

Sandaband Material

A cost saving technical revolution!

Applications for oil & gas wells:

Sandaband: Permanent & Temporary Plugging Material

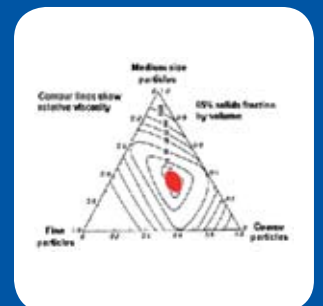
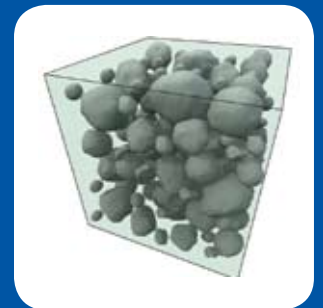
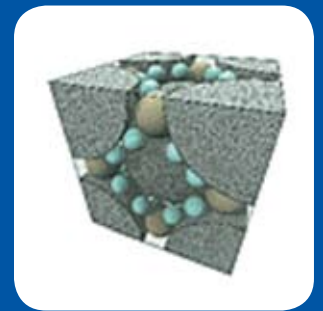
Sandaband: Fill behind Casing

Sandaband: LCM

Sandaband products are developed in Norway and patented worldwide.

Sandaband consists of about 70-80% by volume of solids, together with about 20-30% of water and other fluidising additives. Its rheology can be characterised as Bingham plastic. Sandaband mixture is a solid inside a liquidized annulus of itself when it is in motion, otherwise it's a deformable solid.

- Sandaband is a green/non polluting product.
- Sandaband installation is safe and saves rig time (no waiting on hardening, etc).
- Sandaband is easy to place / replace.
- Sandaband is pre-mixed onshore; no mixing offshore.
- Sandaband is chemically inactive.
- Sandaband mixture does not harden, but remains fluidisable (self healing).
- Sandaband leaves no micro annulus.
- Sandaband maintains its fluid flow prevention effect.
- Sandaband complies with NORSOK requirements for P&A.
- Sandaband has been approved by the environmental authorities, both in UK and Norway.
- Sandaband reduces Life Cycle Well Cost.



Sandaband

Permanent & Temporary Plugging Material

Occasionally it is necessary to plug back wells temporarily, mostly because the well is drilled by use of one rig and the completion operation with a different rig. Historically, the common method to plug back wells in the time period while waiting for the completion rig, has been to partially cement back the wells. The reservoir section formation has been cemented back totally, leaving the completion rig the option of re-drilling this section. A selection of packers and short cement plugs in the bottom of the last casing has been used to obtain total well control.

Sandaband as plugging material is an application that allows a temporary plug back of a reservoir section without the need to re-drill. This system consists of a concentrated sand made into a slurry with water and brines. The sand slurry has a particle fraction in excess of 70% by volume. The particle size distribution controls the rheology, permeability and porosity of the slurry.

This method has been performed with success in a 5000 m deep HPHT well in Norway. Use of Sandaband as plugging material is evaluated to have caused little, if any formation damage. The use of the concentrated sand slurry gives a potential time saving of

approximately one week per well compared to using cement and removing it from the reservoir section. The sand slurry consists of particles in the range from larger than 2 mm sand to smaller than 0.1 μ m. The insignificant permeability of the sand slurry is in a range of several orders of magnitude less than 1 millidarcy.

In the HPHT well, the sand slurry was placed in the well from 4917 mMD to 5150 mMD, at an angle between 30° to 35°. The sand slurry, with a 2.2 s.g. density, was placed using the balanced plug method. Two years later the temporary plug was washed out easily. The hole was in perfect shape and the permeability was intact.

A permanent barrier shall and Sandaband does:

- Hold tight for eternity although the well changes over time (pressure, corrosion, shearing of casing).
- Separate the layers in the overburden and protect the fresh ground water ("inner environment").
- Protect the environment ("outer environment")

Why Sandaband remains impermeable:

- A suspension wherein the distances between the particles stay fixed while in the solid state, i.e. the grain distribution remains fixed and with the low porosity (i.e. the volume fraction of liquid ~30% volume) and the non-sorted particle distribution results in permeabilities in the $\ll 0.1$ mD range.

The natural properties of the Sandaband grains help maintain the plug:

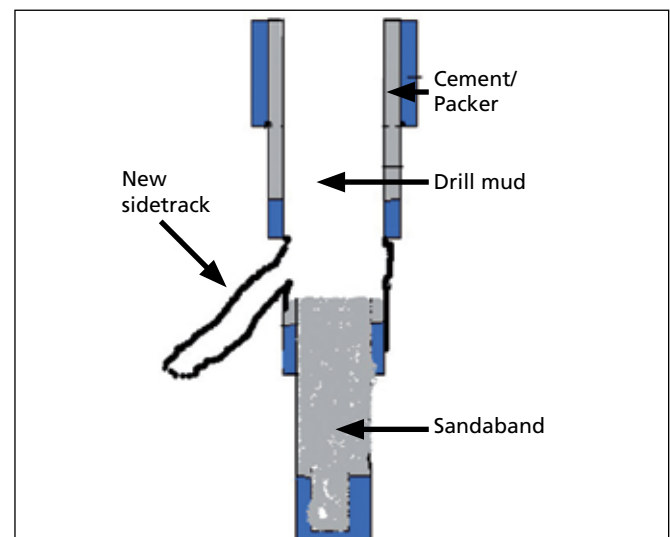
- The electrostatic binding (Zeta potential) between the water molecule and the surface of the smallest micro-silica grains hinders flow in the pore space.
- Sandaband behaves as a Bingham plastic material that becomes a solid unless subjected to its Yield Point limit.

Resistance to fracturing:

- Due to the Yield Point, Sandaband material cannot fracture, because the material in the yielded zone becomes liquid.
- There is no chemical reaction between the solid particles and the liquid phase and therefore no volume shrinkage.

Liquid to solid to liquid:

- Any overburden movement causes the Sandaband plug to move into the liquid state and reshape to the new hole conditions before returning to the solid state.



Sandaband

LCM

The pressure required to move a Bingham Plastic must exceed the product $YP \cdot A$, where YP =Yield Point and A =Area. When a volume of the material is squeezed into a fracture, the Area (between the fracture surface and the Sandaband material) increases very fast. When the squeeze pressure becomes balanced by the increasing $YP \cdot A$, further movement into the fracture stops and the material transforms to solid. The subsequent circulation in the well bore can wash out only an insignificant amount next to the well, but the fracture is left permanently sealed, by Sandaband.

A lost circulation situation can be fixed effectively and permanently by using Sandaband LCM both if the loss took place into high permeability or through fractures without permeability into the matrix. No liquid leak off from Sandaband LCM is required.

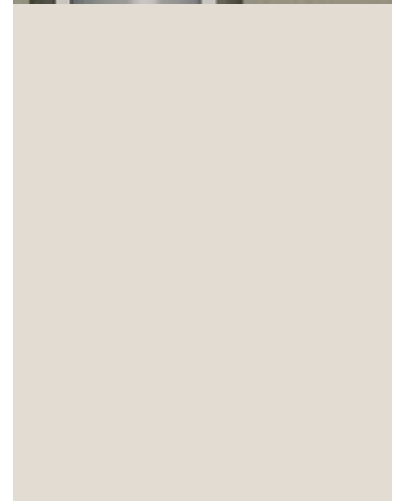
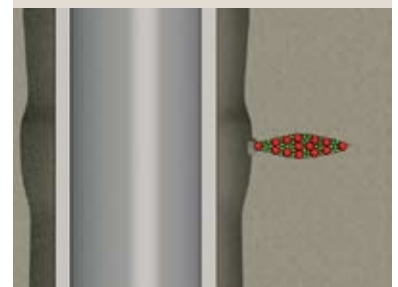
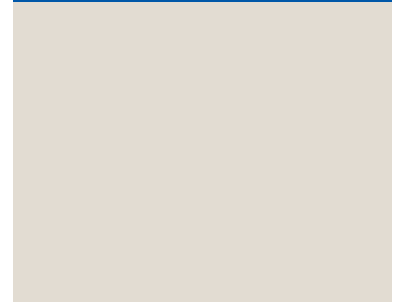
The material will not filter through itself nor into the formation, due to the low permeability and the large particles that cannot move through the lattice. The entire volume is like a screen out from common types of particle/liquid materials.

The pressure closer to the fracture tip falls below the fracture propagation pressure and fracture radius growth stops. When the pressure applied to propagate/bullhead Sandaband material into the fracture is subsequently bled off, the formation closes and traps the material inside the fracture where it acts as a permanent seal.

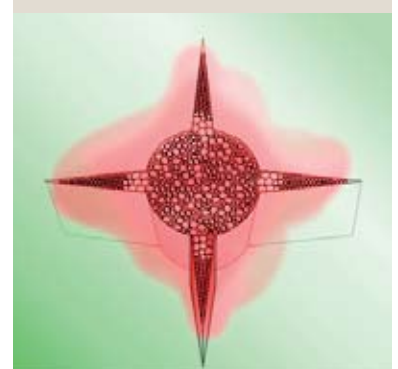
Sandaband material cannot flow into the porosity around the fracture. The way to get more material into a fracture that does not propagate radially from the well is by widening the aperture of the fracture. This creates additional counteracting, circumferentially acting stresses from the formation and increased restriction against new fracture opening, so called hoop stress.

The hoop stressed ring around the well bore will act as a reinforcement element of the near-well rock volume; therefore improved well bore stability. This phenomenon has been observed in building of arches. The phenomenon has been modelled.

Because of the presence of all grain sizes, from 2.5 mm to less than 0.000,5 mm, the permeability of the Sandaband material is much smaller than 0,01 mD. This has been confirmed by testing.



Pink area is stressed, and provides hole stabilization



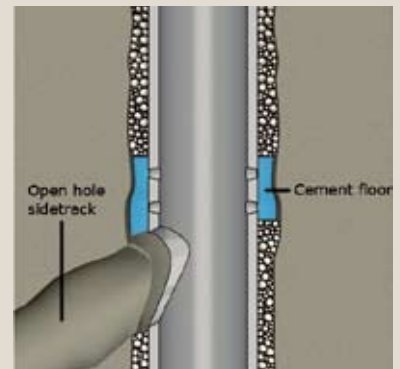
Sandaband

Fill behind Casing

Annulus shear strength is necessary only for transfer of load to the formation, therefore only for the structural casing is cementing necessary (and in cased production interval).

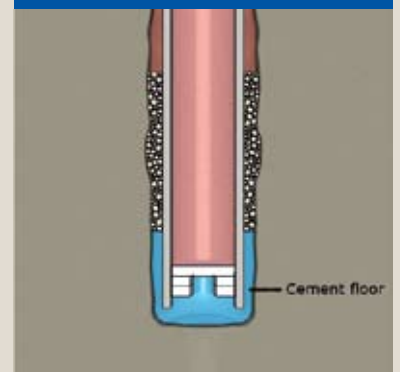
Get rid of the common "cementing problems".

- Sandaband does not shrink and does not set up.
- With Sandaband pressure testing of casing does not create micro annulus or radial cracks.
- With Sandaband mechanical activity inside the casing does not fracture the annulus fill.
- With Sandaband thermal expansion is minimized.
- Use of Sandaband gives less stress on casing.
- Sandaband acts as if the hole is under reamed and facilitates lateral movements in the overburden.
- Casing with Sandaband as the annular pressure integrity medium can easily be recovered, by applying torque and pull on top portion above a casing cut, which will remobilize the Sandaband as a liquid.
- Sandaband gives sufficient stability to the casing.
- Sandaband is placed quicker than cement into the well; no waiting on cement hardening and no pressure testing.
- Sandaband provides annulus seal with everlasting properties.
- Sandaband remains forever as a liquefiable material that deforms as required but without fracturing. Sandaband does not develop micro annulus.
- Sandaband does not lose its hydrostatic head.
- Sandaband is not effected by minor casing leaks.
- Sandaband is the perfect "preparation" for the inevitable final well abandonment, for which the superior Sandaband abandonment method should be applied.
- External forces cause less deformation of the casing and no development of annulus or cracks.
- No migration to result in annulus pressure or cross flow between formations.
- Reduced deformation of casing.
- External forces on the casing will not effect the sealing properties in the Sandaband filled annulus.
- Reduced load transfer results in less buckling tendency, corrosion etc..
- Cement fractures and shrinks. Sandaband will become liquid in order to undergo shape change, and is then incapable of fracturing.



The most evident benefits:

- Environmentally superior.
- Protection of ground water.
- Prevents cross flow all along the well.
- Reduces thermal expansion effects by 70% or more.
- Same material has been used in HP/HT well, up to 175°C.
- Perfect for "cementing" of expandable casings.
- Drastically reduced life cycle cost.



SANDABAND

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