The Swedish KBS-3 nuclear waste repository concept:

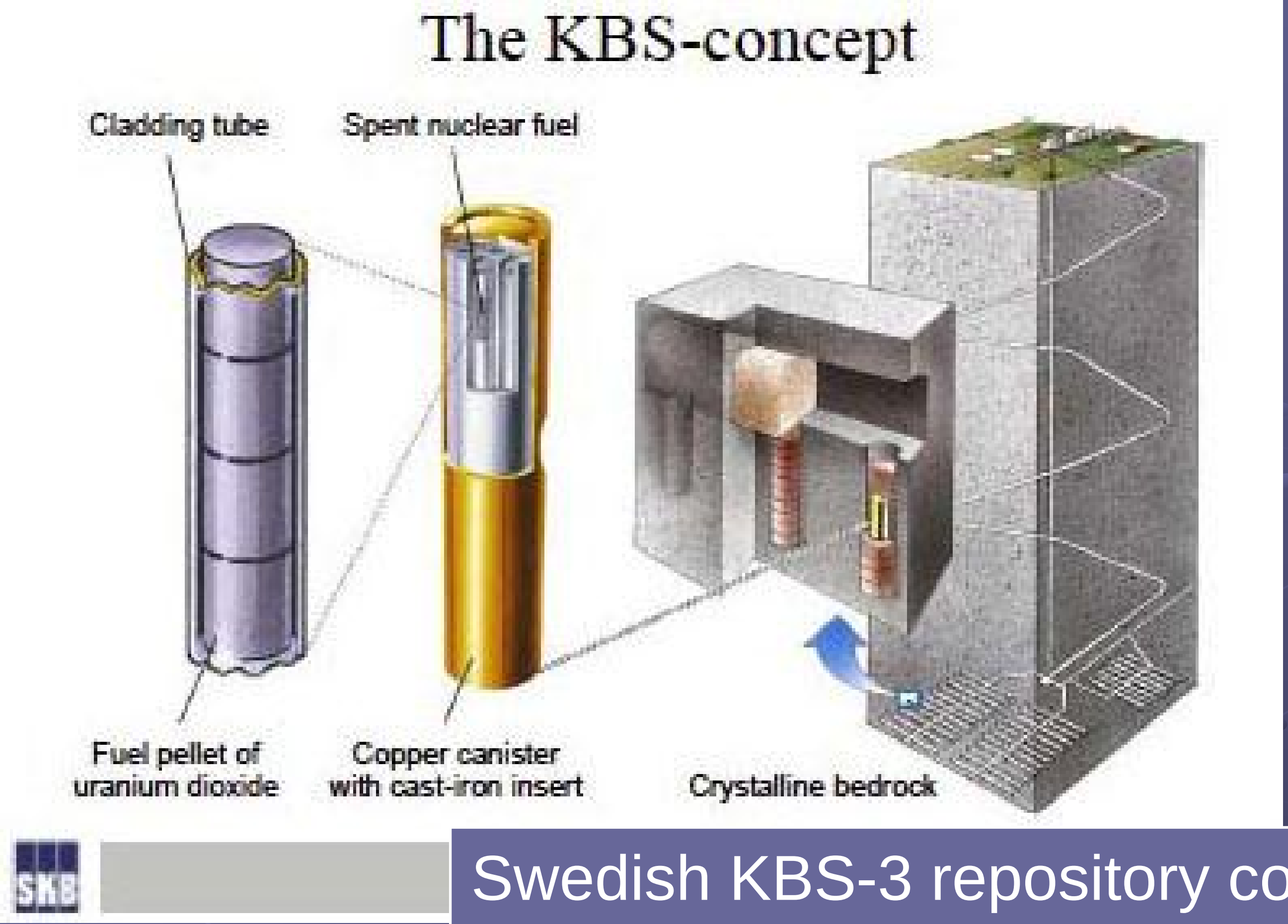
Problems and implications for the UK

David Smythe

November 2012

This disposal concept has been adopted by the UK for high-level waste and spent fuel.

This short slideshow summarises why it does not work.



Swedish KBS-3 repository concept:

- Fuel placed in isolating **copper canisters**
- With a high-strength **cast iron insert**.
- Canisters are surrounded by **bentonite clay**
- In individual deposition holes at **500 m depth**
- In **granitic bedrock**.

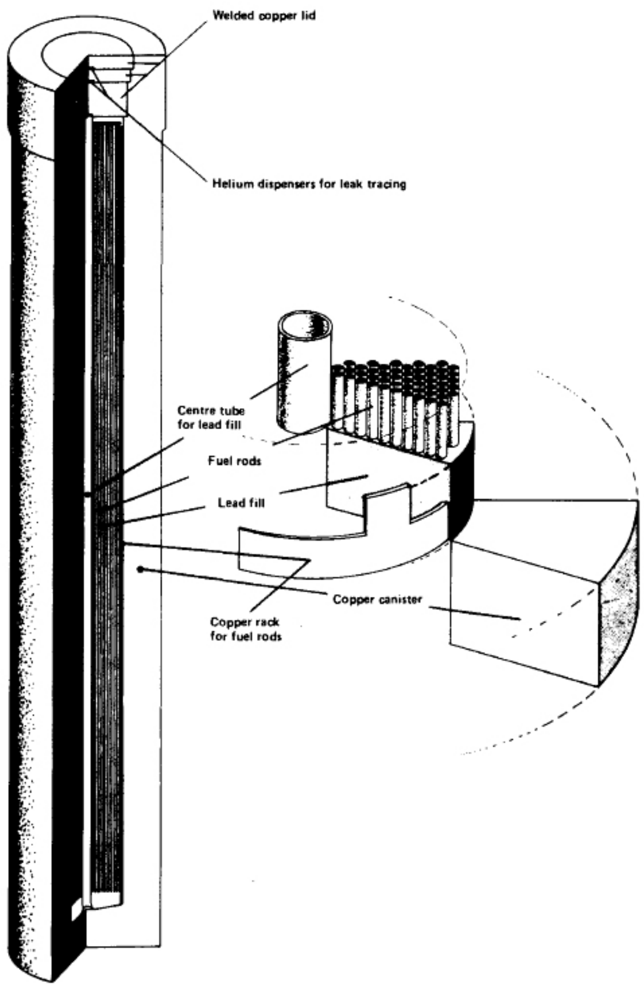


Figure 5. The encapsulated waste. The copper canister is 4.7 metres long and has a diameter of 0.8 metres.

Original KBS copper cylinder:

Wall thickness of copper:

- **1977 – 20 cm (left)**
- **1983 – 10 cm**
- **1999 – 5 cm**

Is the progressive reduction in thickness justified, or merely expedient?

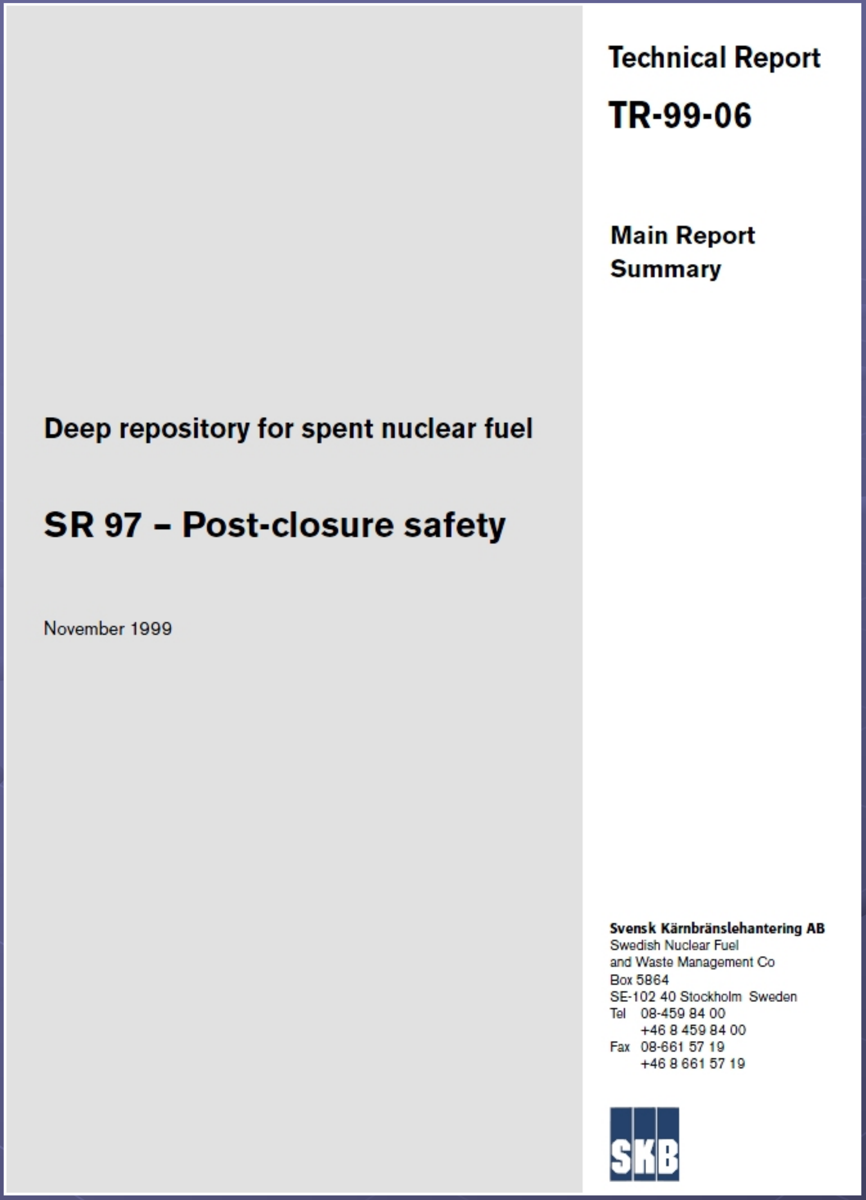
Current copper cost per cylinder (5 cm) = $18K

TABLE 7. Calculated canister dissolution times (yr).

KBS-I:		
Titanium (6 mm)	$>10^4$	pinhole >500
Lead (100 mm)	$>10^6$	pinhole >500
Borosilicate glass	$3 \times 10^4 - 3 \times 10^6$	
KBS-II:		
Copper (200 mm)	$>10^6$	
Lead (interstitial)	not accounted for	
Zircaloy (~1 mm)	not accounted for	
Uranium dioxide	$\sim10^6$ (carbonate complex)	
Alumina (corundum)	$>10^4$	

This table shows that a 20 cm thick Cu canister is supposed to last for more than 1 million years.

Source: Rydberg (1981); KBS-2 is for spent fuel.


Technical Report

TR-99-06

Main Report
Summary

Deep repository for spent nuclear fuel

SR 97 – Post-closure safety

November 1999

Svensk Kärnbränslehantering AB
Swedish Nuclear Fuel
and Waste Management Co
Box 5864
SE-102 40 Stockholm Sweden
Tel 08-459 84 00
+46 8 459 84 00
Fax 08-661 57 19
+46 8 661 57 19

SKB

Further confidence in KBS-3

SR 97, published 1999

"Canister corrosion"

"Copper is very stable in the environment in a deep repository. The only known copper corrodant that has been identified in deep Swedish groundwaters is sulphide. Initially, oxygen is also present in the buffer and the tunnel backfill, as is sulphate which can be converted to sulphide. Soon after deposition, small quantities of nitric acid could also conceivably be formed by radiolysis of the buffer's pore water. **Pessimistic rough calculations show that none of these factors threatens canister isolation, even in a million-year perspective.** Nor has any mechanism that could lead to a local corrosion attack been identified."

BUT

Sweden has a robust and independent safety authority, SSM (as does France),

and

funds an independent NGO office (MKG) to scrutinise work.

[NB The UK has neither of these]

Strål
säkerhets
myndigheten
Swedish Radiation Safety Authority

… and the SSM has recently shown that this confidence in KBS-3 is unfounded

SSM report on copper
(Macdonald and Sharifi-Asl 2011):

“Accordingly, the assumption that copper will be immune during the anoxic storage period is untenable, despite the fact that native deposits of copper do occur in granitic formations. The success of the KBS-3 program must rely upon the multiple barriers being sufficiently impervious that the corrosion rate be reduced to an acceptable level.

…

If the proposed corrosion scenario posed by SKB is correct, that the rate of copper corrosion is determined by the rate of mass transport of sulfide ion through the bentonite buffer, the question must then be asked: “Why use copper?” “Would not a less expensive and hence more costeffective alternative, such as steel, suffice?” Answers to these questions possibly lie outside of the realm of corrosion science.”

mkg

Miljöorganisationernas kärnavfallsgranskning

Swedish NGO Office for Nuclear Waste Review

“Why the KBS method will not work”

MKG interprets these results

“After the emplacement of the canisters and clay the oxygen in the repository is quickly consumed by bacteria and chemical processes. The fundamental assumption in the KBS method is that very little corrosion takes place in an oxygen-free environment. The canister walls are 5 centimetres thick and only a millimetre or two of the copper is supposed to corrode in a million years.

Pitting can result in penetration

Once copper begins to corrode, the process can proceed quickly through so-called pitting, which gives pox-mark indentations in the surface. The risk of pitting has led critical researchers to fear that the copper canisters may start to leak after only some hundreds of years — instead of after hundreds of thousands of years. (Fig 4).”

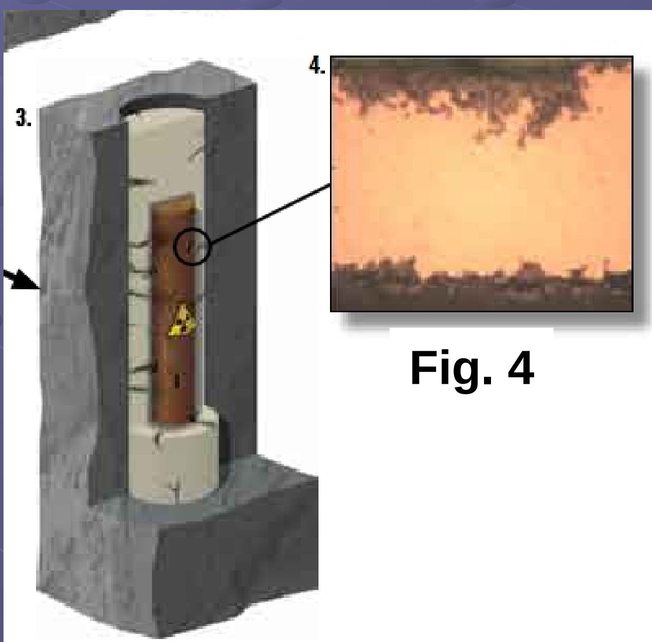


Fig. 4

Is the UK adopting the KBS-3 concept, or not?

Joint BGS/Nirex statement, March 2006

"The BGS has reviewed the characteristics of existing ILW/LLW disposal concepts and the geological factors relating to packaged HLW/spent fuel (KBS-3 concept) and believes that the geological conditions that would be suitable for the former will also be appropriate for the isolation of the latter."

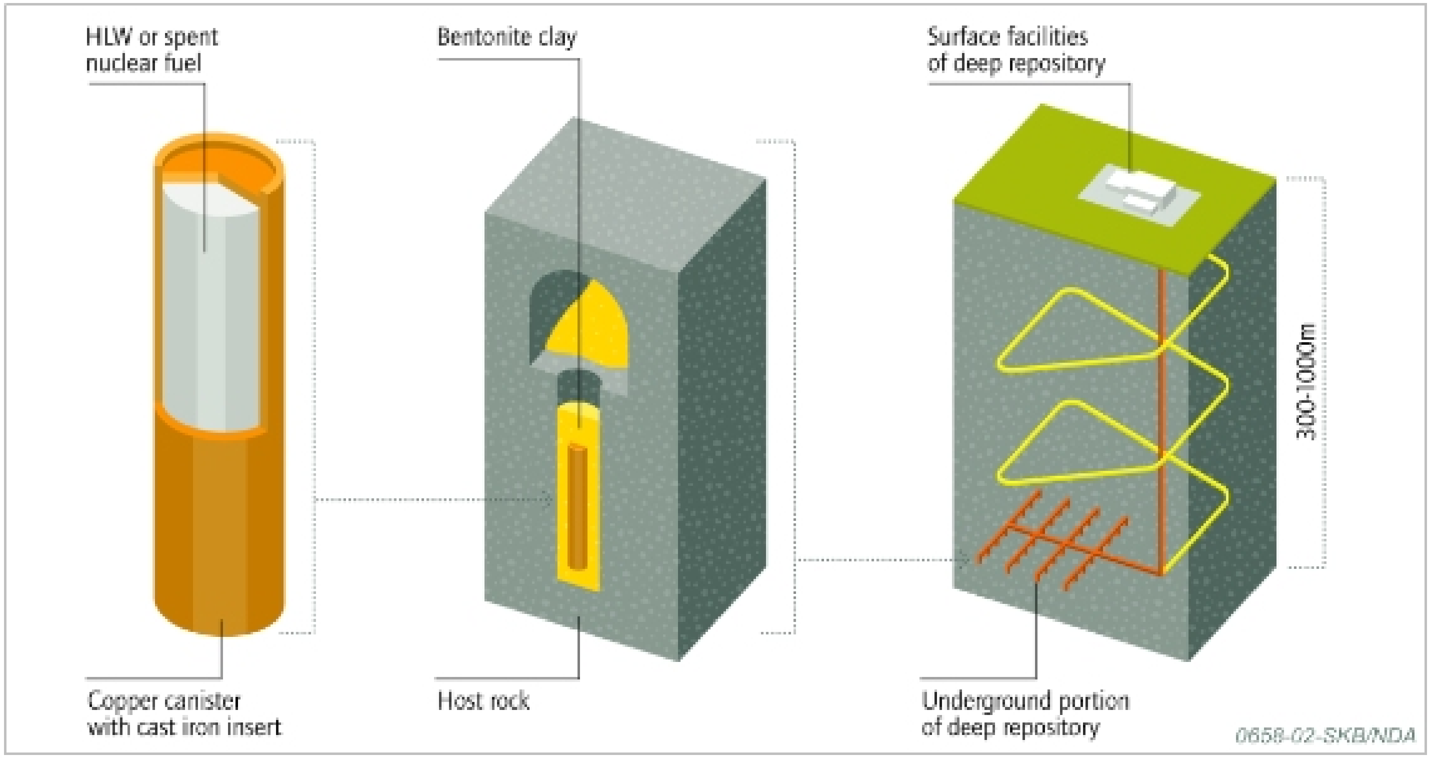
CoRWM doc 2456 Sep08

BGS response to CoRWM (Committee on Radioactive Waste Management) questions:

"BGS do not think the KBS-3 concept is applicable to the UK situation due to the combination of the UK's geology and variety of waste forms."

So the British Geological Survey (BGS) has changed its mind about KBS-3 in under three years.

Figure A2 Illustration of the KBS-3V Concept (SKB, Sweden – as adapted by the Nuclear Decommissioning Authority, 2010)



Source: Nuclear Decommissioning Authority (NDA) (2010)

But the NDA still appears to think that the KBS-3 concept is applicable in the UK

Entec for NDA, October 2010

Table 1.1 Illustrative geological disposal concepts

Host rock	Illustrative Geological Disposal Concept Examples[d]	
	ILW/LLW	HLW/SF
Higher strength rocks[a]	UK ILW/LLW Concept *(NDA, UK)*	KBS-3V Concept *(SKB, Sweden)*
Lower strength sedimentary rock[b]	Opalinus Clay Concept *(Nagra, Switzerland)*	Opalinus Clay Concept *(Nagra, Switzerland)*
Evaporites[c]	WIPP Bedded Salt Concept *(US-DOE, USA)*	Salt Dome Concept *(DBE-Technology, Germany)*

0649-02-NDA

Notes:

a Higher strength rocks – the UK ILW/LLW concept and KBS-3V concept for SF were selected due to availability of information on these concepts for the UK context.

Evidently the NDA is still working with the KBS-3 concept for the UK, despite its intrinsic shortcomings, and despite the declaration by the BGS. The V-suffix means the vertical emplacement option.

Conclusions and lessons to be learned

- The KBS-3 concept is fundamentally flawed
- The UK has not got a viable encapsulation concept
- The final, and most important, barrier remains the geology

We already know that the UK is searching for a repository site in the most unsuitable area in England.

Twenty-five years of proper research into both encapsulation and geological siting now needs to be undertaken by the UK.

The pronouncements of nuclear engineers about the performance of their ‘Engineered Barriers’ such as KBS-3 are grossly optimistic.

Given this under-performance on both fronts, priority should now be given to building interim (100 years) safe surface storage at Sellafield, while geological disposal is researched thoroughly and without haste over the next quarter of a century or more.