

SHORT LEACHING TEST COMPARED TO A COLUMN LEACHING TEST FOR INTERNAL QUALITY CONTROL OF COAL BOTTOM ASH

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ABSTRACT

In an internal quality control system, necessary to obtain environmental certification, it is possible to use a short leaching test. It is desirable to use short leaching test procedures instead of the Dutch regulatory column test (NEN 7343) which lasts over 21 days. Therefore, a study is performed comparing the leaching results of coal bottom ash from the column test by two short leaching test (first step cascade test, NEN 7349, and the CEN 292 WG 2 compliance test). The CEN test method is a possible short test to replace the column test.

1 INTRODUCTION

Coal bottom ash is mainly used as a granular building material in road constructions. To guarantee its use as construction material it is necessary to comply to the immision demands of the Dutch Building Materials Decree. For granular materials the immision demands must be tested by measuring the emission from a column test (NEN 7343). The column test procedure lasts over 21 days. This long test procedure gives problems because big lots of bottom ash have to be stored before it can be used. There is not always enough room at the power station to store these big lots.

In the Building Materials Decree it is possible to use environmental certificates. To obtain this certificate an internal quality control procedure must be used. It is possible to use short test procedures in this internal quality procedure as long as the test results can be translated to the test results of the column test (Lamers, 1997).

The Dutch fly ash corporation has started a study to the possibility of using a short leaching test for examining the emissions from coal bottom ash.

First, the first step of the cascade test (NEN 7349) was studied. The cascade test is a single stage batch test at liquid to solid (L/S) ratio of 20 l/kg; it lasts for 23 hours. For many years the cascade leaching test (NEN 7349) has been used for the quality control of bottom ash and many leaching data from this test are available.

There is a great deal of experience with this test procedure in the laboratories of the power stations. Therefore, it seemed attractive to use the first step of the cascade test as short test.

Results of the cascade test study indicate that statistical correlations can not be found because of external factors influencing the test results. This is further described under "cascade test".

It was decided to study the possibility of another test, the CEN 292 WG 2 test (CEN test). The CEN test is a two stage compliance test which is completed within 24 hours. In theory the CEN test is more comparable with column test. The CEN test procedure that was used consist of a two stage test and the final L/S solid ratio ($L/S = 10$) is the same as the column test. Furthermore, by using the CEN test for quality control of bottom ashes the power plants will follow European developments.

For a good statistical comparison, it is important to know the reproducibility of the different test procedures. Therefore, first the reproducibility of both the column test (NEN 7343) and the CEN test (CEN 292 WG 2 compliance test) procedures was studied. The results of this study are described under "CEN test".

2 CASCADE TEST

2.1 Method

The first step of the cascade test (NEN 7349) was studied as a possible short test procedure. The first step of the cascade test is a single stage batch procedure at L/S 20 for 23 hours. The leaching results of 15 column tests where compared with results of the first step of the cascade test (KEMA, 1996a). The column test and chemical analysis were performed at the laboratory of KEMA, while the cascade test and chemical analysis were performed at laboratories of the power stations.

The leaching of potential critical elements Se, Mo, Ba, V, SO_4 and Sb was measured. These elements are potential critical as was found in earlier column test results (Lamers, 1997).

2.2 Results

It was not possible to relate leaching results of both tests. In figure 1 an example is given of the Se leaching data from coal bottom ash percolated from the column test and from the cascade test. Sometimes more Se is leached in the cascade test and sometimes more Se is leached in the column test.

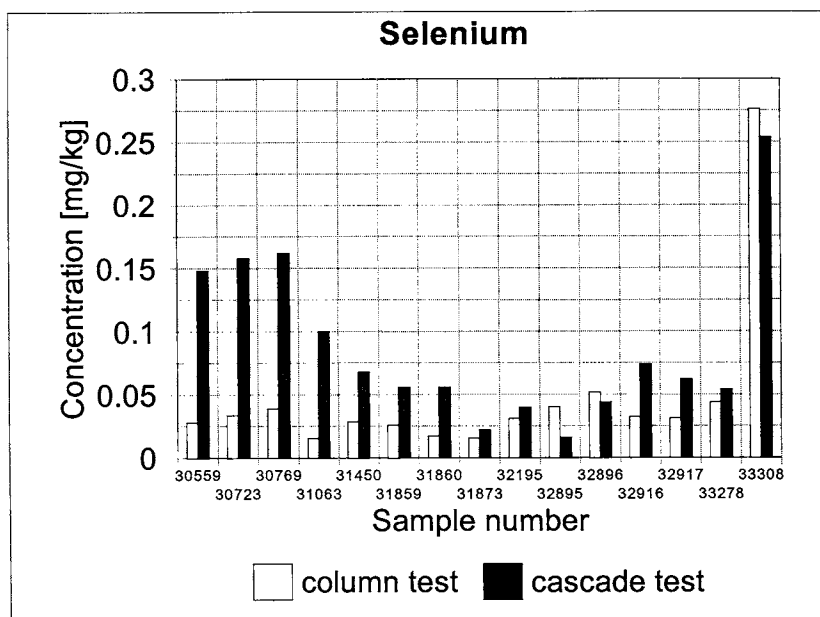


Figure 1 Leaching of Se from 15 coal bottom ashes in the column test and in the cascade test

Both the difference between the tests and external factors can cause differences between the test results. Differences in test procedures which can cause differences in the amount of element leached are:

- leaching time
- percolation versus shaking
- pH differences
- differences in L/S ratio and
- reproducibility of test procedure.

External factors which can cause differences in the amount of element leached are

- aging processes (the test were not always performed at the same time)
- pH differences (caused by aging or by heterogeneity in the sample)
- test performances at different laboratories
- different methods for analysing the percolate and
- sampling and sample handling.

In the cascade test results many external factors could have influenced the results. There are not enough test results to perform a good statistical analysis. For a good statistical evaluation it is important to decrease the number of external factors which can influence the results. It is also important to know the reproducibility of the test.

3 **CEN TEST**

3.1 **Method**

The two stage batch test of the CEN 292 WG 2 was studied as a possible short test (KEMA, 1996b). The test procedure consists of a two stage test at L/S 0-2 for 6 hours and at L/S 2-10 for 18 hours.

To test the reproducibility 10 column tests and 10 CEN test were performed at one bottom ash sample. 20 Kg bottom ash sampled according to NVN 7302 was dried at 40 °C for 24 hours. The sample was divided in 10 subsamples and these samples were crushed and sieved. All particles were smaller then 4 mm. Each subsamples was split into two parts.

One part was submitted to a column test and the other part to a CEN test. For comparison the fractions of the column test were combined to two fractions: L/S 0-2 and L/S 2-10. In the percolates the pH and electrical conductivity were measured. The percolates were analyzed for the critical elements Se, Mo, Ba, SO₄ and Sb.

3.2 Results

The leaching of Sb was in all samples below detection limit and was not further considered.

The deviation in the chemical analysis, based on the accuracy of the analysis, was compared to the deviation in the whole test result. The deviation in the analysis was smaller than the deviation in test, which indicates that the deviation in the analysis can be neglected. As an example the Se test results with their analytical deviation (triangles) are shown in figure 2.

In figure 2 also the emission demands of the Building Materials Decree are given for an application height of 1,5 m, which is considered the maximum height of utilization of coal bottom ash. The average leaching concentration of Se is 0.026 mg/kg which is below the emission demand of 0.036 mg/kg. One column test result gave a Se leaching concentration which was above the emission demand. Se was leached from the CEN test at higher concentrations than from the column test.

Heterogeneity of the subsamples can also change the test results, however no extremes were measured among the 10 different tests.

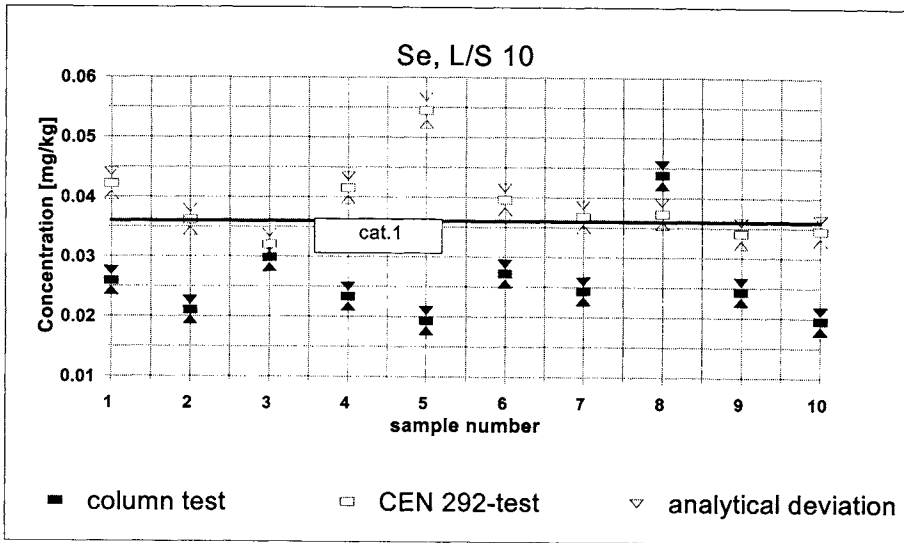


Figure 2 The concentration and analytical deviation of Se leached from the column test and the CEN test. The calculated emission demand for utilization as cat 1 from the Building Materials Decree is indicated as a straight line

The repeatability of a leaching test can be expressed by the variation coefficient. In the testing protocol for the Building Materials Decree it is assumed that the total variation coefficient of the measurement including sampling errors, sample preparation, analysis and the performance of the leaching test is 25% (RIVM, 1995).

For most of the elements leached from the bottom ash we measured a variation coefficient < 20% in both tests. Only the variation coefficient for Se in the column test was 28% and for Mo was 27%. For regulatory purposes, it is possible that the variation coefficient becomes even higher, because in that case the variation of sampling and sample preparation will also be included. Se is the most critical parameter for coal bottom ash. This implies that a higher amount of bottom ash is falsely rejected than was expected in the testing protocol.

Relation of the column test and the CEN test

All experiments were performed on the same bottom ash sample. Therefore, no statistical correlation between the results of column test and the CEN test can be found (there is only one point). The test results at different fractions (L/S ratio 0-2 and 2-10) are plotted in figure 3, to obtain an idea of the correlation of the two tests. Except for sulphate, the reliability (r^2) of the lines is above the 50%. The slopes indicate that, except for Ba, the concentration leached from CEN test are higher than leached from the column test. The correlation lines start almost from the origin, that indicates that the leaching is linear at increasing L/S ratio.

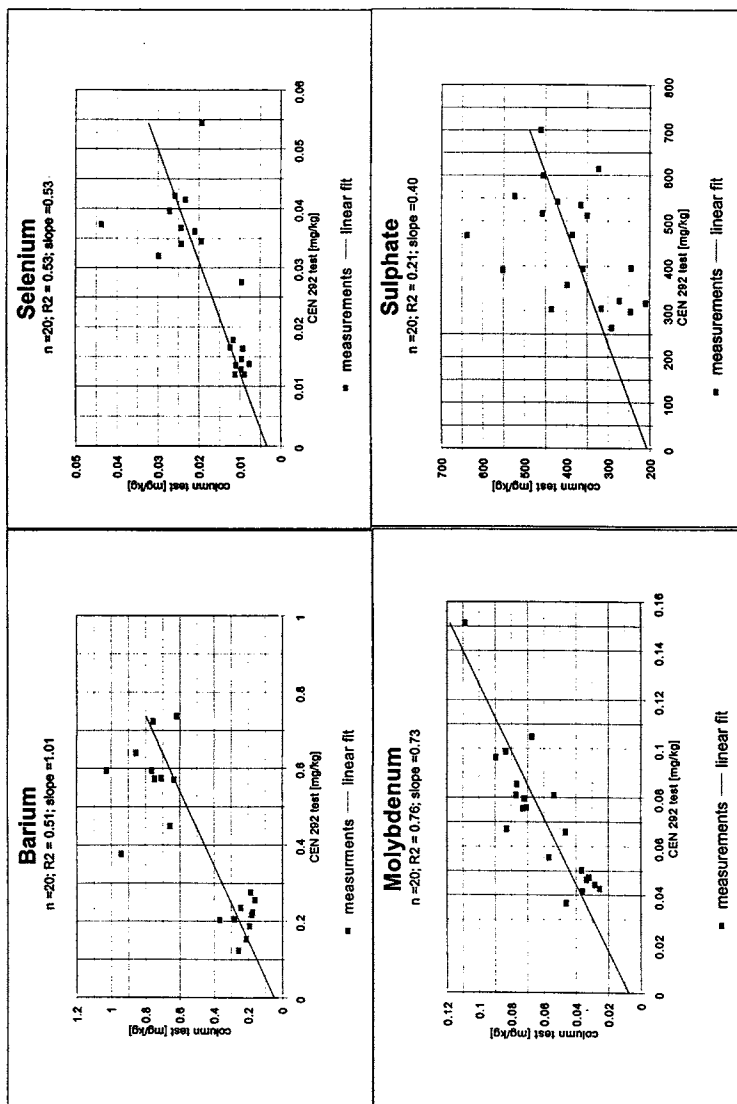


Figure 3 Leaching from the column test at L/S 0-2 and L/S 2-10 compared to leaching in the CEN test at the same fractions

3.3 Discussion on leaching mechanism

In general, to be able to apply short tests it is important to understand the leaching mechanism of the construction material. Leaching is dependent on many factors. The most common leaching mechanisms is leaching controlled by the availability of the elements and leaching controlled by solubility or sorption processes (van der Sloot, 1996). The leaching mechanism will determine the test results. Leaching controlled by the availability is mainly dependent on L/S ratio, whereas leaching controlled by solubility or sorption is mainly dependent on pH. Factors such as aging and sample handling are important when the leaching concentration is controlled by the pH. The L/S ratio in a test controls the amount of leaching at an availability controlled mechanism.

Field leaching studies are helpful in revealing the underlying leaching mechanism. In another study the leaching from coal fly ash in the field is studied by using lysimeters. In this study both the hydrology and the transport of elements have been monitored starting from 1993 (Meij and Schaftenaar, 1994). The collected data is used to model the leaching process in which both the hydrology and chemical reactions are considered.

The results indicate that the leaching of Se from coal fly ash is availability controlled and can be modelled by a linear sorption model, whereas the leaching of Ba is solubility controlled. Figure 4 shows a comparison between the barium solubility and the barium concentration (transposed to the activity of Ba^{2+}) in the pore water over 44 months of natural weathering. The resemblance between the Ba activity and the solubility line of barite indicates that barium leaching is solubility controlled.

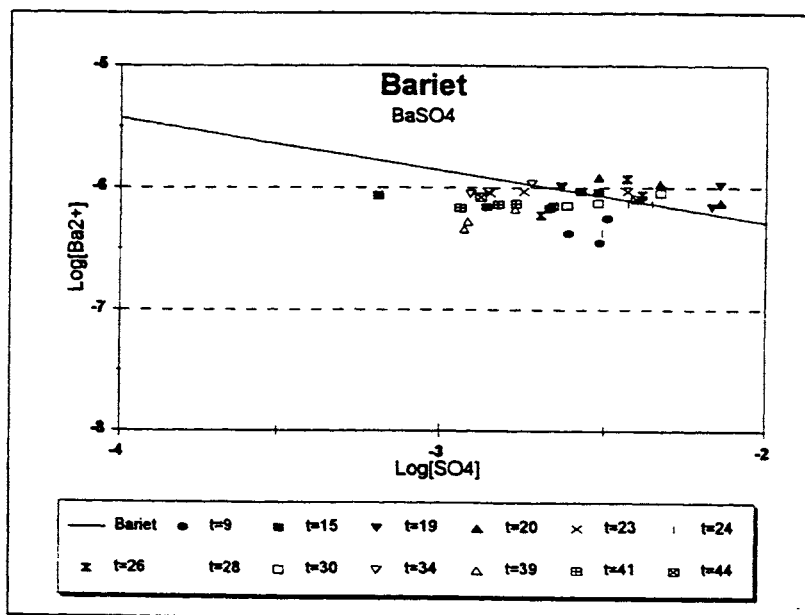


Figure 4 Activity of barium and sulphate calculated with MINTEQA2 in the pore water of a lysimeter filled with coal fly ash and compared with the solubility of Bariet

Leaching models can be helpful in translating short batch test results to results into the results of characterization tests such as the column test.

3.4 Conclusion and further research

The CEN test method seems to be a possible short test to replace the column test for internal quality control. In order to perform a good statistical analysis, it is necessary to obtain a representative data set of both column test and CEN test from coal bottom ash. Special care has to be taken for sampling, sample handling and test performances.

Knowledge of the underlying leaching mechanism can be used in translating the test results from short batch tests to results from characterization tests.

At this moment a study has started to obtain a representative data set. Figure 5 shows the first results of this study. In figure 5 the results of Se leaching from different bottom ashes from 5 different power stations as measured with the CEN test are compared with the results of the column test. The results indicate a good correlation between the two tests.

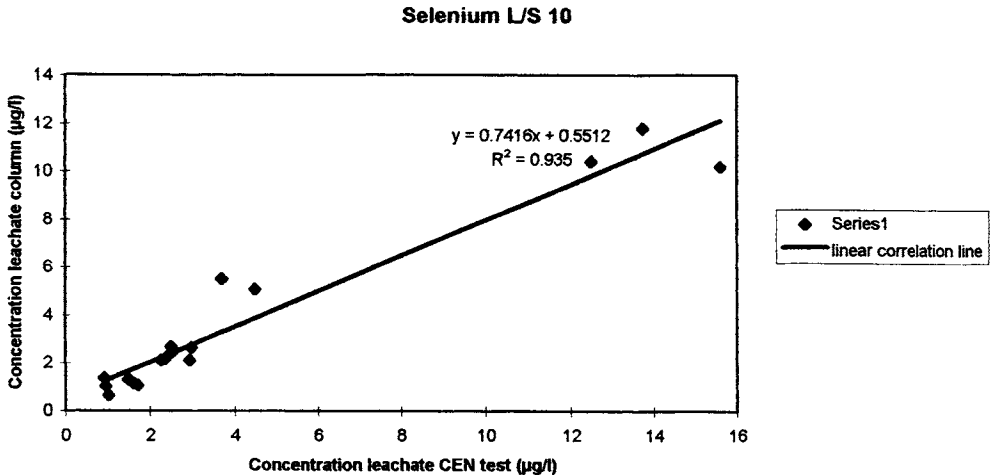


Figure 5 Correlation between the leaching of Se from the CEN test and from the column test from different coal bottom ashes

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