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# Use of test results from the percolation leaching test (TS3) in the framework of the Construction Products Directive

## Policy brief

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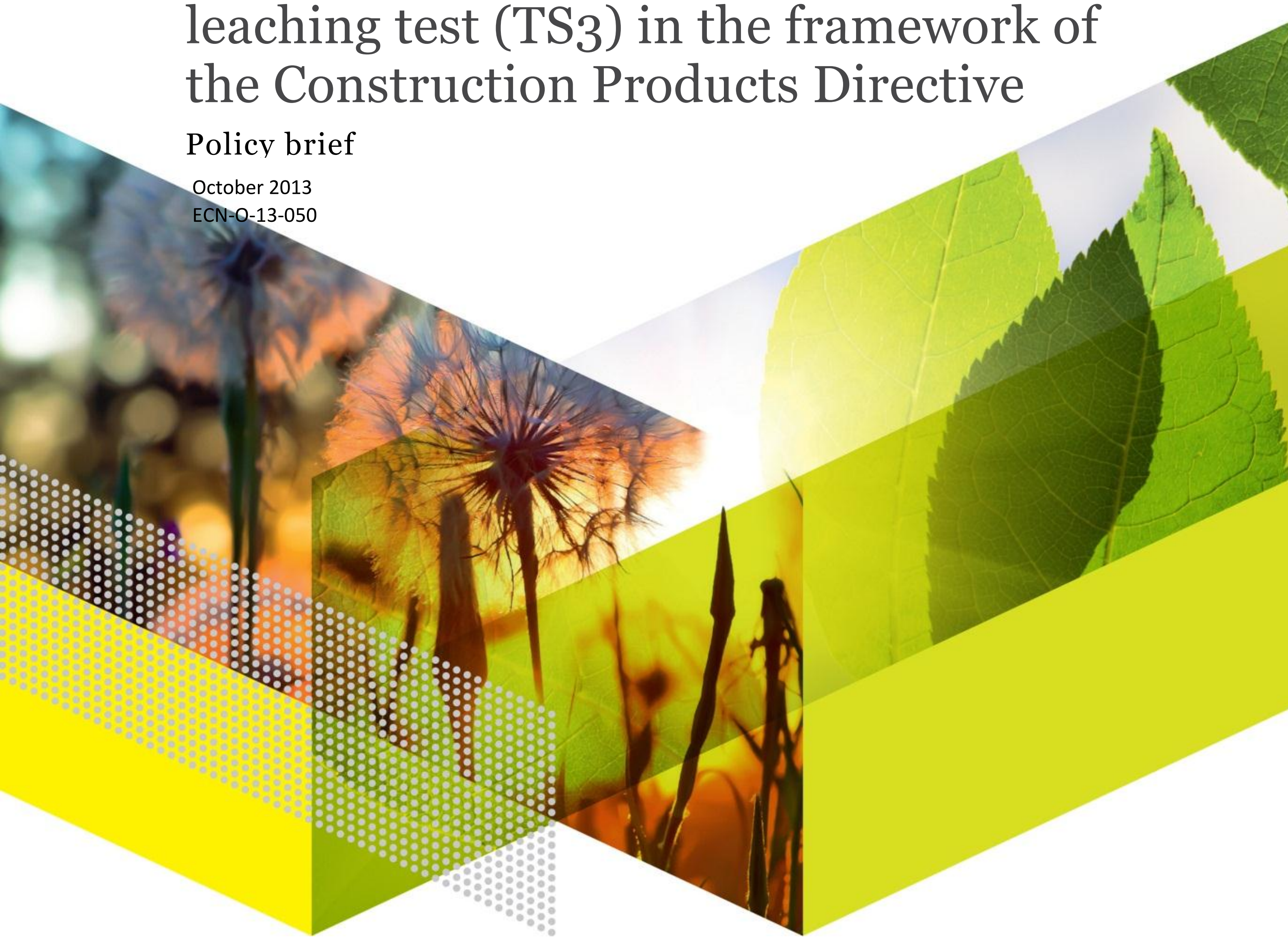

Authors: A. van Zomeren, J.J. Dijkstra, M. Mesman (RIVM), J. Spijker (RIVM), R.T. Eikelboom (IenM)

ECN Environment and Energy Engineering
P.O. Box 1
1755 ZG Petten
The Netherlands

T:+31 88 515 4768
vanzomeren@ecn.nl

ecn.nl

## Background

The enforcement of the European Construction Products Directive (and the more actual Construction Products Regulation) has led to the development of European harmonised standards for assessment of the emission of “dangerous substances” from construction materials. According to Basic Working Requirement (BWR) number 3, the emissions from construction products to soil and groundwater should not have an unacceptable impact on the environmental quality over the life cycle of the product.

In this paper the technical needs and boundary conditions of leaching tests to obtain meaningful and reliable test results are explained. Although this paper will not go into detail on “impact assessment” and the resulting development of regulatory criteria, we will show below that the technical needs and boundary conditions of a test are to some extent dependent on what type of information is needed by regulators for environmental impact assessment.

This short paper focuses on explaining the principles of testing leaching behaviour of aggregates, and briefly explains the leaching of size reduced and non-size reduced particles. It provides information for the actual discussions on size reduction before leaching testing.

## Rationale of laboratory leaching tests in general

Two types of emissions were identified as most relevant and form the basis for assessment of the emission from construction products:

- Percolation from granular products
- Diffusion from monolithic products

In principle, one wants to assess the emission of dangerous substances under a situation as close as possible to the conditions under which the products are applied ("intended use conditions"). However, construction products might have several intended uses (e.g. different applications, different climatic conditions with regard to temperature and/or infiltration, etc.) and it is impossible to develop standardised methods for assessment of release under all these conditions of use. In addition, this would greatly increase the demand for testing, declaration of performance and, hence, increasing costs for producers. Moreover, testing under intended use conditions would imply long-term experiments equal to the time frame of the material life time, which is impossible.

**Testing under intended use conditions leads to unpractical situations**

Testing under intended use conditions would lead to many different tests with different particle size ranges, temperatures, infiltration conditions, etc. (not practical, high cost, time consuming).

Therefore, laboratory leaching tests have been developed to provide answers on emission of dangerous substances in a relatively short time. Consequently, laboratory tests are not meant to mimic the use in practice (see above) but these tests should provide reproducible and "meaningful" results. These test results can form the basis for translation to release in practice to understand the short and long-term leaching behaviour in the intended use situations (impact assessment). The result of impact assessment allows for judgement whether the product fulfils BWR 3. At the same time, these test results can be reported on the Declaration of Performance.

Although part of the discussed items regarding testing and the use of test results is relevant for both granular and monolithic construction products, the remainder of this paper is focussed on granular construction products.

**“There is no single test method that can simulate release of substances under all possible intended use conditions. “**

**“Simulation” of all possible products and scenarios would lead to 1000+ incomparable test methods.**

## How to fulfil legal requirements on leaching and BWR 3?

The CPR/CPD include care for the environment by release of substances during use of a product and (CPR) in the reuse phase. The CPD/CPR leave the decision to the competent authorities (via Member States) in what cases specific requirements should be set, for which substances and which limit values, etc. However the CPD/CPR aims at harmonising the test methods used to provide the relevant data on release of products.

Impact assessment for leaching requires the use of environmental impact models to assess the short and long-term impact of emissions from construction products. These models generally use a so called “source-path-receptor” approach as is schematically given in Figure 1. This figure indicates that contact with rainwater can result in transport of leached substances from the product in an intended use towards soil and groundwater. At some point in the groundwater, the Member States need to specify the desired environmental protection level to fulfil BWR 3.

In this approach, the source term is the emission from a construction product as a function of time under intended use conditions (see Figure 2). The different aspects of the “source-path-receptor” approach are presented in more detail in Figure 2. The construction product represents the source term of the emission. Substances are emitted to the soil and reach the groundwater (receptor, point of compliance) by transport processes (path).

The laboratory leaching test results are the basis for the determination of the source term. Next, the regulators define the path of the emissions through the underlying soil system and the desired environmental protection level to environmental requirements, and so to fulfil BWR 3. The limit values can be calculated by “reverse modelling” starting at the desired environmental protection level to a maximum release of the construction product in the laboratory leaching test.

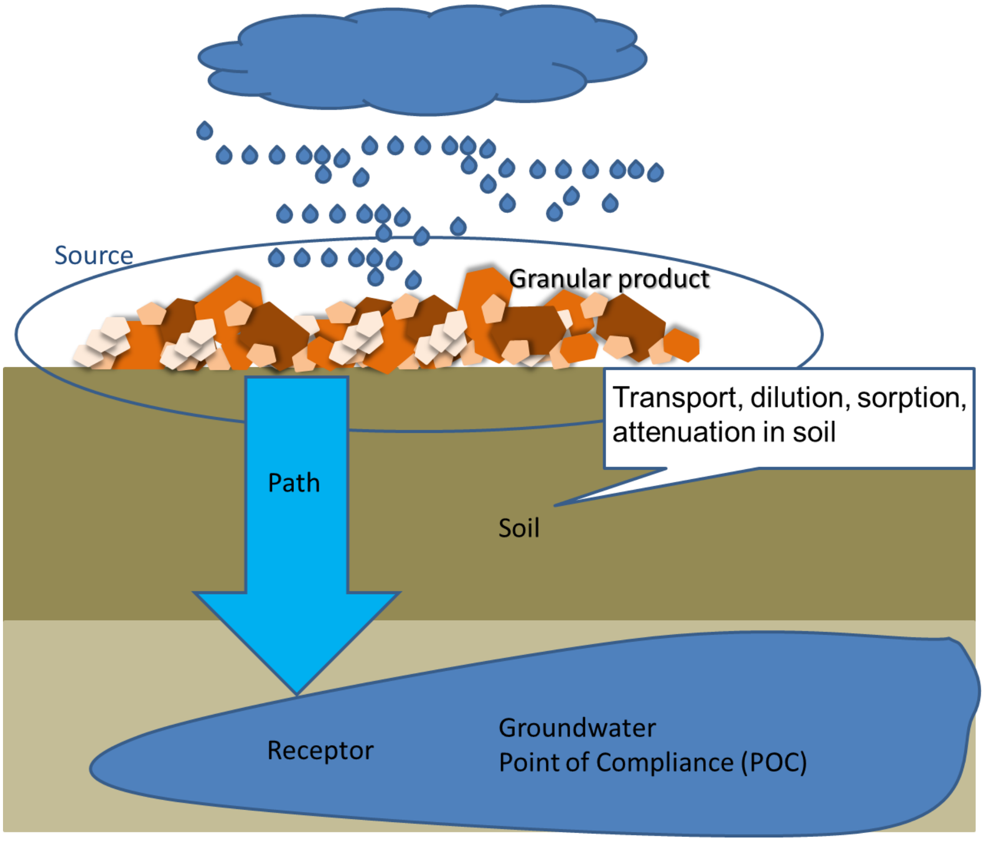


**Figure 1** *Generic representation of an intended use scenario of a granular material and the so called Source, Path and Receptor approach that is a basis for impact assessment*

**Test result needs to be translated to source term and scenario for impact assessment**

It is important to note that the test result itself cannot be translated directly to an environmental impact (i.e. compared to limit values in groundwater) e.g. because the effect of the soil (adsorption/desorption processes over time) that is on the route between source and target ("path") is always influencing the burdening of the groundwater, and so should always be taken into account.

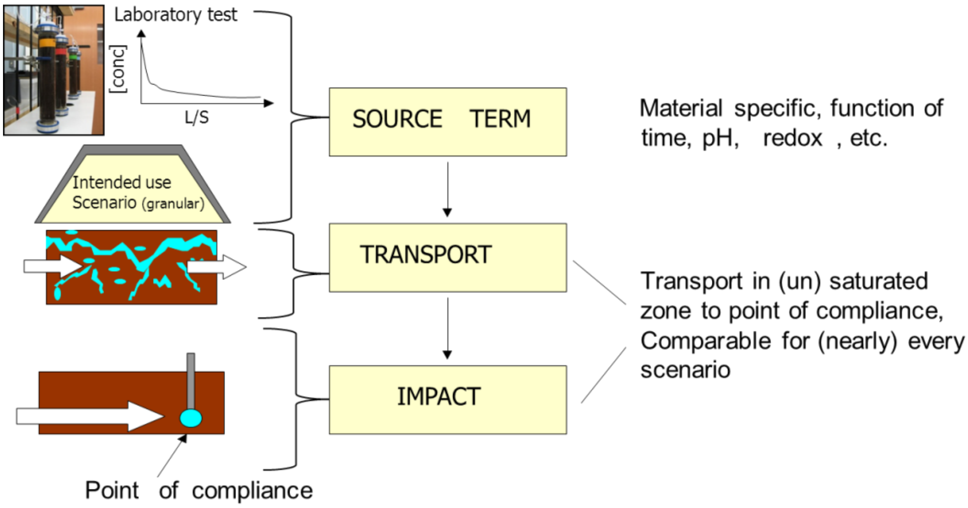


**Figure 2** *Overview of generic approach for impact assessment of granular construction product applications*

## When is a test result "meaningful"?

Test results are considered "meaningful" when the results are understandable (not conditional) and allow a sound interpretation of the test result, e.g. to translate it to a variety of practical conditions. If the results are dependent on a unique combination of flow rate, particle size, and column dimensions, the results are considered "conditional". If results are conditional, their meaningfulness for practice is minimal, because the result is only representative for the conditions chosen in the test. In that case, one will never know whether the test provides an over- or underestimate of the release in practice. When the test result is, on the contrary, understandable (not conditional), one can make a sound interpretation of the test result, and translate it to a variety of practical conditions. Conditionality for percolation tests on aggregates is best avoided when the test is conducted under local equilibrium conditions (see below).

## Why is testing "as it is" not technically preferable?

The above mentioned considerations on the necessity to obtain "meaningful" test results imply that the percolation leaching test should be conducted under (near) local equilibrium conditions (which includes a constant ratio between concentrations in the solid and the liquid phase). Basically, this means that the percolation test results should be independent of test conditions such as particle size and the flow rate (i.e. the contact time). This situation is achieved when local equilibrium is attained during the test.

If the flow rate in the test is too high (i.e. the contact time is too short), there will be no equilibrium and an unknown part of the leachable fraction will not be released in the test. The percolation test is not suitable to specify diffusion characteristics. The test conditions should then be adjusted to assure local equilibrium.

Similar effects occur when the test is performed with particles that are too large under the prevailing flow rate (or contact time) conditions. These large particles are not in equilibrium with the water flow and emission is then also mainly driven by diffusion processes. The effects of contact time for fine and coarse particles on the achievement of equilibrium conditions is schematically represented in Figure 3.

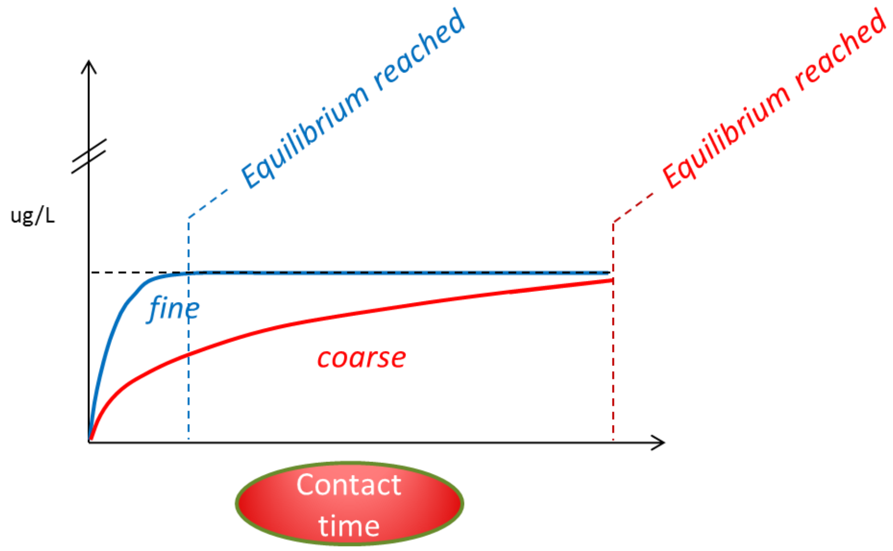


**Figure 3** *Schematic representation of contact time needed to reach equilibrium condition for fine and coarse particles*

In principle it should be possible to attain local equilibrium in a percolation test with products containing a significant part of large particles, but that would require a lower flow rate, resulting in a longer test duration. Small particles (< 4mm) attain equilibrium relatively quickly and ensure local equilibrium under test conditions, even at higher flow rates (shorter test duration). As a result, the emission of dangerous substances as measured in a test with small particles provides a conservative estimate of the potential release, in comparison with test results generated under conditions with large particles and/or relatively high flow rates which might result in an underestimation of the potential release.

**"Local equilibrium" implies that concentrations do not increase further**

- Local equilibrium provides a reference level of release that can be used for impact assessment (possible corrections for non-equilibrium in the field, wet/dry, rainfall, open or closed etc.);
- Results based on local equilibrium rarely are an underestimate and are not over-conservative;
- A test that is not in local equilibrium can be an (unknown!) over- or underestimate; in that case no correction is possible for longer or shorter contact times in impact assessment (only arbitrary);
- Results obtained without equilibrium conditions are unique for particle size / flow rate: multiple testing is needed to cover ranges in grain sizes for one product.

## Does "testing as it is" provide advantages for producers?

Since test results of products tested "as it is" are just linked to the size distribution as investigated, the results are only valid for the specific "as it is" particle size distribution. When the same product is marketed in several different grain size distributions, this practice may result in the need for multiple testing to cover all products (increasing test costs).

Also, it is a widespread misconception that "local equilibrium" in the test is automatically a "worst case" scenario for the predicted release under intended use conditions. In the wide variety of intended use conditions, there are many conditions in which it can be safely assumed that local equilibrium is established and this should be accounted for in order to comply with BWR 3. For instance, any application which is partly water saturated and water replacement is relatively small, contact times are long enough to establish local equilibrium conditions. Moreover, the larger the application (several meters), the longer the average contact time of percolating rainwater and, hence, the closer the release will be to local equilibrium.

Any signs that chosen test conditions will generally not lead to local equilibrium in the test, will be a strong incentive for regulators to correct the result of the test in the estimation of the source term used for impact assessment, and hence, for emission limit values of construction products. This will be the case for at least those intended uses that are evidently in local equilibrium as outlined above.

The recent results of the Robustness validation of the percolation test (TS3) revealed that the use of large particles can lead to approximately up to a factor 1.5-5 lower emissions (depending on the material and the substance) in comparison with test results obtained under local equilibrium conditions. These factors might be a starting point for such corrections. However, it should be noted that the effect of small and large particles on the emission in the test varies with the product and the substance.

Moreover, even the same product can show variations in particle size distribution when these are within the specified normal range of aggregates for a certain intended use, as specified in a product standard. A risk for producers would be that the emissions of their products are partly unnecessarily corrected.

## Conclusions

- Because laboratory tests have to provide answers on short and long-term leaching behaviour (expressed in years) in a relatively short time (expressed in weeks), these tests are not meant to mimic the use in practice. Therefore, these tests should provide reproducible and "meaningful" results that can form the basis for translation to release in practice to judge whether the product fulfils BWR 3. At the same time, these test results can be reported on the Declaration of Performance.

- The percolation leaching test should be conducted under (near) local equilibrium conditions to produce meaningful results that also have a relation with the impact assessment and resulting limit values. Local equilibrium is best and fastest achieved when size reduction is applied.

- In principle it should be possible to attain local equilibrium in a percolation test with non-size reduced coarse particles or products containing a significant part of large particles ("testing as it is"), but that would require a lower flow rate, resulting in a much longer test duration (and higher costs). Depending on the amount and size of coarse particles in a product the test duration may increase with many months till even years.

- A laboratory leaching test on crushed material can be performed with smaller equipment than testing on material "as it is", leading to less work for the laboratory and lower costs.

- Testing and declaration of performance for products without size reduction ("as it is") requires separate test procedures for each marketed product size distribution. This is more expensive and so not automatically advantageous for producers. When size reduction is applied, a whole product range (in terms of marketed grain size distributions) can be tested with a single test to declare performance.

- The desired environmental protection level to fulfil BWR 3 is set by the regulators and is based on a "source (test result), path, receptor" approach. It is important to realize that the test result itself cannot be used directly to understand the environmental impact (i.e. when directly compared with limit values in groundwater) because the effect of the soil (adsorption, desorption, etc.) that is on the route between source and target ("path") should also be taken into account.

- Regulators usually develop legislation with limit values and other criteria that cover a wide range of conditions of use. This requires test results that are valid over a wide range of conditions (i.e. test results can be used as input for different intended use conditions). If test results would only be valid for specific conditions of use, setting of general legal requirements is not possible; the final consequence would be a site/application specific evaluation based on case by case approval or permitting systems.

- The advantage of a single test standard with a single type of test result to be declared is that a single test result can be used for comparison with (possibly) different regulatory criteria, and different intended use scenarios, in all EU Member States.