will be assessed X, unless the metal can be shown to be embedded in stable crystal structures from which it is unlikely to leach in any intended or likely unintended use and end-of-use scenarios (this can be shown through dissolution tests, as described in section 4.3.1 point 2 of the Colorants Assessment Methodology, on the homogeneous material in the finished product). As for the banned list metals, conformance with this requirement may be demonstrated via tests that measure total concentration or via migration testing.

Note: An X-assessment due to toxic metal content will also render a material ineligible for use in products at the Silver level or above in the Material Health category if the corresponding metal has a red rating in the endpoints of carcinogenicity, mutagenicity, or reproductive toxicity (which most of them do).

- Bitumen, tar, and other complex/variable fossil-derived distillation residues must be tested for PAHs. The test method used must be able to detect the PAHs covered by REACH Annex XVII Article 50 at a minimum. If the sum concentration of tested PAHs exceeds 100 ppm the material will be X assessed and ineligible for use in products at the Silver level or above in the Material Health category.

  Bitumen, tar, and other complex/variable fossil-derived distillation residues may be associated with CASRNs that are in and of themselves associated with hazard ratings. In such cases, any hazard information available for the relevant CASRNs must also be considered and may lead to an X-assessment independent of testing. If it is clear that the mixture will receive an X-assessment and render the product ineligible for use in products at the Silver level or above in the Material Health category based on hazard information available on the mixture itself (i.e. classified as carcinogenic, mutagenic, or reproductively toxic), no analytical testing beyond the banned list metal testing must be conducted.

- For indoor use products: Homogeneous materials subject to review that are or that contain rock or stone-based material (e.g. granite, etc.) or industrial by-products defined as geological materials (e.g. coal fly ash, phosphogypsum, blast furnace slag[4]) must be evaluated for the presence of radioactive elements[5].

  These materials must be tested for the presence of radioactive elements, namely radium, thorium, and potassium 40 (K40) (see testing frequency requirements in section 2.3.2). Since radioactive elements are not listed on either the technical or biological nutrient Banned Lists,

[4] Radiological Protection Principles concerning the Natural Radioactivity of Building Materials. Directorate-General Environment, Nuclear Safety and Civil Protection. 1999. https://ec.europa.eu/energy/sites/ener/files/documents/112.pdf

[5] The material will receive an x-assessment and be limited to products certified at the Basic or Bronze levels by default if testing is not conducted OR the alternative literature review and historical data approach employed and approved by C2CPII.

the presence of radioactive elements on their own will not prevent a material from being used in a certified product.

For these materials, an activity concentration index (I), as outlined in the European Union Council Directive 2013/59/Euratom[6], must be calculated as follows:

$$I = C_{Ra226}/300\ Bq/kg + C_{Th232}/200\ Bq/kg + C_{K40}/3{,}000\ Bq/kg$$

where C_{Ra226}, C_{Th232} and C_{K40} are the activity concentrations in Bq/kg of the corresponding radionuclides in the building material. As noted in the European Union Council Directive 2013/59/Euratom[1], an activity concentration index value of 1 can be used as a conservative screening tool for identifying materials that may cause the reference level provided in Article 75(1) of the Directive (i.e., the reference level applying to indoor external exposure to gamma radiation emitted by building materials, 1 mSv a^{-1}) to be exceeded. However, the calculation of dose needs to take other factors related to the intended use of the material into account. As noted in the European Commission's technical guidance[7], the most important factor to consider is whether a material is used in bulk (e.g. concrete) or for superficial and other restricted uses (e.g. tiles, boards). For the latter material types, an activity concentration index of 6 or less will ensure the reference level of 1 mSv a^{-1} will not be exceeded. Therefore, if the index is >1 for bulk materials (e.g. concrete, bricks) or >6 for superficial materials (e.g. tiles, boards), the material will receive an "X" assessment.

ALTERNATIVE: If it can be demonstrated, based on a comprehensive literature search and/or historical data for multiple years relevant to the extraction/production locations in question, that it is highly unlikely for the activity concentration index to exceed 1 for the material in question, then testing is not required. Estimates of radioactivity at the homogeneous material level may be made in cases where the rock, stone, or industrial by-product material makes up only a portion of the homogeneous material subject to review. C2CPII will review the documentation provided and accept this alternative approach on a case by case basis.

The alternate approach has already been accepted for the materials listed below. For these materials, it may be assumed that the activity index is less than 1 without testing for

[6] COUNCIL DIRECTIVE 2013/59/EURATOM of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom

7 European Commission, 1999, Radiation protection 112 - Radiological Protection Principles concerning the Natural Radioactivity of Building Materials

radioactive elements unless there is reason to believe that the specific material under review has a high degree of radioactivity compared to the norm.

- Limestone/calcium carbonate
- Natural gypsum
- Dolomite
- Marble

This list will be extended as new comprehensive literature searches are provided and accepted.

Bitumen, tar, and other complex/variable fossil-derived distillation residues do not require testing for radioactive elements.

- If used in indoor use products, bitumen, tar, and other complex/variable fossil-derived distillation residues must undergo VOC emissions testing as described in section 3.9 of the standard (regardless of achievement level). VOC tests must be conducted at a temperature that is representative of the upper temperature limit that may be experienced by the product the material is in during the use phase. If the material fails the VOC emissions testing, it will be X-assessed. If the failure is due to one or more CMR substances being emitted above the detection limit, the material will be ineligible for use in products at the Silver level or above in the Material Health category unless they are below (0.01) x [the lower of the TLV or MAK value]. (See Guidance for the Cradle to Cradle Certified Product Standard, Version 3.1, section 3.9, sub-section titled 'VOC Emission Limits Related to Whether or Not a TLV or MAK Value is Known for the VOC of Relevance' for further information).

- If no banned metal has been detected above the allowable threshold, other toxic metals have not been detected in excess of 100 ppm (or it can be demonstrated via dissolution tests as described in section 4.3.1 point 2 of the Colorants Assessment Methodology that these metals are contained in stable crystal structures), and the levels of radium, thorium, and K40 are below the thresholds (i.e. I < 1), the following modified version of the conventional Material Health Assessment Methodology must be used to assess the substances known to be present in the material based on its typical chemical composition. With the exception of toxic metals and radioactive elements, for which the subject-to-review criteria are specified above, substances are subject to review if expected to be present in the material at a concentration of 1% or higher.

  For example, research shows that kiln fired clay bricks typically consist of the following:

  - 50 – 60% silica (sand)
  - 20 – 30% alumina (clay)
  - 2 – 5% lime
  - <= 7% iron oxide

- < 1% magnesia

In this case, all substances believed to be present above the subject to review threshold (1%) in the brick must be researched and evaluated following the conventional Material Health Assessment Methodology to see if they are associated with any known human or environmental health hazards. Relevant routes of exposure to these individual hazards are then considered. Frequently, no relevant routes of exposure may exist as assessed substances are interfused in the matrix. A common exception to this is exposure via inhalation if the materials are cut or ground during installation or use, thus releasing dust or inhalable particles.

Because of the physical nature of geological materials, toxicological data for all hazard endpoints is frequently unavailable. Therefore, the following criteria are used to assign a B, C, or X rating to the material. Note that grey ratings for hazard endpoints are permitted if the assessor has conducted a thorough review of available resources to identify any known hazards,

- If one or more hazard endpoints (other than bioaccumulation and persistence) for a substance subject to review within the material receive a red rating and there is a relevant route of exposure to the substance for the endpoint(s), the material receives an X assessment.
- If one or more hazard endpoints (other than bioaccumulation and persistence) receive a red rating and there is <u>no</u> relevant route of exposure for the endpoint(s), the material receives a C assessment.
- If no red hazard ratings have been identified, but one or more hazard endpoints (other than bioaccumulation and persistence) receive a yellow rating and there is a relevant route of exposure for the endpoint(s), the material receives a C assessment.
- If no red hazard ratings have been identified, but one or more hazard endpoints (other than bioaccumulation and persistence) receive a yellow rating and there is <u>no</u> relevant route of exposure for the endpoint(s), the material receives a B assessment.
- If no red or yellow hazard ratings have been identified, the material receives a B assessment.

2.3.2 TESTING REQUIREMENTS

The following testing procedures must be used:

- All testing must be conducted by an ISO 17025 accredited laboratory.
- Toxic metals: DIN EN 71-3:2013-07 is accepted. Sample preparation should be in accordance with section 7.3.3.1 *Coatings of paint, varnish, lacquer, printing ink, polymer and*

similar coatings: There should be at least 10 mg of material that is able to pass through a sieve with aperture of 0.5 mm. However, if it is possible to obtain 100 mg of material that can pass through a sieve with aperture of 0.5 mm from a single product, then 100 mg must be used, even if the material is not obtained from a coating. The migration procedure described in section 7.4.3.1 must be followed. To prevent interconversion of Chromium III and Chromium VI, the migration solution must be neutralized directly after the migration step.

- VOC emissions testing: follow the procedures as outlined in section 3.9 of the standard.
- Other testing procedures may be accepted at C2CPII's discretion.

Frequency: All analytical testing must be conducted at the time of initial certification, at recertification, and if or when the quarry or extraction area changes, whichever comes sooner. Note: if it is not possible to trace the material back to a specific extraction area, a minimum of three samples from three separate shipments and batches must be tested for each analyte. If there is any variability in the results, the applicant must work with the analytical testing laboratory to establish a statistical testing plan that accounts for variation in the concentrations of all target analytes and will ensure that based on the number and frequency of samples taken, compliance with the relevant thresholds can statistically be expected for all batches and shipments.