



Working Report 2009-64

# MANU - Purchase of Bentonite - Process Description

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The conclusions and viewpoints presented in the report  
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## **MANU - PURCHASE OF BENTONITE - PROCESS DESCRIPTION**

### **ABSTRACT**

The aim of this study is to describe the entire bentonite purchasing process accurately. This will enable efficient and focused use of information related to the purchasing phase and to each individual bentonite batch. This work continues from the work started in the report by Ahonen et al. (2008), Quality Assurance of the Bentonite Material, Posiva Working Report 2008-33.

The current work includes a short enquiry for all relevant and at the time known producers or re-sellers of bentonite. Questions about relevant products suitable for civil engineering use, more specifically nuclear waste disposal site use, were asked together with test methods, typical test results and test standards.

The following aspects and opinions have been processed from the results that were obtained during the project. Each seller/producer has a quality management system, QMS (typically ISO 9001), and ability to perform the basic tests, but there is not an established common set of properties to be tested. Some producers are willing to test according to customers' specifications. Posiva could arrange a network of capable laboratories to carry out tests according to its selected standards. This activity should then be accredited with a reasonable testing volume.

Before starting the purchase of bentonite at a large scale, Posiva should go through negotiations and audits with each seller in order to make sure that both parties are testing with the same methods and both understand the range where the values of key parameters may lie. A database is needed for gathering statistically relevant information from the bentonite material parameters over the long run. This is needed for determining the limits within which the material parameters should remain in order to be acceptable. Posiva is encouraged to create a process to optimize the test types and the amount of tests should be identified for immediate and long term use. This process ensures the required quality and costs involved.

**Keywords:** bentonite; purchase; quality assurance; bentonite producers; re-sellers

## **MANU - BENTONIITIN HANKINTA - PROSESSIKUVAUS**

### **TIIVISTELMÄ**

Hankkeen tavoite on kuvata hankintamenettely niin tarkasti, että kaikki hankinnassa tarvittavat tiedot sekä yksittäiseen erään liittyvät tiedot saadaan käyttöön tehokkaasti ja keskitetysti. Tämä projekti laajentaa ja tarkentaa raportissa Ahonen et al. (2008) tehtyä työtä.

Tässä selvityksessä lähetettiin tiedossa olleille bentoniitin tuottajille ja jälleenmyyjille kysely, jossa tiedusteltiin mitä soveltuvia tuotteita heillä on erityisesti loppusijoitusta ajatellen. Lisäksi kysyttiin käytettyjä testimenetelmiä, tyypillisimpiä testituloksia sekä käytettyjä standardeja.

Projektissa todettiin kaikkien tuottajien käyttävän jotain laatustandardia (tyypillisesti ISO 9001) sekä heillä olevan kapasiteettia tehdä perustason testausta bentoniiteille, mutta yhtenäistä tapaa näiden testien suorittamiseen ei vielä ole määritelty. Osa tuottajista tekee testauksia ostajien määrittämien speksien mukaan. Posiva voisi luoda akkreditoitun laboratorioverkoston, joka kykenee suorittamaan heidän tarpeidensa mukaisen testauksen riittävällä volyymilla.

Ennen suurien bentoniittimäärien hankintaa tuottajat tulee auditoida ja heidän testimenetelmiensä yhdenmukaisuus valittuun standardiin olisi hyvä tarkistaa. Lisäksi on varmistuttava siitä, että tärkeimpien parametrien vaihtelurajat ovat hyvin valmistajan tiedossa. Parametrien tilastollista käsittelyä varten tulee luoda tietokanta, jonka avulla voidaan tehdä pidemmän aikavälin tarkasteluja ja analyysseja. Bentoniitin alkuperän varmentamiseksi tulee myös luoda menetelmä, tällainen voisi esimerkiksi olla laboratoriotuloksiin perustuva yksilöllinen sormenjälki tai valtuutetun edustajan käyttö louhoksilla. Hankinnassa tarvittavien testien tyypit ja määrä tulee optimoida sekä lyhyille että pitkille aikaväleille tarkasteltuina, jolloin tarvittava ominaisuudet ja kustannukset ovat hallittavissa.

**Keywords:** bentoniitti; hankinta; laadunvarmistus; tuottajat

## TABLE OF CONTENTS

ABSTRACT  
TIIVISTELMÄ

1.	INTRODUCTION .....	2
2.	BACKGROUND .....	3
3.	METHOD OF IMPLEMENTATION.....	4
4.	CONTACTS.....	5
5.	RESULTS .....	7
	5.1 Questioner .....	7
	5.2 Findings.....	10
6.	DOCUMENTS .....	11
7.	QUALITY .....	12
	7.1 Purchasing .....	12
	7.2 Producer.....	12
	7.3 Authorities .....	13
8.	SUMMARY .....	14
9.	RECOMMENDATIONS.....	15
	REFERENCES .....	16
	ANNEXES .....	17
	ANNEX 1. PURCHASE INSTRUCTIONS .....	18
	ANNEX 2. QUALITY REQUIREMENTS FOR THE BENTONITE .....	21
	ANNEX 3. TEST METHODS.....	23
	ANNEX 4. SUMMARY OF INFORMATION GIVEN BY PRODUCERS .....	25
	ANNEX 5. ORDER FORM .....	31
	ANNEX 6. REQUEST FOR QUOTATION.....	32

## 1. INTRODUCTION

The aim of this study is to describe the purchasing process in such detail that all information necessary for acquisition together with information of the delivered batch will be available in an efficient fashion. This work continues from the earlier aspects reported in Ahonen et al. (2008) on the Quality Assurance of the Bentonite Material.

The purpose of the current work is to:

- describe and list the information needed in the purchasing process
- create an example of a purchasing document – an example form containing all possible alternatives
- create a checklist for purchasing: producer, re-seller, contact person, country of origin, type and properties of bentonite
- list the relevant bentonite properties in the purchasing process: bentonite type (sodium/calcium), mineral compositions, moisture content, etc.
- clarify the responsibility issues concerning both transport and acceptability
- produce a list of required quality control documents (including the producer and the batch in question)
- describe the minimum level of producer's quality control results (tests and number of tests) and audit of the producer's quality management system
- describe the acceptance tests: what is done, when and by whom
- describe the quality audit of the possible Finnish or Swedish testing organizations.

## 2. BACKGROUND

This work aims at helping the personnel purchasing bentonite to choose the supplier/producer, suitable product and to define and specify the relevant properties in the order. The bentonite purchased will be used either for manufacturing buffer blocks or tunnel backfill material.

For small amounts of bentonite, with specific and mainly scientific use in research projects, the requirements can be different from those used when purchasing large quantities over long periods of time. In the latter case one must also be ready to change the supplier in case of quality deviations or other reasons.

The ordered bentonite has to fulfil certain requirements for key properties. This ensures that the material meets the functional requirements in short and medium scale tests and in the repository space for long timeframes. Most requirements for the purchased product arise from these functional properties, like permeability and durability. SKI Report (2004) lists the following functional requirements: hydraulic conductivity, gas permeability, swelling pressure, deformability, filtration properties and thermal conductivity. All these properties must be fulfilled simultaneously and in general they depend on the composition, density and water content of the material.

Bentonite is quite an expensive material and it is reasonable to ensure that only valid material is purchased.

It should be remembered however that bentonite is a natural material containing inherent variations in all its properties (despite processing made by the producer of the bentonite) and thus the user is either forced to verify the quality of the bentonite with accurate procedures or to allow this inherent variation to some degree by creating such manufacturing processes and criteria with no risk for the final use in the repository conditions. To be able to adjust the limits, a database of material properties needs to be established.

### **3. METHOD OF IMPLEMENTATION**

This work was started by sending a short enquiry to all relevant and at the time known producers or re-sellers. Questions about relevant products suitable for civil engineering use, more specifically nuclear waste disposal site use, were asked together with test methods, typical test results and test standards. The aim was to gather this information and check it against the work done earlier in Ahonen et al. (2008).

Handling the obtained information turned out to be challenging because the producers or re-sellers do not use similar properties to describe their products. This is naturally partly due to the wide use of bentonite in different types of industries (foundry, forest, litter).

This work was limited to bentonite used in civil engineering earthworks and nuclear barrier products.

## 4. CONTACTS

During the project, contacts were made to organizations and individuals mentioned in the list below.

- Purchasing department/VTT and Kauppatalo Hansel Oy:
  - Possible methods to define the purchased material
  - Responsibility of cargo/at sea and in harbour
  - Response from Kauppatalo Hansel Oy was:
    - reasonable demands or quality limits can be set
    - mutual agreement is most probably useful
  
- Bentonite producers and contact persons:
  - Ashapura Minechem Ltd ([www.ashapura.com](http://www.ashapura.com)): Ronak Mehta ([ronak@ashapura.com](mailto:ronak@ashapura.com))
  - Star Bentonite Exports ([www.starbentoniteexports.com](http://www.starbentoniteexports.com)): ([bipin@starbentoniteexports.com](mailto:bipin@starbentoniteexports.com))
  - Cetco Lining Technologies (AMCOL International Corp.): Piotr Wojewoda ([piotr.wojewoda@cetco.pl](mailto:piotr.wojewoda@cetco.pl))
  - S&B Industrial Minerals GmbH/IBECO (<http://www.ibeco.com>)
  - Beijing Research Institute of Uranium Geology, China National Nuclear Corporation, P.O. Box 9818, Beijing 100029, P. R. China: Yuemiao Liu ([liuyuemiao@yahoo.com.cn](mailto:liuyuemiao@yahoo.com.cn))
  
- Bentonite re-sellers in Finland:
  - SP Minerals Oy Ab ([www.spm minerals.fi](http://www.spm minerals.fi)): Nina Piippo ([n.piippo@spm minerals.fi](mailto:n.piippo@spm minerals.fi))
  - De Neef Finland Oy ([www.deneef.fi](http://www.deneef.fi)) (S&B Industrial Minerals GmbH/IBECO): Pekka Salmenhaara ([pekka.salmenhaara@deneef.fi](mailto:pekka.salmenhaara@deneef.fi))
  - Kaitos Oy ([www.kaitos.fi](http://www.kaitos.fi)) (Cetco Lining Technologies, [www.cetco.com](http://www.cetco.com)): Tomi Neva ([tomi.neva@kaitos.fi](mailto:tomi.neva@kaitos.fi))
  - Minelco Oy ([www.minelco.com](http://www.minelco.com)): Kari Laukkanen ([minelco.oy@minelco.com](mailto:minelco.oy@minelco.com))
  - Cemex Oy (no www -address): Juha Lundgren ([juha.lundgren@cemex.fi](mailto:juha.lundgren@cemex.fi))
  - Oy Lux Ab ([www.lux.fi](http://www.lux.fi)) (S&B Industrial Minerals GmbH/IBECO): Lasse Nybergh ([lasse.nybergh@lux.fi](mailto:lasse.nybergh@lux.fi))
  - Oy Beijers Ab ([www.beijers.fi](http://www.beijers.fi)) - only planning to import bentonite
  
- Other bentonite re-sellers:
  - Askania Ab, Sweden ([www.askania.se](http://www.askania.se)): Martin Leman ([m.leman@askania.se](mailto:m.leman@askania.se))
  - Dasico A/S, Denmark ([www.dasico.dk](http://www.dasico.dk)): Pirjo Mäljä ([dasico@dasico.dk](mailto:dasico@dasico.dk))
  - Rotek A/S, Denmark ([www.rotek.dk](http://www.rotek.dk)): ([mail@rotek.dk](mailto:mail@rotek.dk))
  - Minelco Ab, Sweden ([www.minelco.com](http://www.minelco.com)): Peter Esko ([peter.esko@minelco.com](mailto:peter.esko@minelco.com))
  - Cebo Holland BV, The Netherlands ([www.cebo.com](http://www.cebo.com)): Fred Blomsma ([f.blomsma@ceboholland.nl](mailto:f.blomsma@ceboholland.nl))
  - China - several companies: not contacted.

Available bentonite product types were asked to be identified (possibilities: powder, granulate, pellet, sodium/calcium, natural, acid activated, ion-exchanged). Table 1 contains known producers or re-sellers with corresponding trademarks and quarries/sources.

Orders of bentonite with well-specified properties would need an agreement between the producer and the customer to be achieved with documents with request for quotation, technical specifications, and submission of the order.

## 5. RESULTS

### 5.1 Questioner

The results received for the enquiries sent and from other sources have been gathered in Tables 2 and 3. Table 1 shows the contacted companies. The questions were listed in the following order:

- Materials available for specified purposes (nuclear repository use):
  - Trademarks (for certain use or industry)
  - Quarries/sources (raw bentonite, spatial variability)
  - Homogenized/non-homogenized (process, quality control, storage)
  - Market of the product: civil engineering/environmental, oilfield services, minerals, etc.
  
- Tests carried out to determine the parameter values and deviation needed:
  - Typical tests done by the producers and the customers
    - index and geotechnical properties (preliminary list)
      - water content
      - gradation
      - swelling index
      - liquid limit
      - absorption (ability to absorb water)
    - mineralogy and chemistry
      - smectite content (total) and montmorillonite content
      - (semi)quantitative mineral composition
      - chemical composition
      - CEC - cation exchange capacity
      - MBI - methylene blue index
  - Test methods used and expression of measurement uncertainty for each method.
  
- Test standards used in testing
  - See Table 2 and Table 3 - standards, in-house methods, others.

**Table 1.** Contacted, known bentonite producers and re-sellers and their trade mark products.

Producer or re-seller	Trade mark(s)/Country of origin - stated by re-seller
S&B Industrial Minerals GmbH	Ibeco Seal GE/Georgia, Ibeco Seal S/Milos, Greece
Ashapura Minechem Ltd	Versogel, Highbond C/-, India, Asha 505, Asha 229/Kutch, India
Star Bentonite Exports	Starbent 500, Starbent HLM/Kutch, India
Cetco <sup>®</sup> Drilling Products	Volclay <sup>®**</sup> /several quarries (granular)
SP-Minerals Oy	AC-bentoniitti/Milos, Greece MX 80/USA
CEBO Holland BV	Cebogel QSE/Milos, Greece (pellet)
Minelco Group (LKAB)	Milos, Greece, several quarries Deponit CA-N, Minelco granules
BPM Minerals LLC	Bara-Cade <sup>®xx</sup> /USA (granular)
China National Nuclear Corporation (CNNC)	GMZ/Mongolia, China

**Table 2.** The tests and test standards used by producers to determine the key properties of their products. Index and geotechnical properties.

Producer	Water content % (by mass)	Swelling Index ml/g	Gradation	Consistency limits % (by mass)	Specific density
S&B Industrial Minerals GmbH	DIN 18121		DIN 53734		DIN 18124
Ashapura Minechem Ltd	IS 12446	IS 12446		IS 12446, ASTM D 281	
Star Bentonite Exports	ASTM D 2216	ASTM D 5890	ASTM D 422	ASTM D 4318	
Cetco <sup>®</sup> Drilling Products (AMCOL)	ASTM D 4643	ASTM D 5890		ASTM D 4318	
SP-Minerals Oy	ASTM D 5890	ASTM D 5890	SFS-EN 933-10 (in-house) ISO 2591-1		
CEBO Holland					
Minelco Group (LKAB)					
BPM Minerals LLC					
China National Nuclear Corporation (CNNC)			GBJ 123-1988	SL 237-007-1999, GB 7961-87	

**Table 3.** The tests and test standards used by producers to determine the mineralogical and chemical properties.

Producer	MBI	CEC meg/ 100 mg	Smectite content %	Montmorillonite content %	Chemical composition %
S&B Industrial Minerals GmbH					
Ashapura Minechem Ltd					
Star Bentonite Exports	Alther 1983				
Cetco®, Ashapura Volclay Ltd. (AMCOL)	VDG P69				
SP-Minerals Oy	VDG P69				
CEBO Holland					
Minelco Group (LKAB)					
BPM Minerals LLC					
China National Nuclear Corporation (CNNC)		JC/T593-1995	SY/T5163-1995, SY/T 6210-1996	SY/T5163-1995, SY/T 6210-1996	Q/ASC-7-2001

- Quality system in use at the producer laboratory or external QC-laboratory:
  - ISO 9001:2000 - and others, given by industry.
  - General demands on quality documentation. The supplier should confirm the condition of the material in accordance with a quality assurance and control programme (SKI Report 2004). The bentonite manufacturer shall provide the customer with Manufacturer Quality Control (MQC) certifications for each shipment of bentonite. The certifications shall be signed by a responsible party employed by the manufacturer and shall consist of certificates of analysis for the bentonite clay in accordance with the parameters, methods, frequencies and required values (Ahonen et al. 2008).
- Possibility to make a delivery agreement between Posiva Oy and producer/re-seller
- Freight and delivery terms
  - CIF (Cost, Insurance and Freight). Trade term requiring the seller to arrange for carriage (and insurance) of goods by sea to a port of destination, and provide the buyer with documents necessary to obtain goods from the carrier.
  - FOB (Free On Board). Trade term requiring the seller to deliver goods on board a vessel designated to buyer at the port where loading takes place. The seller fulfils its obligations to deliver when the goods have passed over the ships rail.
  - Incoterm. Because the trade terms (CIF, FOB, etc.) are legal trade terms the buyer must make reference to correct governing law (for example: Incoterms 2000, see: <http://www.incoterms.tk/> and [http://www.if-insurance.com/web/marine.nsf/noframes/FB69E3AE3F8D26A7C1256DC500392435/\\$file/English.pdf](http://www.if-insurance.com/web/marine.nsf/noframes/FB69E3AE3F8D26A7C1256DC500392435/$file/English.pdf)).

## 5.2 Findings

It appeared that the producers test their products with quite a limited set of tests. The tests are mostly done according to ASTM-standards which have been modified to some extent. Some re-sellers are also doing some regular acceptance tests to verify the batch quality before delivering it to the customer. Part of the testing is carried out with national or European standards, which are modified slightly to allow testing of bentonite.

The conflict arises from the fact that differences may exist between the values of properties stated by the producer and the values obtained from acceptance tests done in Finland. This may be due to the differing methods. Neither party is totally adapted to the concept of measurement uncertainty, repeatability and reproducibility and the judgment of acceptability of the product based on that information. All batches contain inherent variation in properties (in batch and between batches) probably due to different origins of bentonite material.

Bentonite (pure bentonite, without additives) is used in Finland in several branches of industry: foundry, forest, earthwork and cat litter industry among others.

During the last two years it has become evident that it is not possible to verify with certainty the country of origin of the bentonite delivered. Currently the purchaser has to rely on the statement given by the producer or re-seller.

At present only one company (SP-Minerals Oy) is importing pure raw bentonite (crushed) and grinding it in Finland at two locations. One representative of re-sellers emphasized that the use of bentonite must increase to a level of ca. 55000 - 60000 tons before it is economically feasible to grind and produce good quality bentonite products in Finland. Although the information in Tables 2 and 3 is limited, it shows great variability in the test methods and a lack of uniform standards. More detailed information will most likely be received with the quotations.

## 6. DOCUMENTS

Within this project a set of documents was prepared to serve as templates for later purchase documents in various instances. These documents could serve also as a check list for purchase (order form: all relevant information given: seller, buyer, addresses, goods and specified terms, freight). The documents include:

- Quality requirements for the bentonite (buffer and backfill) (Annex 2)
- List of test methods to measure the property values (Annex 3)
- Purchase order (detailed description of purchasing information: properties, test standards, range of allowable values) (Annex 5)
- Request for Quotation (Annex 6) and Technical specification to define the requirements for the bentonite.

## 7. QUALITY

### 7.1 Purchasing

To ensure that the bentonite purchased fulfils the stated requirements with high confidence, Posiva should prepare general guidelines, detailed documents and make delivery contracts and audit visits to the producer's premises to check the source and process together with QA methods and tests.

Typically ISO 9001 certification assures that the producer has a written "product description" to define the whole production process including QA-methods.

Posiva may utilize two alternative methods to accept the producer and the product: either count on the certified quality system or go through Posiva's own acceptability process. Depending on the safety classification, Posiva should reserve the right to ask additional clarifications and to make audit visits to the producer's sites and QA laboratories.

Posiva should produce the following documentation and create the necessary tools:

- Description of general QM-process dealing with bentonite purchase and buffer manufacturing
- Description of bentonite purchasing organization (organization, staff, qualification, responsibilities, delegated tasks)
- List of accepted producers and resellers and products
- Guide to estimate the producer's ability to deliver valid material in future
- Guides for bentonite purchasing (including this report)
- Document management guide (according to Posiva's QM-system)
- Description of material recognition and control along the whole delivery process.
- Guides and means to ensure the QA-test are according to nationally and internationally accepted standards
- Procedure for dealing with deviations in quality and reclamations
- Description of QA procedures in general and especially in connection with acceptability processes
- Material parameter database and test methods.

The final contents and elaborateness will partly depend on the demands given by the authorities and is connected to the final safety classification of buffer (bentonite, water, additives). Because there is no quality acceptance method for bentonite at the moment, it is necessary to wait for the final requirements to be established by the authorities.

### 7.2 Producer

The producer or the re-seller must provide at least the following information:

- In connection with delivery agreement:
  - Quality system certificate

- Reports of relevant internal and external audits
  - Process description (quarrying, drying, milling, mixing, stockpiling, shipping, environmental conditions)
  - Method descriptions, uncertainty (tests used in this case)
  - List of subcontractors: accredited laboratories, others
- In connection with each larger lot:
- Place of quarry, date and time of excavation
  - Results of QA-tests of each lot, including all predefined tests
    - Water content
    - Swelling index
    - Smectite content
    - Liquid limit
    - Cation exchange capacity.

The exact amount of tests carried out at the producer's laboratories will be defined in the delivery agreement. A site and laboratory audit visit should be done to ensure that the process description is valid and that the laboratory is capable of carrying out the necessary tests. Normal acceptance tests will be carried out in Finland for each batch delivered.

### **7.3 Authorities**

The Finnish Radiation and Nuclear Safety Authority (STUK) has no quality related requirements directly for bentonite as a material. Analogously to this material is, for example, concrete structures which are covered by the requirements of YVL 4.1 (22.5.1992). Bentonite will require a quality management system to be established also for the buffer production and as a part of it a quality control system for bentonite as a raw material is needed. Because there is no national regulation, guidance or test procedures currently established for bentonite, a proposal for reasonable quality management system, covering the laboratories and buffer raw materials - bentonite, water and additives - should be created by Posiva Oy and proposed to STUK (see Annex 1/YVL 4.1).

## 8. SUMMARY

The following aspects can be summarized from the results obtained during the project:

- Each seller/producer has a QMS (typically ISO 9001) and sufficient and even sophisticated laboratories to make the basic tests, but these values and the standards are seldom mentioned in documentation.
- It seems that there is not an established set of tested properties, instead and due to a variety of branches where bentonite is used, the given properties are a summary of tests not always relevant.
- Some producers have declared that they are willing to test according to the customer's needs (CETCO, Ashapura).
- National standards are used to determine reference or quality assurance values to some extent.
- There is a large variation in test standards used, especially for chemical properties.
- The information collected shows that neither the producers nor the re-sellers have all necessary information from the point of view necessary for geological disposal of spent nuclear fuel.
- The network of bentonite producers, quarries and trademarks is complicated and one can not assume anything about the origin of material. It has to be asked and verified in written form.
- Posiva should arrange a network of capable laboratories to carry out tests according to selected standards. This activity must be accredited and it should have a reasonable testing volume.
- It was difficult to reliably verify the country of origin of the bentonite delivered.

It is important to remember that bentonite is a natural material containing inherent variation in all its properties (despite processing made by the producer of the bentonite) and thus the user should allow this inherent variation to some degree by creating such manufacturing processes and acceptance criteria that has no risk for geological disposal of spent nuclear fuel.

## 9. RECOMMENDATIONS

The following recommendations are derived from the results of this report and that of Ahonen et al. (2008):

- Posiva Oy (the buyer) should, before starting purchasing bentonite on a large scale, go through mutual negotiations and audits between each seller in order to make sure that both parties are testing by the same methods as far as possible and both understand the range where the values of key parameters may lie.
- The purchasing process, including the integrated QA system, should be tested with one or a few pilot purchase processes. This process should bind together the sampling, measurement uncertainty and risks.
- The requirements for each parameter should be periodically checked to agree on the functional requirements set for the end product being either buffer, pellet or backfill. In principle all parameters in Tables 2 and 3 should be checked. This requirement is based on the experience gained.
- Posiva should make a proposal for a reasonable quality management system, covering the laboratories and buffer raw materials - bentonite, water and additives – and propose it to STUK, if necessary.
- A database is needed for gathering statistically relevant information of the material parameters for different bentonite batches to determine the limits within which the material parameters should remain to be acceptable.
- A handbook covering materials and methods could be useful. This handbook could then be updated at specified intervals (upon receiving more data, development of testing methods, etc.).
- Posiva should create a process for verifying the country of origin of the bentonite used. There are various methods, for example detailed laboratory tests (bentonite fingerprints) or an authorized representative at the quarry.
- A process to optimize the test types and amount of tests should be created for immediate and long term use. This process ensures the required quality and costs involved.

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STUK-YVL 3.1, Version 2, 22.08.2008. STUK-YVL 3.1 Nuclear power plant systems, structures and their safety classification. In Finnish: Ydinlaitosten järjestelmien, rakenteiden ja laitteiden luokitus.

STUK-YVL 4.1, Concrete structures nuclear facilities. (In Finnish: Ydinlaitosten betonirakenteet), 22.5.1992.

**ANNEXES**

1. Purchase instructions
2. Quality requirements for the bentonite, from the report by Ahonen et al. (2008).
3. Test methods, from the report by Ahonen et al (2008).
4. Producer specific description of received quality specific information (including source, process, freight, delivery, quality, storage, tests, standards, etc.)
5. Order form
6. Request for Quotation form, including the technical specification

## ANNEX 1. PURCHASE INSTRUCTIONS

### General

The bentonite shipping, handling and storage /Ahonen et al. 2008/

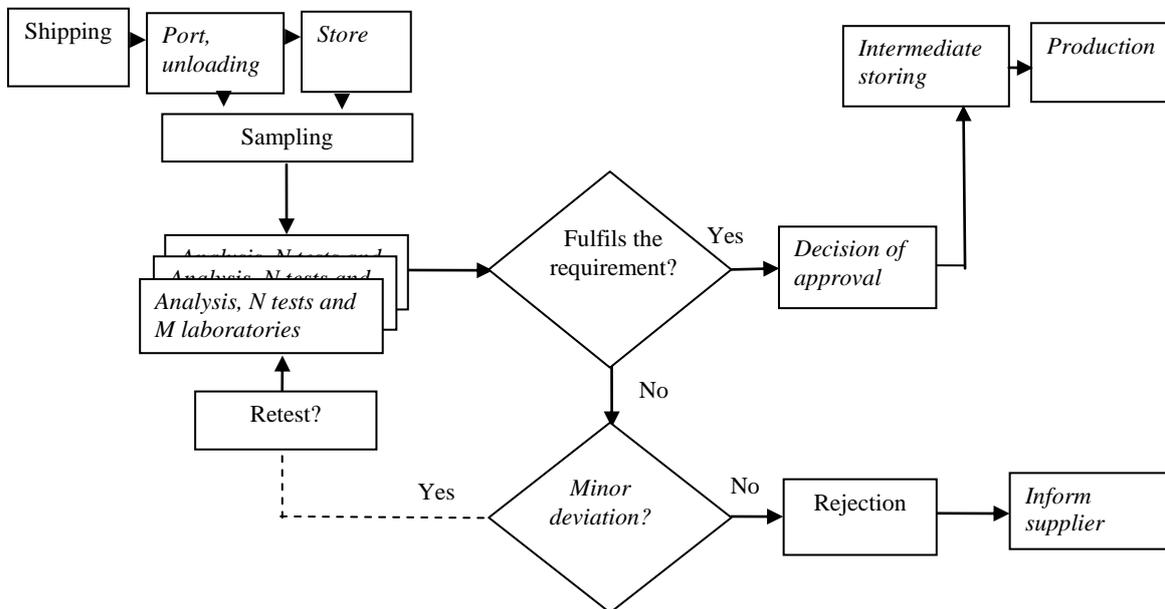
The bentonite manufacturer has the responsibility for initial loading and shipping of the bentonite. Unloading, on-site handling and storage of the bentonite are the responsibility of the customer or other designated party.

Storage of the bentonite shall be the responsibility of the customer. A storage area should be selected at the job site and it shall be level, dry and well drained. The selection of the room depends on the amount of the stored bentonite. There are several possibilities: containers, storage halls and silos.

Quality assurance at customer end - a short process description

The aim of the acceptance process shown in Figure 1 is to ensure that the chosen properties of delivered bentonite fulfil both the values declared by the producer and the requirements arising from the use in geological disposal.

Through extensive preliminary tests the similarity and deviation or bias of determined values will be checked (producer/customer laboratories). This information is needed during ordering and receiving the correct product and to eliminate useless shipments.



**Figure 1.** Schematic figure covering the acceptance process of raw bentonite material (before manufacturing of block or backfill material).

Bentonite material certainly has inherent variance in basic properties due to geological origin and processing (gradation, mineral properties, and impurities).

During the acceptance inspection this average changing in time (shipment to shipment) will be estimated by a limited number of tests and samples that includes numerous sources of variance. The end goal of the analyses is to obtain an accurate picture of the value of certain properties in the batch of sample studied.

During the sampling of the material batch one must take samples frequently enough to guarantee that the analysis can be repeated in an independent laboratory if a quality deviation happens and there should also remain material for later, yet unspecified studies. Sampling is the most critical stage in the analytic determination process, and it is not possible to compensate later the errors made at that early stage.

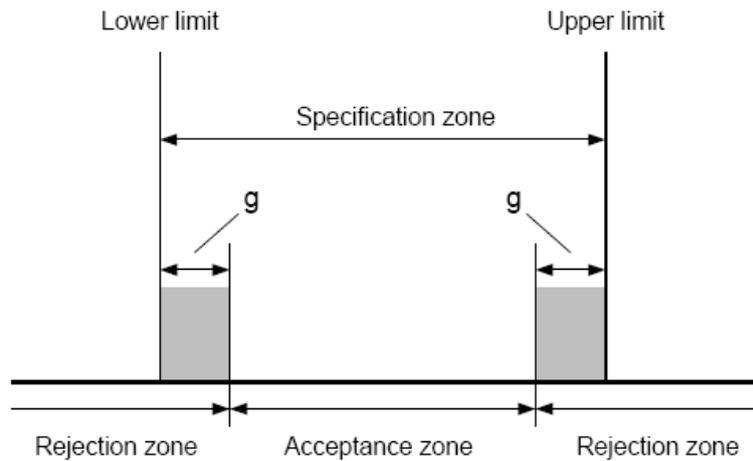
### **Procedure for approval or rejection**

The approval/rejection process based on the results of the testing procedure will be described in the quality assurance plan. The tested product either fulfils the requirements or not and in the latter case it will be rejected temporarily and auxiliary tests will be carried out. With this supplementary testing it is possible to check the test results of temporarily “rejected” material.

Posiva Oy has stated the criteria values for all properties, but more data is needed to verify that the criteria are set correctly. The test results can then be compared to these criteria values.

The criteria will be stated by a mean value and permissible variation around the mean. In addition the amount of discrepancies and magnitude will be set. Results from control tests should lie between the limits defined by the mean value and deviation.

The reference “Use of uncertainty information in compliance assessment /Eurachem 2007/” specify quite clearly the methods to establish the limits for checking the compliance of delivered products, as demonstrated in Figure 2. Determination of uncertainty is described in the reference “Quantifying Uncertainty in Analytical measurement /Eurachem 2000/”.



**Figure 2.** Relative positions of the specified limits and of the acceptance and rejection zones for low risk of false acceptance (EURCHEM 2007).

In Figure 2 the guard band ( $g$ ) is a multiple of standard uncertainty ( $u$ ). With a normal distribution and a 5 % risk level,  $g = 1.64 * u$ . The specification zone implies the band of values including the acceptance zone and guard bands. This procedure ensures low risk for false acceptance decision.

Posiva Oy should develop an acceptance criteria based on the test results (mean and deviation) and known values of test uncertainties, repeatability and reproducibility.

## ANNEX 2. QUALITY REQUIREMENTS FOR THE BENTONITE

Quality requirements for the bentonite depend on purpose (buffer on backfill) and used material. Preliminary required values for the buffer bentonite are presented in Table 1. The values are set based on current knowledge. Values for buffer block swelling pressure, hydraulic and thermal conductivity are based on the given dry density range of a block (below Table 1). The required values may be updated along with increasing amount of information and test data on suitable buffer bentonites.

**Table 1.** Preliminary required values for the buffer bentonite. Separate requirements for Na-/Ca-bentonite (Ahonen et al. 2008 and SKB 2009).

High-grade Na-bentonite

	Required average value	Single test, maximum value	Single test, minimum value
Water content	$\leq 13\%$	15%	6%
Swelling index	$\geq 20$ ml/2 g		15 ml/2 g
Smectite content	$\geq 75\%$		65%
Liquid limit	$\geq 250\%$		200%
Cation exchange capacity (CEC)	$\geq 70$ mEq/100 g		60 mEq/100 g
Hydraulic conductivity*	$\leq 10^{-12}$ m/s	$\leq 10^{-11}$ m/s	
Swelling pressure*	$\geq 1$ MPa and $\leq 10$ MPa		
Thermal conductivity**	$\geq 1.0$ W/m/K		$\geq 1.0$ W/m/K
Content of organic carbon***	$< 1\%$		
Sulphide content****	$\leq 0.5\%$		
Total sulphur content (including the sulphide)****	$\leq 1\%$		

## High-grade Ca-bentonite

	Required average value	Single test, maximum value	Single test, minimum value
Water content	$\leq 13\%$	15%	6%
Swelling index	$\geq 15 \text{ ml/2 g}$		10 ml/2 g
Smectite content	$\geq 75\%$		65%
Liquid limit	$\geq 80\%$		60%
Cation exchange capacity (CEC)	$\geq 60 \text{ mEq/100 g}$		50 mEq/100 g
Hydraulic conductivity*	$\leq 10^{-12} \text{ m/s}$	$\leq 10^{-11} \text{ m/s}$	
Swelling pressure*	$\geq 1 \text{ MPa}$ and $\leq 10 \text{ MPa}$		
Thermal conductivity**	$\geq 1.0 \text{ W/Km}$		$\geq 0.9 \text{ W/Km}$
Content of organic carbon***	$< 1 \text{ wt-}\%$		
Sulphide content***	$\leq 0.5 \text{ wt-}\%$		
Total sulphur content (including the sulphide)***	$\leq 1 \text{ wt-}\%$		

\* Dry density of buffer blocks 1655 - 1754 kg/m<sup>3</sup>

\*\* In dry density of 1655 kg/m<sup>3</sup>, water content 17% and degree of saturation 70% or in dry density of 1754 kg/m<sup>3</sup>, water content 17% and degree of saturation 81%. After saturation thermal conductivity of buffer block should be 1.3 W/Km (TKS 2006).

\*\*\* SKB 2009.

## Quality requirements for the mixture of bentonite and ballast

Required values for the mixture of bentonite and ballast are presented in Table 2. Because these values are dependent on both the aggregate used and the density, no requirements can be set based on these values. The proportions between aggregate and bentonite in the mixture may vary in time.

**Table 2.** Required values for the mixture of bentonite and ballast (30:70) (Ahonen et al. 2008).

	Required average value	Single test, maximum value	Single test, minimum value
Hydraulic conductivity**	$\leq 10^{-10} \text{ m/s}$	$\leq 10^{-9} \text{ m/s}$	
Swelling pressure***	$\geq 0.2 \text{ MPa}$		$\geq 0.15 \text{ MPa}$

\*\* dry density 1700 - 1890 kg/m<sup>3</sup> (in salinity of 3.5%), saturated backfill material consisting of mixture of bentonite and ballast (30:70)

\*\*\* dry density 1730 - 1800 kg/m<sup>3</sup> (in salinity of 3.5%), saturated backfill material consisting of mixture of bentonite and ballast (30:70)

### ANNEX 3. TEST METHODS

The following Tables 1 to 3 specify the test methods that are used in Finland to test the quality of purchased bentonite and also the end products made of bentonite and aggregate.

In all three tables the functional properties given in the right column correspond to the following: 1. Low hydraulic conductivity, 2. Sufficient swelling pressure, 3. Workability, 4. Sufficient density, 5. Sufficient thermal conductivity.

**Table 1.** Test methods to assure the quality of bentonite.

Test	Standard/Reference [*]	Functional properties
Smectite content	XRD, In-house method (**)	1, 2
Grain size distribution	ASTM C958-92 (2000)	1, 2, 5
Cation exchange capacity (CEC)	ISO 11260, ASTM C837-99 (2003)	1, 2
Semi-quantitative mineral composition	XRD	1, 2
Chemistry of the bentonite	XRF, ICP-MS/AES	1, 2, 3, 4, 5
Water absorption capacity	DIN 18132	1, 2
Swelling index	ASTM D5890-06	1, 2
Liquid limit, plastic limit and plasticity index	ASTM D4318-05 CEN ISO/TS 17892-12:2004	3
Thermal conductivity	ASTM D5334-05	5
Hydraulic conductivity	ASTM D5084-03	1
Water content (convection/microwave oven)	ASTM D2216-05, ASTM D4643-00	1, 2, 3, 4, 5
Compaction properties	SFS - EN 13286-2	4
Swelling pressure	ASTM D4546-03	2
Water retention properties	ASTM D3152-72 (2000)	1

\* Short method description can be found from reference (Ahonen et al. 2008).

\*\* GTK, Geological Survey of Finland.

**Table 2.** Test methods to assure the quality of ballast.

Test	Standard [*]	Functional properties
Grain size distribution	ASTM D422-63(2002)e1	3, 4
Particle density	SFS-EN 1097-7	4
Particle shape - Flakiness index	SFS-EN 933-3	3
Particle shape - Shape index	SFS-EN 933-4	3
Water content	ASTM D2216-05, ASTM D4643-00	3, 4
Compaction properties	SFS-EN 13286-2	4

\* Short method description can be found from reference (Ahonen et al. 2008).

**Table 3.** Test methods to assure the quality of mixture of bentonite and ballast.

Test	Standard [*]	Functional properties
Water content	ASTM D2216-05, ASTM D4643-00	1, 2, 3, 4, 5
Hydraulic conductivity	ASTM D5084-03	1
Compaction properties	SFS-EN 13286-2	4
Swelling pressure	ASTM D4546-03	2
Bentonite content	C837-99 (2003)	1, 2

\* Short method description can be found from reference [Ahonen et al. 2008].

## ANNEX 4. SUMMARY OF INFORMATION GIVEN BY PRODUCERS

### ANNEX 4.1: Ashapura Minechem Ltd.

	Name	Contact
Producer	Ashapura Minechem Ltd	Ronak Mehta, ronak@ashapura.com
Dealer/re-seller	none/Salvor Oy ?	
Trade name	Mine no. 209 (Saran)/505 (Hamla) (raw Na bentonite). Versogel, Highbond C (trademarks for blended material)	
Name by source/quarry	Mine no. 209/505 Kutch, Gujarat	
Country of origin	India	
QMS (quality management sys.)	ISO 9001:2000	
Property	Test standard	Typical values (unit)
Index values		
- water content (% by weight)	IS 12446	< 14 %
- swell index (note: ml/1 g)	IS 12446	> 12.5 - 16 (ml/1g)
Geotechnical		
- gradation		75 µm: 85 (%) powder granulate: 0.5 - 5 mm
- liquid limit	IS 12446	
- plasticity index (% by weight)	ASTM D 281-95 (2002)	> 350 - 430 (%)
Chemical		
- CEC (meqv/100 mg)		
- MBI (meqv/100 mg)	IS 12446	> 400 (meqv/100 mg)
- chemical composition (iron, ...)		
Mineralogical		
- mineral composition		SiO <sub>2</sub> : < 52 % Al <sub>2</sub> O <sub>3</sub> : 13 - 18 % Fe <sub>2</sub> O <sub>3</sub> : 11 - 18 %
- smectite content		
- montmorillonite content		
General		
- Process description at quarry		
Other business	Tests according to ASTM and Indian standards. Tests can be made to meet customer's needs.	

## ANNEX 4.2: S&amp;B Industrial Minerals S.A./AMCOL.

	Name	Contact
Producer	S&B Industrial Minerals S.A./ AMCOL	
Dealer/re-seller	SP Minerals Oy, Finland  Askania Ab, Sweden	Nina Piippo, n.piippo@spminerals.fi Martin Leman, m.leman@askania.se
Trade name	AC-bentoniitti/MX 80	
Name by source/quarry		
Country of origin	Greece, Milos/USA	
Property	Test standard	Typical values (unit)
Index		
- water content (% by weight)	ASTM D 5890-06	8.5 - 14.5 (%)
- swell index (note: ml/1 g)	ASTM D 5890-06	11 - 19 (ml/g)
Geotechnical		
- gradation (% passing)	SFS-EN 933-10 (in-house) ISO 2591-1 (> 355 µm)	32 µm: 35.2 (%) 71 µm: 75 - 85 (%) 355 µm: 99.8 (%)
- plasticity index, liquid limit	no information	
Chemical		
- CEC (meqv/100 mg)		
- MBI (ml/g)	VDG P69	65 - 90 (ml/g)
- chemical composition (iron, ...)	unknown (XRD/XRF, in-house)	SiO <sub>2</sub> : 63.0 %, Al <sub>2</sub> O <sub>3</sub> : 21.1 %, Fe <sub>2</sub> O <sub>3</sub> + FeO: 3.6 %
Mineralogical		
- mineral composition		
- smectite content	unknown (XRD, in-house)	
- montmorillonite content	unknown (XRD, in-house)	87.7 - 90 (%)
General		
- Process description at quarry	no information	

## ANNEX 4.3: CETCO/AMCOL International Corp.

	Name	Contact
Producer	CETCO/AMCOL International Corp.	
Dealer/re-seller	Kaitos Oy, Finland  CETCO Lining Technologies	Tomi Neva, tomi.neva@kaitos.fi Piotr Wojewoda, piotr.wojewoda@cetco.pl
Trade name	Bentonite Wyoming T16 -powder. (Also VOLCLAY-family of products, coming from Kutch area, India)	
Name by source/quarry		
Country of origin	USA	
Property	Test standard	Typical values (unit)
Index values		
- water content (% by weight)	ASTM D 4643	95 - 13 (%)
- swell index (note: ml/ 1g)	ASTM D 5890	> 12 (ml/g)
Geotechnical		
- gradation (% passing)	unknown	75 µm: ≥ 70 (%) 3.55 mm: ≤ 99.8 (%)
- plasticity index, liquid limit	ASTM D 4318 (possible if needed)	
Chemical		
- CEC (meqv/100 mg)		
- MBI (mg/g)	VDG P69	≥ 300 (mg/g)
- chemical composition (iron, ...)	unknown (XRD/XRF, in-house)	SiO <sub>2</sub> : 63.0 %, Al <sub>2</sub> O <sub>3</sub> : 21.1 %, Fe <sub>2</sub> O <sub>3</sub> + FeO: 3.6 %
Mineralogical		
- mineral composition		
- smectite content	XRD, in-house	
- montmorillonite content	XRD, in-house	
General		
- Process description at quarry	no information	
Other business	Tests can be made to meet customer's needs.	

## ANNEX 4.4: S&amp;B Industrial Minerals GmbH.

	Name	Contact
Producer	S&B Industrial Minerals GmbH	
Dealer/reseller	DeNeef Finland Oy, Finland Oy Lux Ab, Finland	Pekka Salmenhaara, pekka.salmenhaara@deneef.fi Lasse Nybergh, lasse.nybergh@lux.fi /Koch 2007/
Trade name	IBECO B2, SEAL GE-FGS, SEAL S-FGS Buffer: Deponit CA-N (old) IBECO RWC (new)	
Name by source/quarry		
Country of origin	Greece/Milos	
Property	Test standard	Typical values (unit)
Index		
- water content (% by weight)	DIN 18121	10 ± 2 (%)
- swell index (note: ml/1 g)		> 11 ml/g (SEAL)/ 6 - 10 (RWC)
- specific density (g/cm <sup>3</sup> )	DIN 18124	2.65 (g/cm <sup>3</sup> )
- water absorption capacity	DIN 18132	≥ 500 % (SEAL)
Geotechnical		
- gradation (% passing)	DIN 53734	63 µm: 20 ± 5 (%)
- plasticity index, liquid limit		
Chemical		
- CEC (meqv/100 mg)		90 ± 10 meq/100 g (SEAL)
- MBI (mg/g)	VDG P69	420 ± 20 mg/g
- chemical composition (iron, ...)		SiO <sub>2</sub> : 55.2 %, Al <sub>2</sub> O <sub>3</sub> : 16.5 %, Fe <sub>2</sub> O <sub>3</sub> : 5.6 %, MgO 3.1 % (RWC)
Mineralogical		
- mineral composition		
- smectite content		75 - 85 (RWC)
- montmorillonite content		
General		
- Process description at quarry	Open pit mining	

## ANNEX 4.5: Star Bentonite Exports.

	Name	Contact
Producer	Star Bentonite Exports	
Dealer/re-seller	Dasico A/S, Denmark	Pirjo Mäljä, dasico@dasico.dk
Trade name	Starbent 500/Starbent HLM	
Name by source/quarry	Kutch, Gujarat	
Country of origin	India	
QMS (quality management system)	ISO 9001:2000 DNV very detailed description	
Property	Test standard	Typical values (unit)
Index		
- water content (% by weight)	ASTM D 2216	11 - 14 (%)
- swell index (note: ml/1 g)	ASTM D 5890	> 12/> 15 (ml/g)
Geotechnical		
- gradation (% passing)	ASTM D 422	
- liquid limit	ASTM D 4318	> 450 (%)/> 600 (%)
- plasticity index	ASTM D 4318	> 400 (%)/>500 (%)
Chemical		
- CEC (meqv/100 mg)		
- MBI (mg/g)	Alther 1983	350 - 390/430
- chemical composition (iron, ...)		
Mineralogical		
- mineral composition		
- smectite content	XRD, in-house	
- montmorillonite content	XRD, in-house	
General		
- Process description at quarry	Very detailed description	

ANNEX 4.6: Beijing Research Institute of Uranium Geology, China National Nuclear Corporation.

	Name	Contact
Producer	“China”, Beijing Research Institute of Uranium Geology, China National Nuclear Corporation	Yuemiao Liu (liuyuemiao@yahoo.com.cn)
Dealer/re-seller		
Trade name		
Name by source/quarry	GMZ01, Na-bentonite	GMZ01, Na/GMZ-Ca, Ca
Country of origin	China	
Property	Test standard	Typical values (unit)
Index		
- water content (% by weight)		9/30 (%)
- swell index (note: ml/1 g)		7/- (ml/1g)
- specific density (g/cm <sup>3</sup> )	GB5161-1985	2.66/2.61 (g/cm <sup>3</sup> )
- specific surface area (m <sup>2</sup> /g)	GB/T 13390-1992	570/617 (m <sup>2</sup> /g)
Geotechnical		
- gradation (% passing)	GBJ123-1988	97 % < 18.7 μm/96 % < 50 μm
- liquid limit (% by weight)	SL237-007-1999, GB7961-87	350/100 (%)
Chemical		
- CEC (mmol/100 mg)	JC/T593-1995	77/83 (mmol/100 mg)
- MBI (mmol/100 mg)	not specified	94/- (mmol/100 mg)
- chemical composition (iron, ...)	Q/AS.C-7-2001	SiO <sub>2</sub> : 67.4/61.0 %, Al <sub>2</sub> O <sub>3</sub> : 14.2/12.7 %, TFe <sub>2</sub> O <sub>3</sub> +FeO: 2.7/1.4 %
Mineralogical		
- mineral composition	XRD, in-house SY/T 5163-1995, 6210-1996	Quartz: 11.7/2.3 (%) Feldspar: 4.3/2.0 (%) Cristobalite: 7.3/12.9 (%)
- smectite content	unknown	
- montmorillonite content	XRD, in-house SY/T 5163-1995, 6210-1996	75.4/82.9 (%)
General		
- Process description at quarry	Ca-bentonite: from surface to depth of 30 m. Na-bentonite: from 20 to 100 m depth.	25 m/10 m

## ANNEX 5. ORDER FORM



No:	1234567
Date:	20.4.2008 (dd.mm.year)
Assignment:	

Supplier:	Ashapura Minechem Limited
	Plot No 206, Opp. Kutch Diary
	Madharpar, Bhuj-Kutch
	Gujarat
	India

Bill to:	Posiva Oy
	Olkiluoto
	FI-27160 Eurajoki
	Finland

<b>Purchase Order</b>
-----------------------

Customer Account No.	Supplier No.	Payment Terms	Freight Terms	Incoterms	Freight Carrier
	XXXXXX	zz days net	CIF / FOB / Helsinki	2000	ship
Confirm To / Telephone / E-mail					
N.N, +358-2-837231, posiva@posiva.fi					

No:	Item/Description/Supplier Item	Delivery Date	Quantity	Unit	Unit Price (USD)	VAT%	Amount (currency)
1	Asha 505, raw bentonite, properties given below.	15.5.2008	10	ton (metric)	500.00	0	5000.00

Specific requirements for the ordered bentonite (sodium bentonite):

1. Swell index (ASTM D 5890):  $\geq 20$  ml/2g
2. Smectite content (XRD –analysis):  $\geq 75$  % by weight
3. Iron content (XRD –analysis /XRF –analysis):  $\leq 10$  % by weight
4. Cation exchange capacity (ASTM C 837):  $\geq 70$  meq/100 g
5. Water content (ASTM D 2216):  $\leq 13$  % by weight
6. Content of organic carbon  $< 1$  % by weight
7. Sulphide content  $\leq 0.5$  % by weight
8. Total sulphur content (including the sulphide)  $\leq 1$  % by weight

Acceptance inspection and the decision of approval of the lot will be carried out in the destination port as described in the Technical specifications (Annex 1).

Requester:	Mr./Ms. M.M / person ordering the goods
Deliver to Address:	Small amounts: Postal address. Large amounts: Depends on the trade term: CIF, FOB. Name the destination port.
Original Quantity ordered:	10 t (metric)
Total: 5000.00 (USD)	

## ANNEX 6. REQUEST FOR QUOTATION



Supplier:	Ashapura Minechem Limited
	Plot No 206, Opp. Kutch Diary
	Madharpar, Bhuj-Kutch
	Gujarat
	India
Your handler:	N.N.

	<b>Request for Quotation</b>
No:	1234567 All documents shall include the identifying number of the request
Date:	xx.9.2008 ( <i>dd.mm.year</i> )
Commercial handler:	K. LATVALA, +358-2-83815600

Sender:	Posiva Oy
	Olkiluoto
	FI-27160 Eurajoki
	Finland

### REQUEST FOR QUOTATION

WE ASK FOR YOUR TENDER of pure bentonite for buffer/backfill manufacturing purposes to be used in nuclear waste disposal work.

#### GENERAL

The bentonite will be used for nuclear repository use as such or mixed with other material. Bentonite must fulfil strict requirements and the quality must remain unchanged for long periods.

#### SCOPE OF SUPPLY

Pure bentonite in the form of dry powder, granulate or pellet. Required material properties with limit values have been listed in the separate "Technical specifications for bentonite used in buffer/backfill material" annex (Annex 1). This document also contains the description of the Quality Assurance (QA) process.

The amount of bentonite covered with this request is ca. 5000 metric tons per year. Smaller pilot lots will also be purchased.

#### ORDER

The order for contract is Posiva Oy, Olkiluoto, FI-27160 Eurajoki, Finland.

#### TIME SCHEDULE

The bentonite shall be delivered to a destination in Finland given by the Purchaser no later than 30.6.2008.

**PLACE OF DELIVERY**

Port of Pori, Finland (<http://www.pori.fi/port/english/>).

**DELIVERY TERMS**

CIF, Incoterms 2000, Port of Pori, Finland

**OTHER MANDATORY INFORMATION**

The producer must always provide the following documentation with a new shipment of material: source, lot, batch, shipping, storing, required QA results of key properties (listed in Annex 1): mean value, range for each property.

This request for information is valid and mandatory also in cases where this request comes through a local re-seller or representative.

**TRIAL SAMPLE**

The producer should send a trial sample to Posiva Oy for preliminary testing of the most relevant properties.

**AUDIT OF THE PRODUCER**

In case of a new supplier, Posiva Oy reserves the right to check the QM system, make an audit visit to the quarry and the laboratory carrying out the QC tests. Details of this audit will be agreed upon together.

**FOR MORE ADVICE**

Any questions concerning technical or quality issues of this request for tender should be addressed to the contact person:

Mr. Keijo Haapala  
Posiva Oy, Olkiluoto  
FI-27160 Eurajoki, Finland  
Tel. +358 440 565356, E-mail: keijo.haapala@posiva.fi

In commercial issues, the contact person is:

Mr. Keijo Latvala  
Teollisuuden voima Oyj, Olkiluoto  
FI-27160 Eurajoki, Finland  
Tel. +358 2 8381 5600, E-mail: keijo.latvala@tvo.fi

**THE TENDER**

The tender must be given as an all-inclusive price.

For minimal alteration purposes, unambiguous unit prices are needed. For alterations, these prices are used as the basis.

The tender must be valid until 30.6.2009.

**SENDING THE TENDER**

Submit the tender no later than 31.12.2008 to the address:

Teollisuuden voima Oyj  
Keijo Latvala  
Olkiluoto  
FI-27160 Eurajoki  
Finland

Note the tender and envelope with "Bentonite for buffer".

**OTHER CONDITIONS**

Posiva Oy, General terms and conditions of Posiva Oy.

**APPENDIX**

1. Technical specifications for bentonite used in buffer/backfill material (Annex 1 of Annex 6)
2. Posiva Oy, General terms and conditions of Posiva Oy (17.3.2008), not included.

**TECHNICAL SPECIFICATION****Purpose of this document is to:**

- describe the use of bentonite in question
- state the chemical type of bentonite (Na-/Ca-bentonite)
- clarify the properties describing the goods purchased
- declare the allowable range of parameters describing the properties
- specify the test methods used in the acceptance tests/quality control tests
- describe the acceptance process

**Status of this document**

This is a legal document describing the product or goods to be purchased. All delivered material/goods must fulfil all the properties declared later in this document. This document is an annex (Annex 1) to the Request for Quotation nr. "1234567".

**Beneficial for the tenderer**

QA-system audited by independent organization. Delivered statistics of value of properties determined later in this document.

**Use of purchased bentonite**

This bentonite will be used for nuclear repository use as such or mixed with other material.

**Chemical type of the ordered bentonite**

The bentonite type for buffer use is always high-grade Na-bentonite. The material may not be modified in anyway nor are any additives allowed. Ca-bentonite is an alternative for other purposes.

### Type of ordered bentonite

The ordered bentonite shall be delivered in the following form:

- powder
- granulate
- pellet
- other

In all cases the gradation of the material must be given at three values of percent of passing: 10, 50 and 90 % or with a complete gradation curve.

### Properties that are specified for this purchase and allowable range of parameters

Properties that are given a range are listed in Table 1. Only parameters associated with values are valid. Table 1 contains also properties with upper limits, like iron content which has a definite upper level. The test methods used in acceptance tests have also been listed in the table.

*NOTE: The person making this purchase must choose and fill correct average and limit values into the table. The values in the table depend on the use of the material under purchase (buffer/backfill/other).*

**Table 1.** Properties used to describe the purchased lot of bentonite. Bentonite for buffer is high-grade Na-bentonite. For other purposes bentonite may be Na/Ca-bentonite.

Property	Required average value	Single test, maximum value	Single test, minimum value	Test Standard
Water content	≤ 13 %	15 %	6 %	ASTM D2216-05, ASTM D4643-00
Swelling index	≥ 20 ml/2 g		15 ml/2 g	ASTM D5890-06
Smectite content	≥ 75 %		65 %	XRD-method (in-house) ***
Liquid limit	≥ 250 %		200 %	ASTM D4318-05 CEN ISO/TS 17892-12:2004
Cation exchange capacity (CEC)	≥ 70 mEq/100 g		60 mEq/100 g	ASTM C837-99 (2003)
Iron content	< 5 %		< 10 %	XRD, XRF ***
Content of organic carbon	< 1 %			
Sulphide content	≤ 0.5 %			
Total sulphur content (including the sulphide)	≤ 1 %			

\*\*\* Description of the method is needed together with an estimate of uncertainty (U).

### **Procedure for sampling**

Random testing will be carried out from the customer stock in Finland. Each container will be sampled. At least two samples will be taken from each flexible intermediate bulk container, i.e. big bag in the freight container.

The sampling will be carried out either in the presence of both parties (the re-seller and the customer) or it will be done by a third party accepted by both parties.

### **Acceptance testing**

The following tests (three parallel tests in one series) will be carried out /Ahonen et. al. 2008/:

- water content (one test series per 21 tons of bentonite)
- swell index (one test series per 21 tons of bentonite)
- cation exchange capacity (CEC) (one test series per 21 tons of bentonite)
- XRD (one test series per 21 tons of bentonite)
- XRF, others (one test series per 21 tons of bentonite)
- Thermo balance analysis (one test series per 21 tons of bentonite)
- Grain size distribution (one test series per 21 tons of bentonite).

These tests will be made for powder, granulate and pellets. Material will be milled down to required analysis size if needed.

### **Process to handle the test results and make the acceptance decision**

The decision is based on average values but only 1 test of 5 test value may end up with results outside the predefined range of values. No value may exceed or go under the set range of values or limits by more than 20%. This value is calculated from the given mean value and if the maximum or minimum values are given then they apply.

### **Process followed if delivery requirements and conditions have been violated**

If there has happened such a violation against mutually agreed delivery requirements or conditions suggesting that there is reason to believe that bentonite properties may have been altered, additional testing or clarifications may have to be done by an independent third party. In this case all tests and costs involved are paid by the producer or re-seller. With mutual agreement between the purchaser and the producer, a batch not fulfilling the requirements for the buffer can be used in manufacturing the backfill. Excess costs can be compensated in the price of future batches.

### **Process followed if specified values are not met**

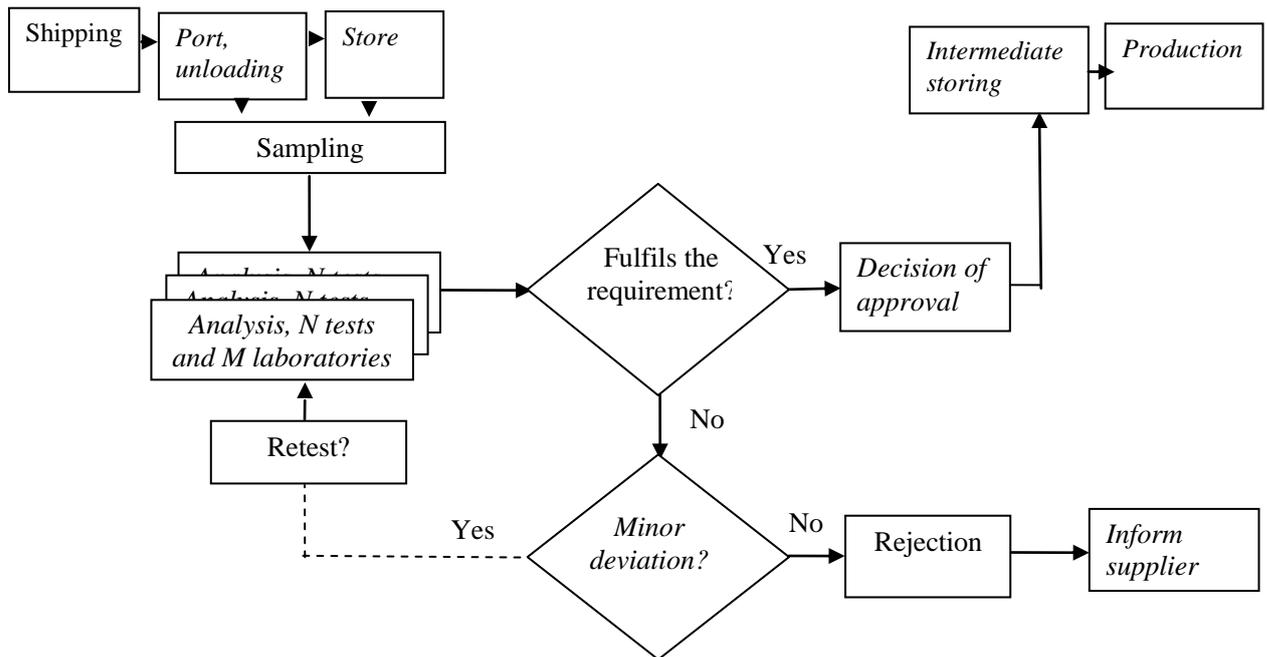
The overall diagram of acceptance testing is shown in Figure 1. If the measured values of key parameters are not met in the additional testing then the material will be rejected and it will not be accepted for use in buffer manufacturing. In this case all tests and costs involved are paid by the producer or re-seller. Reclamation issues will be dealt with by the procedures described in "General terms and conditions of Posiva Oy".

### Type of shipment and cargo

Cargo will be transported on ship in big bags in watertight containers. Bentonite is not allowed to be in contact with water vapour or liquid water, other liquids or chemicals of any kind during the transport from the mine to harbour in Finland. The material is not allowed to freeze during the transport on ship or truck.

### The delivery terms

The delivery terms are stated either in the “Request for Quotation” or in the Order.



**Figure 1.** Schematic figure covering the acceptance process of raw bentonite material.