GRANULAR BENTONITE PRODUCTION AS BUFFER MATERIAL FOR A FULL-SCALE EMPLACEMENT ("FE") EXPERIMENT

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Introduction

In the Swiss repository concept for the disposal of spent fuel (SF) and high-level waste (HLW), the canisters are emplaced in galleries surrounded by a bentonite buffer. These engineered barriers with favourable and well-known properties and predictable performance provide the secondary containment of the waste. The bentonite buffer has the following functions: a) to keep the canisters in place and protect them by homogenising the stress field; b) to mechanically stabilise the space between the canisters and the geological barrier; c) to act as a transport barrier for radionuclides and as a barrier for colloids; d) to ensure low corrosion rates of both the canister and the waste form and e) to limit microbial activity. In order to provide these functions, it is necessary for at least a significant part of the thickness of bentonite not to be altered in an unacceptable way by temperature or chemical interaction with the formation water or corrosion products of the canister.

The FE experiment ("Full-Scale Emplacement Experiment") at Mont Terri URL, which develops and demonstrates on a 1:1 scale of the Swiss repository concept for disposal of SF and HLW in Opalinus Clay, is supported by the LUCOEX project (2011-2014), co-funded by the European Commission (EC) as part of the seventh Euratom research and training Framework Programme (FP7) on nuclear energy.

In this poster, a strategy based on previous experiences and the production concept based on current technology for producing a granular bentonite is presented.

Objectives for the production of granular bentonite

The main objectives of manufacturing granular bentonite for the LUCOEX/FE project are as follows:

- Production of a suitable grain size distribution of the granules in order to achieve a target emplacement density (required bulk dry density is 1450 kg/m^3) and homogeneous emplacement (de-mixing during the emplacement process will be prevented with a with a multi-auger device);
- Optimization of different parameters during the production process (e.g. grain dry density, water content, grain size distribution and grain shape);
- Evaluation of rational production processes for the production of suitable granular material;
- Development and standardization of verification- and QA-measures with regard to the requirements a) after production and b) after emplacement of the granular bentonite material.

Experience gained in previous experiments

The raw material which Nagra decided to use for the FE experiment is the Wyoming bentonite. The sodium-bentonite MX-80 is delivered in a conditioned, slightly granulated state to improve the pourability and pelletizing. During the pelletization process of the bentonite, an increase of the bulk grain dry density from 1.33g/cm^3 to 2.10g/cm^3 with a simultaneous reduction of the porosity can be achieved (e.g. ESDRED and GAST[i]). However, the angular shape of the coarse particles obtained from the production process is not ideal. It is well understood that rounded aggregates exhibit higher bulk density than angular shaped aggregates which are subject to bridging effects. In previous Nagra investigations, an enhancement in bulk density could be verified by a subsequent rounding process, lea[i]ding to better pourability and compactibility. For the ESDRED Project the rounding was therefore carried out in situ by blowing the granular bentonite under air pressure through a 200 m long steel pipe with conventional shotcrete equipment. A side effect of this method was an adjustment of the grain size distribution to the Fuller curve and thus an optimisation in terms of the highest possible bulk dry density. Subsequent large-scale emplacement tests with granular bentonite using a twin auger system showed that an emplacement dry density of approximately 1500 kg/m^3 could be reached (e.g. ESDRED).

For the previous experiments the water content of the raw material was reduced to ca. 5% by further drying. The same granular bentonite produced for ESDRED was re-used in the PEBS project after 5 years storage without significant water uptake and a similar emplacement dry density was reached.

Neither rounding processes nor drying was performed during the production of the granular bentonite for GAST project. Emplacement tests with the auger system showed emplacement densities well below the target value of 1.45 g/cm^3.

Comparing the grain size distributions of the granular bentonite used for ESDRED/PEBS and for GAST with the Fuller curve allows for specific adjustments through the production process of granular bentonite needed for the FE experiment.

Production technique

Starting from the raw material delivered in big bags the production of granular bentonite at J. Rettenmaier & Söhne GmbH + Co KG (Germany) can be described as follows:

- Compaction of the raw material with the objective to obtain the maximal grain dry density;
- Crushing, rounding and sieving the product into 3 single fractions;
- Blending of all single fractions to be able to reach a final grain distribution as close as possible to the prefixed target (mixing system with friction adjustment via variable adjustable rotation speed and duration of the mixing step);
- Performing QA measures on site (measurement of grain dry densities with a geo-pycnometer, determination of grain size distributions)
- Deliver the final product in air tight big bags to prevent water uptake through air humidity (quality assurance).

Acknowledgments

Research leading to these results has received funding from the European Atomic Energy Community's Seventh Framework Programme (FP7/2011-2014) under grant agreement n° 269905.

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[i] GAST (Gas-Permeable Seal Test), currently under construction at Grimsel URL.