

Recutting at a planned barrier site of the Asse Salt Mine (Photo: Annette Parltitz)

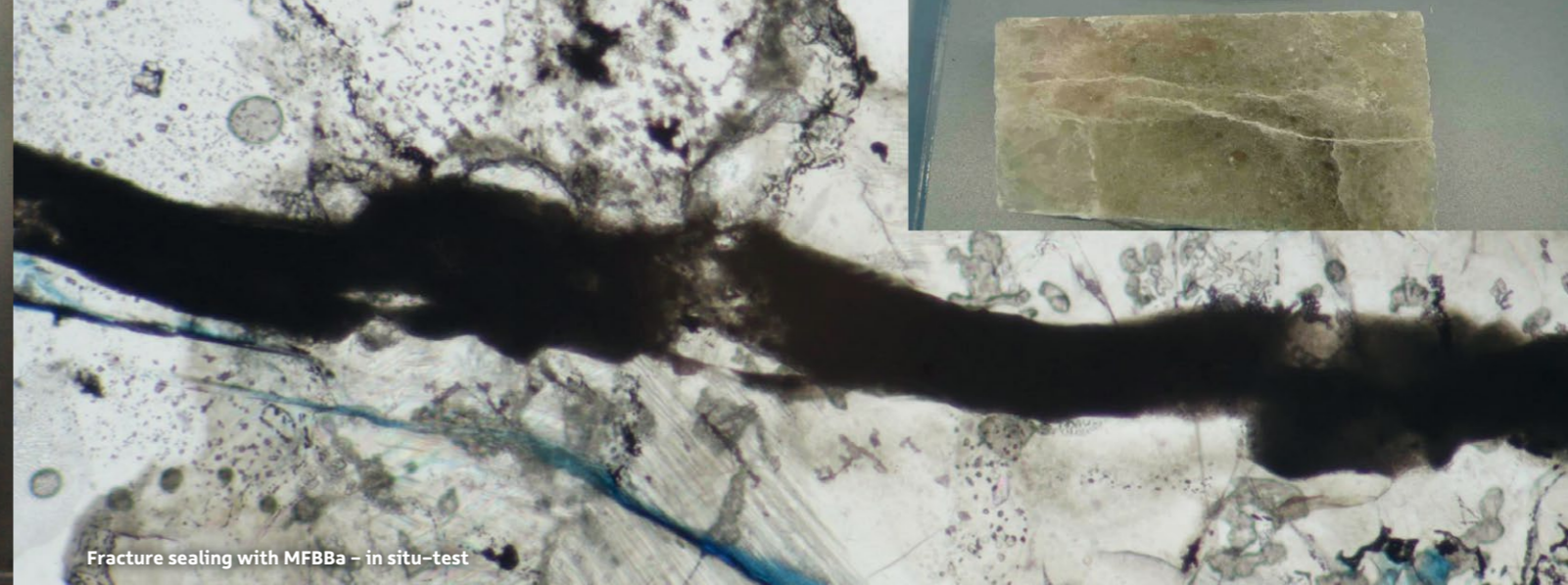


BGE TECHNOLOGY GmbH

- SUPPORT OF RWM'S "SEALING SITE INVESTIGATION BOREHOLES" PROJECT
- BUILDING MATERIALS FOR SEALING AND INJECTION MEASURES AT THE ASSE MINE
- SEALING OF EXPLORATORY BOREHOLES IN THE GORLEBEN AND ASSE SALT MINES
- CONCRETE SEALING ELEMENTS EXPOSED TO HIGH TEMPERATURES



Visitors from RWM and the John Wood Group Plc (UK) at the Asse salt mine



Fracture sealing with MFBBa – in situ-test



The exploration of a repository site requires a number of exploration drillings both from the surface and underground. Some of them have lengths of several hundreds of meters. All these boreholes have also to be sealed. For example, exploratory boreholes at the Gorleben site have been properly sealed, with special focus on long-term stability, low permeability, and complete filling. The experience gained in such tasks was used for instance to support RWM's "Sealing Site Investigation Boreholes" project.

Dear Readers,

A key factor for long-term safety in a repository system is the development and quality assured implementation of the Engineered Barrier System (EBS). Man-made openings in a repository mine like shafts and ramps may act as potential pathways for fluids between the repository and the biosphere and have thus to be sealed. In the last two decades, BGE TECHNOLOGY GmbH has been involved in the development and the implementation of backfilling measures and sealing systems for repositories in different host rocks, both nationally and internationally. Some examples of this work are compiled in this newsletter.

Within the scope of the emergency plan to minimise the consequences of excessive brine inflow into the Asse mine, BGE and BGE TECHNOLOGY GmbH jointly developed backfilling and construction materials and designed and constructed seals. The challenge was to develop a material recipe that guarantees long-term stability and compatibility with the host rock, has a low permeability, and that at the same time ensures workability for long times. Suitable site-specific solutions have been developed and tested.

We continuously work on optimising the scientific and engineering tools for sealing material application in repository mines. Several months ago, we were commissioned by the Federal Ministry for Economic Affairs and Energy (BMWi) with the R&D project UVERSTOFF, which is an analysis of the impact of high temperatures on concrete structures.

BGE TECHNOLOGY GmbH's work on the design and optimisation of engineered barriers will be fundamental for a safe long-term enclosure of radioactive waste in a repository.

Happy reading!

Nina Müller-Hoeppe
Head of Repository Safety Department
BGE TECHNOLOGY GmbH

Support of RWM's "Sealing Site Investigation Boreholes" Project

Site investigations of deep geologic repositories (DGR) require a large number of exploration drillings in order to obtain information about the geological situation. Drillings are also to be performed during DGR construction, operation, and closure. However, the boreholes are also potential flow paths for liquids and gases. To ensure long-term safety, an effective sealing of the boreholes is thus very important. The tightness of the borehole seals depends on the properties of the sealing material, its bonding to the rock, and the quality of the adjacent rock zone. Adequate preparatory measures, the use of optimised sealing materials and technical equipment as well as sophisticated quality assurance measures ensure the proper performance of the seals.

BGE TECHNOLOGY GmbH has carried out these tasks for many years, always using its extensive practical experience, e.g. from the construction of drift seals, to optimise the work results.

Due to our extensive expertise in this field, Radioactive Waste Management (RWM UK), commissioned a consortium with Wood Group PLC as leader and BGE TECHNOLOGY GmbH as one of the partner organisations with the project "Sealing Site Investigation Boreholes". The aim is to demonstrate the successful sealing of boreholes at potential DGR sites in the United Kingdom. This project will not be restricted to theoretical concepts but will lead to full-scale demonstration tests of borehole sealing in different host rocks, so that specific solutions will be developed. Recently, employees of RWM and John Wood Plc

visited the Konrad mine, the Morsleben repository, and the Asse mine to gather information about the state of the art in drilling technology and the sealing of boreholes.

Building materials for sealing and injection measures at the Asse Mine

For more than a decade, BGE and BGE TECHNOLOGY GmbH have gained experience in the planning and construction of drift seals (= flow barriers) at the Asse mine. In order to guarantee long-term chemical stability and compatibility with the host rock, these drift seals are made of magnesium oxychloride concrete. The concrete consists of magnesium oxide (MgO) and crushed salt mixed with magnesium chloride solution. Due to its high reactivity, the workability time of the concrete is short and the transportability distance of the mixtures is limited to several hundred meters. Consequently, concrete production has to be done underground with a semi-mobile plant.

To ensure that the concrete is produced according to the requirements, the quality assurance measures focus on the control of the parameters of the components and on the production process. The delivery notes of the components are checked routinely. In the laboratory, the grain size distribution, the density, and the water content of the solids, the reactivity of MgO, and the chemical composition of the mixing solution are investigated. During the production process, the density, the air void content, the temperature and temperature evolution, the electric conductivity as well as the flow velocity of the mixture in a flow channel are measured.

Increasing fineness and reactivity of the MgO and increasing temperatures cause a decrease in the workability and setting times of the concrete. The initial temperature of the mixture corresponds to the temperature of the raw materials. The temperature of the mixture increases due to the shear effects during mixing and pumping and due to friction during hydraulic transport.

As the Asse mine has been operated for more than 100 years, a large number of boreholes have to be sealed in order to avoid that fluids bypass the drift seals. Because borehole diameters are much smaller than drift diameters, concretes with coarse salt aggregates cannot be applied for borehole sealing measures. Thus, a fine-grained and highly flowable MgO-mortar – called IM-Asse-1 – was developed, which is based on the same components as the magnesium oxychloride concrete in order to ensure compatibility of the building materials. To optimise the material properties, experts of BGE TECHNOLOGY GmbH modified the proportions of the mortar components. Moreover, the different production and processing conditions of concrete and mortar were taken into account. In the case of borehole sealing, it has to be considered that the borehole itself induces friction on the mortar suspension. The shear stresses



Salt crushing installation at the Asse salt mine

and the resulting increase in temperature could affect borehole sealing if the length of the borehole is not taken into account. Fortunately, the lengths of the boreholes that compromised the drift seals did not lie in a range that required special measures. By now, several hundreds of boreholes have been sealed.

The so-called injection material MFBBa 17/3/30 completes the family of MgO-based building materials. During material development, a part of the MgO was replaced with magnesium hydroxide (brucite) in order to ensure sufficient workability time. Barite instead of salt aggregate is used as long-term stable inert filler. Again, the solids are mixed with MgCl₂-rich brine. This way, the injection material is compatible with MgO-concrete and -mortar. The grain sizes of the solid components are extremely fine and the mixture fulfils the requirements of very fine binders. As a result, the material seals tiny fractures, has a low permeability, and a pot life that allows its application under typical in-situ conditions.

From the emergency measures at the Asse mine, a lot of practical knowledge has been gained in applying MgO-based building materials in order to achieve high quality sealing results in salt mines.

Sealing of Exploratory Boreholes in the Gorleben and Asse Salt Mines

After completion of the Gorleben salt dome exploration, seven exploratory boreholes remained open in the mine. Due to their high volumes, great lengths, and the high requirements on their long-term tightness, sealing of these boreholes posed a major challenge.



Borehole injection work in the Gorleben salt mine

For reasons of long-term stability, it was decided to use magnesia binder as sealing material, and for reasons of efficiency, a tried and tested recipe was adapted to the needs. Nevertheless, this recipe could not be used to fill the largest and longest boreholes. Consequently, a new recipe had to be developed and tested. Experts of BGE TECHNOLOGY GmbH prolonged the workability time (pot life) of this material significantly by changing the type of magnesium oxide binder and by optimising its calcination process in consultation with the producer. The second part of the work focused on adapting the material properties by adjusting the proportions of the components. Innovative was the use of cooled magnesia binder in order to lengthen the pot life and to avoid thermal stresses, which could lead to cracking during hardening.

All tests and the sealing of the boreholes were accompanied by a sophisticated quality assurance programme in order to guarantee smooth running of the work and to demonstrate that the property requirements were met. The measurement results clearly showed that all exploratory boreholes could be successfully sealed. Due to the very positive experience gained in Gorleben, it was decided to use this mixture for sealing the boreholes in the Asse II salt

mine. For a first sealing measure, the material was mixed above ground and transported in tanks to the job site on the 700-m-level. This procedure, which required an extremely long pot life, was a first for high-quality magnesia binders. Finally, it was decided to use the mixture as reference material for the sealing of further boreholes that are planned for exploring the position of a new mine shaft at the Asse mine.



Borehole endoscopy – set MgO-concrete of a drift seal and surrounding rock salt (red arrows mark the interface)

Concrete sealing elements exposed to high temperatures

On behalf of the Federal Ministry for Economic Affairs and Energy (BMWi), the Project Management Agency Karls-

ruhe (PTKA) assigned the R&D project UVERSTOFF to analyse the impact of high temperatures on concrete constructions in a repository to BGE TECHNOLOGY GmbH.

Drift sealing measures are planned in every repository concept in all host rocks. Some elements of the sealing systems are made of different types of concrete. These elements are often categorised as mass concrete structures. When designing the sealing systems, the hydration heat during concreting must be taken into account in order to avoid thermally induced cracks. By now, many investigations have been carried out, and results concerning the construction phase of mass concrete structures are available.

All necessary steps to model temperature evolution and to acquire the data for model parametrisation are known. In the case of heat-generating high-level radioactive waste and spent fuel, sealing elements close to the waste will be exposed to a significant temperature increase. Although it is well known that concrete shows a thermally-activated behaviour even if it is hydrated to a high degree, systematic investigations are missing. The research work carried out within the scope of R&D project UVERSTOFF is to close this gap.

For further information, visit www.bge-technology.de or scan the QR code below.



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