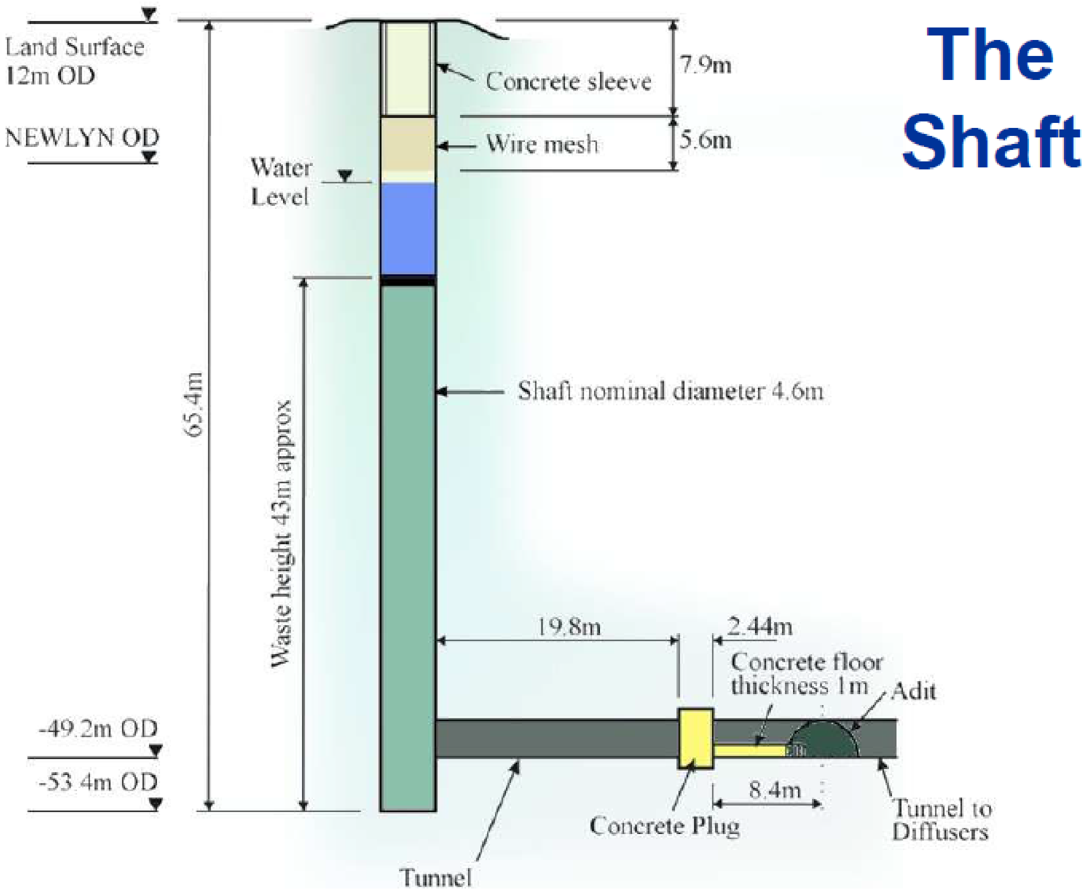
[Form 2 (to be reported to Committee on Countermeasures for Contaminated Water Treatment and to be disclosed to public)

Technology Information	
Area	5
Title	**Management measures to block groundwater from flowing into the site**
Submitted by	**Cavendish Nuclear Ltd (part of Babcock International Group and previously known as Babcock Nuclear Services Ltd)**

1. Overview of Technologies (features, specification, functions, owners, etc.)

At the Dounreay site in Scotland, there is a deep shaft (~4.6m diameter and ~65m deep) that is cut directly into the rock adjacent to the reactor buildings. This shaft was used for disposal of radioactive waste items during the operational phase of the site. Although originally considered to be a final waste disposal option, during the 1990's it was recognised that ground water was penetrating the shaft and leaching out contamination into the surrounding rock structure. As part of the Site closure programme, the waste in the shaft must now be recovered to improve its containment and to decontaminate the shaft.



In preparation for recovering the waste from the shaft, a major project was carried out by DSRL (now part of Babcock International Group) between 2004 and 2009 to hydraulically isolate the shaft from the surrounding rock structure. This operation was necessary to stop ground water flow into and out of the shaft, and thereby prevent any further spread of contamination into the ground.

The shaft is located within a few meters of the sea shore.

Several options and techniques were considered to hydraulically isolate the shaft and these were subject to a detailed technical assessment in order to select the appropriate technique for the shaft hydraulic isolation conditions and requirements:

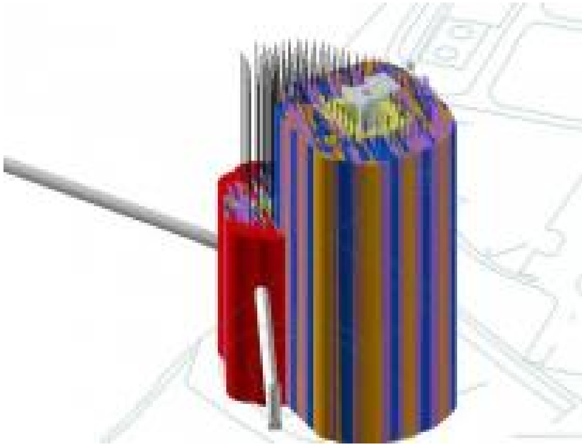
- In-Situ Shaft Pumping
- External Dewatering
- Artificial Ground Freezing
- Secant Piling
- Diaphragm Walling
- Grouting
- Secant Pile with a Grouted Base

The selected method of hydraulic isolation was use of pressure grouting and this process involved drilling approximately 400 boreholes in the rock around the shaft and injecting very fine grout under pressure to seal up the fissures in a 10-metre wide surrounding band of rock. The inner perimeter of the grout curtain is in excess of 100 meters long, as the isolation curtain also has to contain the side tunnel.

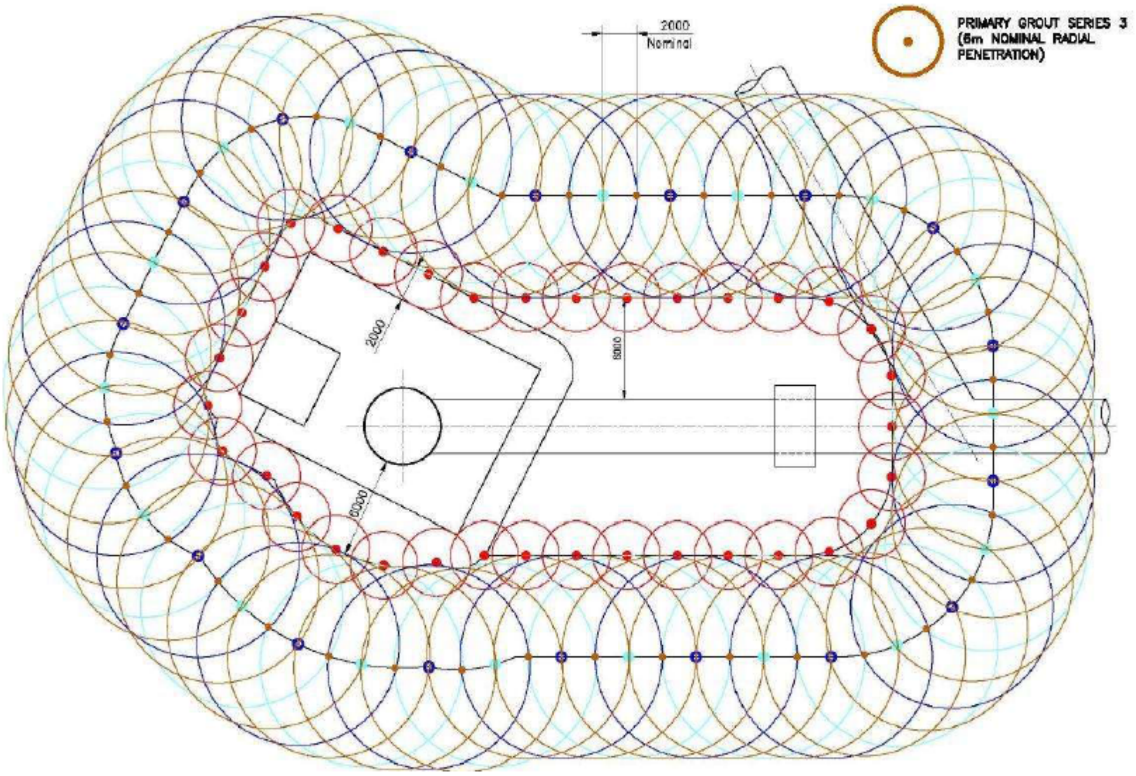
The working concrete platform built around the top of the shaft is shown above.

The preparatory work included the construction of a raised working platform around the top of the shaft and infilling part of the tunnel. The working platform was completed in early 2006 and infilling of the lower tunnel was carried out later in 2006. The grout curtain was constructer in two main phases. Firstly an inner wall of closely spaced grout columns was injected in order to slow down the bulk water flow, and secondly an outer row of larger overlapping grout columns was injected to complete the isolation curtain. In Spring 2008, the team completed the pressure grouting of the rock around the shaft and thereby created the hydraulic isolation wall around the shaft.

The volume of water that needs to be pumped daily from the shaft to maintain its water level below that of sea-level reduced from a maximum of 15 cubic metres per day before the start of grouting in December 2006 to ~ 1.3 cubic metres per day upon completion. Hydro testing has been carried out to validate the performance of the curtain.

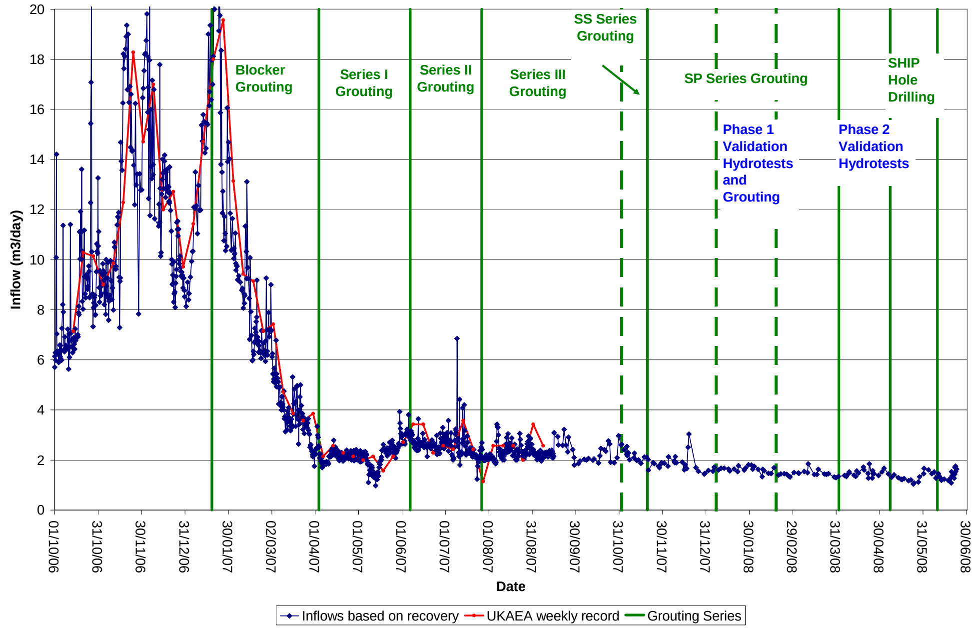


The image above is a computer-generated view of the grout curtain around the shaft, and the image below shows the inner and outer rows of grout injection points that surround and isolate the shaft and side tunnel.



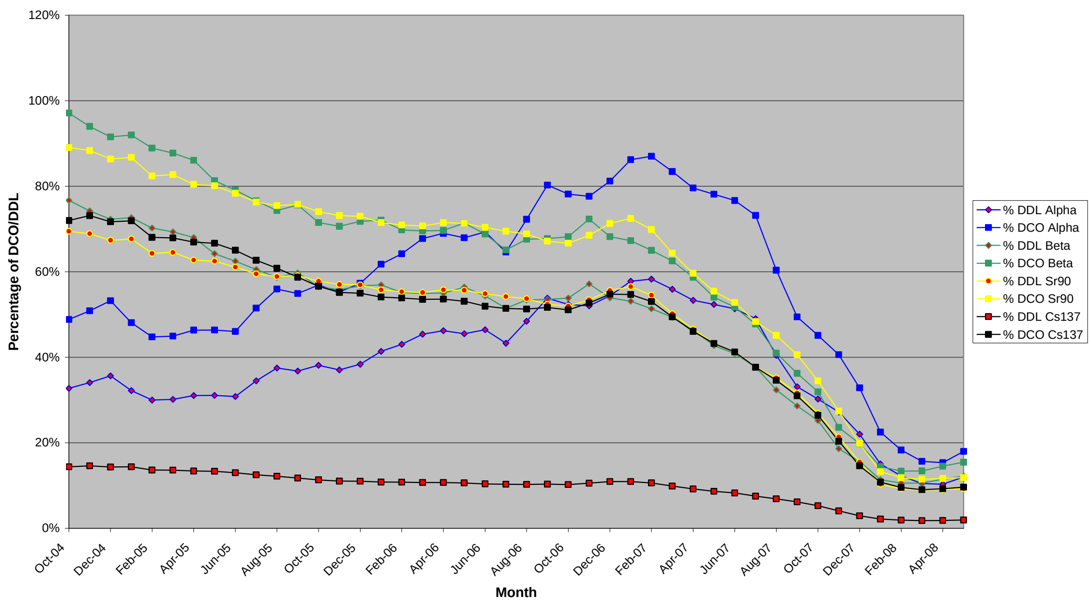
The diagram below shows the groundwater inflow into the Shaft (in metre cubed per day) over the period of the isolation.

Reduction in Shaft Inflow (m³/day) during Shaft Isolation Project



The diagram below shows the Shaft annual rolling liquid discharges as a percentage of the limits set on the facility for alpha, beta, Cs137 and Sr90. From December 2006, it is clear that the levels of these species in the pumped effluent from the Shaft have markedly fallen in line with the reduction in groundwater inflow.

D1225 Shaft Annual Rolling Liquid Discharges



2. Notes (Please provide following information if possible.)

- Technology readiness level (including cases of application, not limited to nuclear industry, time line for application)

Babcock had the same sort of problem that is now faced at Fukushima Dai-ichi – how to stop ground flowing into a contamination zone and how to stop it flowing out.

Babcock considered many techniques for hydraulically isolating the vault - all of which are in common use by the civil or mining industries. After an extensive selection process, the use of a grout curtain was selected as the most effective option for the specific conditions and requirements of the Dounreay project.

The following link shows a video that describes the Dounreay shaft isolation project:
http://www.dounreay.com/news-room/dounreay-tv/hydraulic-isolation-of-the-dounreay-shaft

- Challenges

The use of grout injection may or may not be the correct solution at Fukushima. Further understanding of the geological, hydrogeological and physical ground conditions are needed to confirm the appropriate solution. Cavendish Nuclear has the technical reports and records that describe the very detailed assessment processes and considerations that were used to decide on the correct technical approach for hydraulically isolating the Dounreay shaft. It is worth noting that Babcock did consider use of an ice wall to isolate the shaft, but this option was discounted after due consideration, primarily due to cost considerations.

Babcock has the know-how that is needed in the decision making process. Key issues that need to be addressed are:

- The nature of the ground/soil/rock into which the water is leaking into, or coming from.
- The way in which the ground isolation techniques will function, and how the materials that are inserted into the ground interface with and work with the ground conditions.
- The constraints that the local site imposes and how that affects access for the heavy equipment that is needed to install the ground isolation systems.
- What to do with the contaminated soil that is excavated with some of the isolation techniques.
- How to optimise the solution to give either: the quickest implemented solution, or the lowest cost solution, or the most leak tight solution, or the most durable solution.

- Others (referential information on patent if any)

Cavendish Nuclear now has the know-how and access to the historical records relating to the shaft isolation technology, and records of the shaft isolation project. There are significant lessons learned regarding the nuclear safety implications for such projects. For example, large volumes of contaminated waste may have to be removed and subsequently carefully managed. Considering the effect of the structure or system that is inserted into the ground on the surrounding ground is a major technical issue. The level of leak tightness of the isolation system has to be assessed to ensure that ground water flow can be reduced sufficient to meet the requirements, and also to ensure that groundwater cannot be trapped and cause other problems due to hydrological pressure head and/or effect on ground conditions. Cavendish Nuclear has the know-how and records that captured the lessons learned during the Dounreay project.

If Cavendish is asked to submit a commercial proposal for this technical scope, then we are currently in discussion with Shimizu Corporation (http://www.shimz.co.jp/index.html) regarding future collaboration on this project with Cavendish Nuclear bringing the technical know-how and lessons learned from the Dounreay project, and Shimizu Corporation providing the civil engineering implementation capability.

【Areas of Technologies Requested】

(1) Accumulation of contaminated water (Storage Tanks, etc.)

(2) Treatment of contaminated water (Tritium, etc.)

(3) Removal of radioactive materials from the seawater in the harbor

(4) Management of contaminated water inside the buildings

(5) Management measures to block groundwater from flowing into the site

(6) Understanding the groundwater flow