



Stabilising mine workings with pfa grouts

Environmental Code of Practice

Since the 1970s, hundreds of thousands of cubic metres of disused underground mine workings have been successfully stabilised by filling with grouts based on pulverized-fuel ash (pfa) and Portland cement in order to prevent surface collapse. Similar volumes of disused workings will need to be filled in coming years as pressure grows on land for development. Pfa is particularly favoured for such work as it is cost-effective, technically effective and consumes a nationally available and abundant by-product.

However, concerns have been expressed over the potential for contamination of controlled groundwaters by bleed water and leachate released from pfa grout, disruption and dust arising from the work and the effect on land and property prices, and the risk of subsequent classification of the land above the mine workings as being contaminated.

This Code of Practice on the use of pfa grouts for filling disused underground mine workings addresses these concerns by providing guidance on the selection of environmentally compatible and cost-effective materials and techniques, with authoritative guidance on good practice. The information and guidance is based on information in the literature, laboratory studies carried out at BRE, data from the use of pfa grouts and expertise from an industry steering group.

A detailed report describing an in-depth laboratory study carried out at BRE to assess the leaching characteristics, permeability and physical properties of pfa grouts at different levels and from different sources, is included on the accompanying CD Rom in pdf format. It draws on considerable field experience, and includes a review of groundwater risk assessment models and a specification for mine infilling works. (See overleaf)

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Executive summary

1. **Introduction** (Background, Pfa production and use, Advantages of using pfa grouts in remediation works, Potential contamination of groundwater)
2. **Overall assessment methodology**
3. **Conceptual model for the release of leachates to groundwater** (Background, Source-pathway-receptor concept, Water quality limits)
4. **Preliminary risk assessment** (Overall preliminary risk assessment)
5. **Simple risk assessment** (General, Leachate composition and required dilution factors, Extent of leachate dilution available from groundwater, Estimation of dilution factors, Assessment of risk)
6. **Complex risk assessment** (Conceptual model for complex risk assessment, Groundwater risk assessment models)
7. **Assessment and characterisation of the site** (Introduction, Size of void, Hydrogeology, Groundwater)
8. **Assessment of material properties** (Introduction, Assessment of pfa/cement grout mixes, Materials variables that can be used to control release from pfa grout)
9. **Engineered measures for minimising contamination of controlled groundwater** (Control of the groundwater regime, Engineered barriers)
10. **Guidance on site practice** (Safety, Nuisance, Storage of materials, Grout mix, Backfilling boreholes, Cost of filling operations)
11. **Guidance on environmental monitoring during and after filling** (Approaches to monitoring, Monitoring groundwater – quality and flow, Groundwater monitoring devices)
12. **Assessment of other risks associated with the use of pfa grouts** (Events potentially leading to environmental risk, Risk screening)
13. **References**

In addition to the Code of Practice a detailed Technical Report is included in pdf format on a CD Rom included with this publication. It describes an in-depth laboratory study carried out at BRE to assess the leaching characteristics, permeability and physical properties of grouts made using different levels of pfa addition, and the effects of using pfa from different sources. Also included on the CD Rom are four supplementary documents:

- A review of groundwater risk assessment models
- Leaching tests
- Long-term effects of pfa grouts on the environment
- A sample specification for mine infilling works.

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LABORATORY AND FIELD DATA FOR PFA GROUTS

Technical Report (BRE Report 220192)

- 1. Introduction**
- 2. Test methods, raw materials and mixes studied** (Test methods, Materials, Compositional variables studied)
- 3. Properties of wet grout and compressive strength development** (Flow characteristics, Compressive strength, Bleeding tests)
- 4. Permeability, pH and conductivity measurements** (Permeability, pH measurements, Conductivity measurements)
- 5. Leaching** (Sample preparation, Results, NRA tests)
- 6. Field data**
- 7. Conclusions**
- 8. References**

Appendices. Tables, Graphs, Graphs of element concentration v No of sample volumes permeated for all elements, NRA test results, Field data

134 pages

SUPPLEMENTARY DOCUMENTS

- 1. Groundwater risk assessment models** (Remedial Targets Methodology (P20), Key features of the groundwater modelling capability, ConSim, The RBCA tool kit for chemical releases, BP RISC, AEA Technology approach)
- 2. Leaching tests** (Background, Maximum leachable tests, NRA leaching test, NEN 7341 leaching test, Water Research Unit (WRU) leaching test, CEN procedure, DIN 38414 S4 leaching test, Limitations of maximum leachability tests, Percolation tests, Triaxial permeation leaching tests, Lysimeters)
- 3. Long-term effects on the environment** (Background, Impact on ecology, Classification of materials and land after filling)
- 4. Sample specification for mine infilling works** (*General specification:* General description of the works, Site location and description, Brief site history, Geology, Ground investigations, Method statement, General requirements, Site control and safety. *Particular specification for mine stabilisation works:* General requirements mine stabilisation works, Layout of boreholes, Area of treatment, Naked lights, Drilling and pressure grouting procedure, Exploratory open-hole drilling procedure to locate mine shafts, Drilling and pressure grouting procedure for abandoned mine shafts and adits. *Noise control*)

36 pages

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