

### **3DD - Three Dimensional Disposal of Spent Nuclear Fuel - 12449**

Marketa Dvorakova\*, Jiri Slovak\*

\*Radioactive Waste Repository Authority (RAWRA), Prague, Czech Republic

#### **ABSTRACT**

Three dimensional disposal is being considered as a way in which to store long-term spent nuclear fuel in underground disposal facilities in the Czech Republic. This method involves a combination of the two most common internationally recognised disposal methods in order to practically apply the advantages of both whilst, at the same time, eliminating their weaknesses; the method also allows easy removal in case of potential re-use.

#### **CURRENT SITUATION WITH REGARD TO DEEP GEOLOGICAL REPOSITORY PROJECTS**

It is currently assumed that the permanent disposal of spent nuclear fuel (SNF) and high level waste (HLW), following the reprocessing of spent nuclear fuel, will be disposed of in deep geological repositories (DGRs) located at a substantial depth within homogenous rock massifs. Currently, a number of technologically advanced methods are being considered for the storage of spent nuclear fuel and high level waste in deep geological repositories all of which combine two basic principles.

The first method assumes the disposal of SNF and HLW in so-called disposal overpacks or containers in short vertical disposal wells sunk in underground disposal galleries accompanied by the filling of the space between the container and the surrounding rock with a bentonite buffer layer. Due to heat dissipation from the container and in order to avoid the potential negative effects of a substantial temperature increase caused by the container, as well as for other construction reasons, it is necessary to construct disposal wells with a sufficient distance between them. It is planned that just one container will be stored in each of the wells in order

to allow for potential future ease of handling should removal be necessary. The roof of the disposal gallery above the disposal well will have to be high enough so as to allow the container to be turned from the horizontal transport position to the vertical position prior to insertion into the disposal well. This method of disposal is potentially challenging in terms of handling space requirements - the height of the roof of the disposal gallery must be sufficient so as to allow for the turning of the container into a vertical position above the disposal borehole. Moreover, the storage of a single container in each disposal well means that the space requirements of the repository within the rock massif will be substantial. In summary, this method will require a large amount of valuable disposal space especially in terms of area as well as the removal of a huge amount of rock during construction due to the vertical space required for this type of emplacement process.

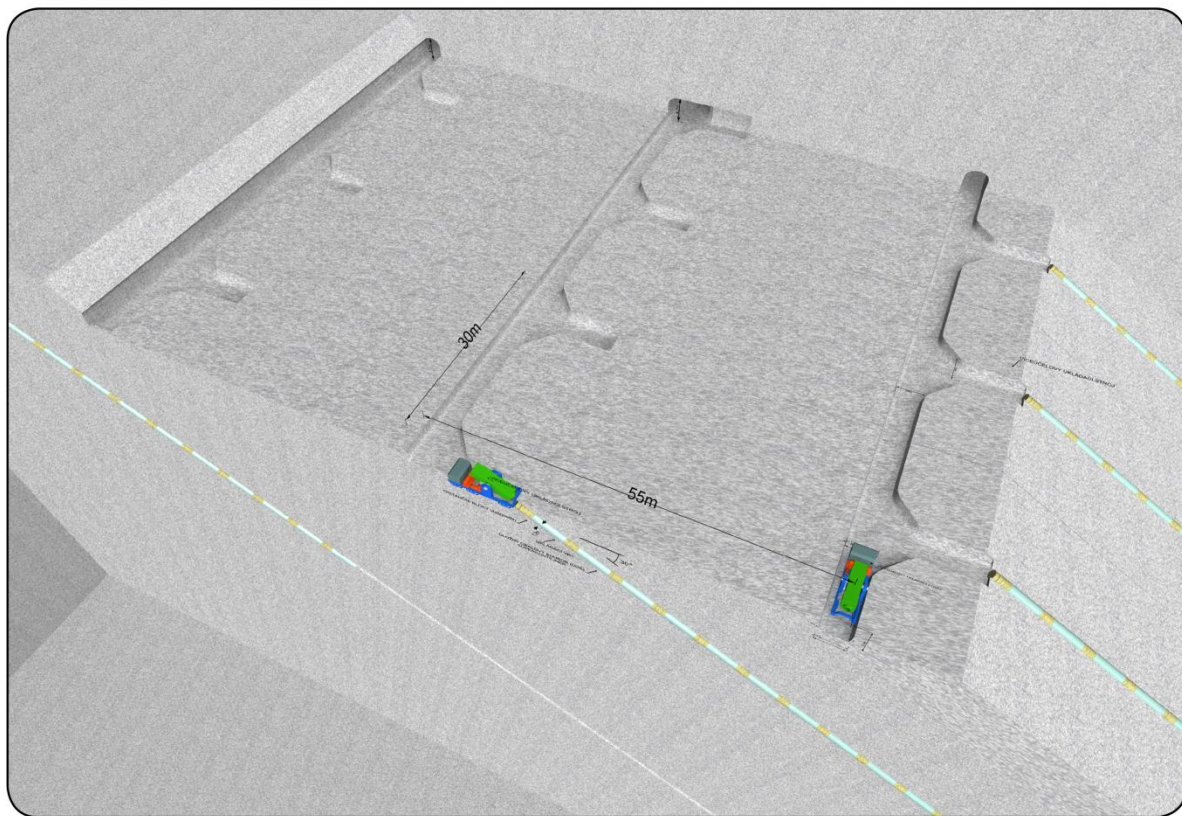
The second method assumes the disposal of containers in long horizontal wells (approximately 250 to 300m long) leading from the disposal galleries in the form of so-called supercontainers fitted with a bentonite buffer layer. This method optimises the use of the limited space available in the underground environment. Nevertheless, this method also requires the use of a complicated mechanism for the insertion of the supercontainer into the final disposal position in the horizontal disposal well the reasons being the distribution of gravitational forces and handling in a very limited space. In addition, this method, as with the first, does not lend itself to removal of the SNF container should it be necessary; in other words handling is very complicated and expensive. The advantage of this method over the first method, however, consists of a reduction in the excavated space required in the disposal wells and the consequent extraction of smaller quantities of rock and the more efficient use of the disposal space. This method of disposal is especially suitable for homogeneous rock massifs - homogeneous granite or complex layers of homogeneous sediments (clays, clay stones). Complications occur in heterogeneous disposal locations in terms of ensuring the stability of the well over the long time period required and in terms of characterisation and compliance with the many functions required of such a facility.

Both the above methods do not adequately consider the potential removal of stored

SNF for reprocessing or other further use. Should it be necessary to remove SNF in the future, it would entail employing a complex handling procedure to physically extract the container which, due to the swelling pressure of the surrounding bentonite seal, would be firmly anchored in the well.

### **THE THREE DIMENSIONAL DISPOSAL WELL METHOD**

The principle of spent nuclear fuel disposal in inclined wells is based on disposal in sloping disposal wells wherein the individual components of the disposal system are constructed gradually in 3 basic stages, with the maximum use of gravitational forces and without a complex handling procedure, in long, narrow disposal wells.



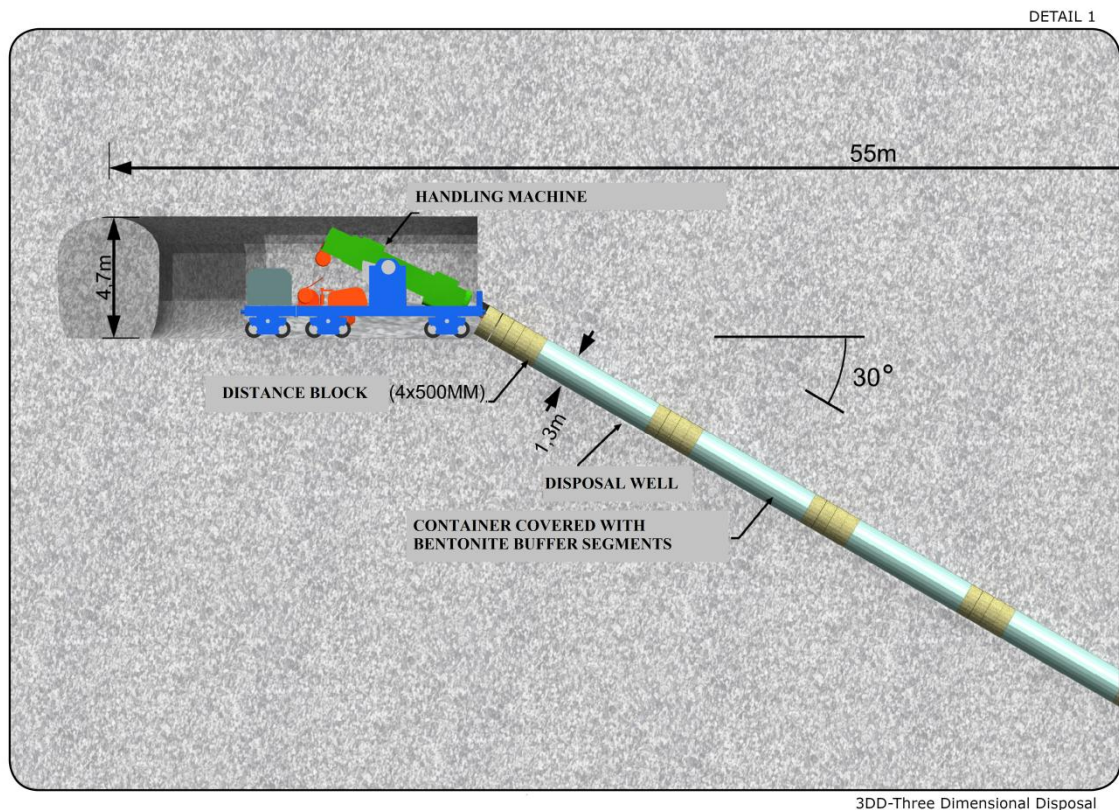
The three stages consist of:

#### **1. Preparation of the disposal well**

-A characterisation (guide) borehole is drilled into the gallery floor or side of

the gallery at an angle of around 25 degrees (range 20 to 30 degrees) with a diameter of 120mm and in excess of the planned length of the disposal well to be used to characterise the disposal well and for decision-making purposes with regard to the exact positioning of the stored waste.

-A disposal well of the required diameter is then drilled following the line of the characterisation borehole.



## 2. Disposal - the construction of individual components of the disposal system and placement of the first disposal container

- Firstly a bentonite “plug”, which will serve as the end backfill for the first container, is inserted into the disposal well so as to rest against the end of the well. The plug is transported to the lower part of the well using a specially-designed storage “head” which is able to move freely within the whole length of the well.

- Using the storage head, the first container is inserted into the well so as to lie upon a pre-prepared layer of bentonite segments placed on the sloping “floor” of the well and resting against the bentonite plug.
- The remaining space around the disposal container is then filled with sprayed buffer material or with bentonite segments identical to those used to support the container. In this way the container will be securely sealed within the disposal well.

### **3. Disposal of further containers**

- Once the first container has been firmly anchored within the well, a second bentonite plug is inserted so as to cover the top of the container and to form a supporting layer upon which the second disposal container will rest. Subsequently the process described above is repeated until the whole of the well has been filled with disposal containers. The top of the well is then sealed with a concrete plug and disposal continues in the next inclined disposal well.

## **ADVANTAGES OF THE PROPOSED SOLUTION**

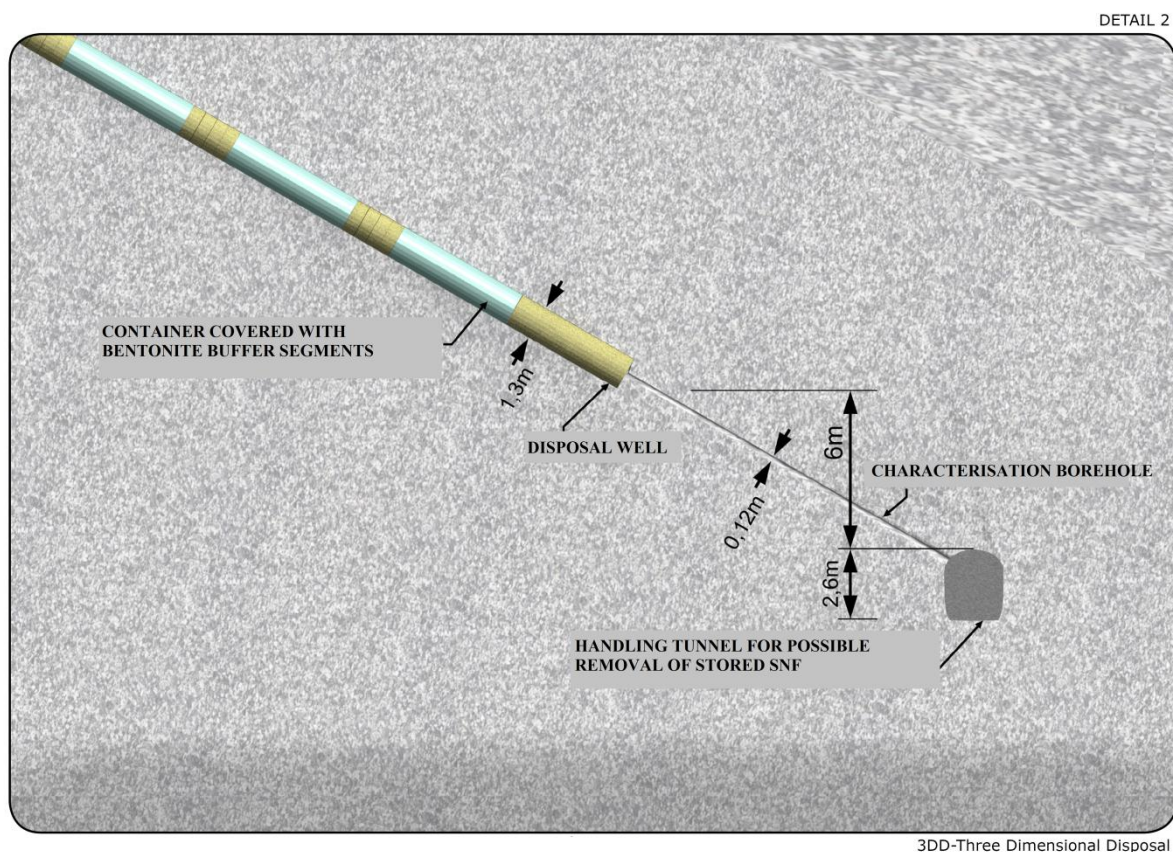
- a) Simplified disposal handling procedure. The three dimensional disposal system using disposal wells inclined at an angle of 20- 30° will allow the simplified disposal handling of both the container and the bentonite buffer segments. Disposal of the container will be assisted by gravitational forces and a cable connected to a specially-designed storage head.

- b) Removal of stored SNF.

The angled design will allow containers to be removed via tunnels constructed independently of the disposal and access galleries and running below the bottom of the disposal wells. Access tunnels will be constructed in intact rock using technological processes which will have no connection to the original disposal tunnel complex; the inclined nature of the disposal wells will guarantee the stable positioning of the containers even after the release of pressure following the removal of the first container. The disposal wells will be located by means of the extended



characterisation borehole running the length of the disposal well and beyond. The part of the characterisation borehole running beyond the disposal well proper will be filled with a suitable marking material of an easily distinguishable colour. The procedure may trigger the release of pressure conditions around the container created by the bentonite buffer material which may require the subsequent capture of the container by specially-designed recovery equipment whereupon the container will be “pulled” into the tunnel and thence removed from the repository for further use. Such handling will require the radiation protection of repository workers by means of the use of remote technical methods.



## CONCLUSION

The proposed method for the disposal of spent nuclear fuel will reduce the areal requirements of future deep geological repositories by more than 30%. It will also simplify the container handling process by using gravitational forces in order to meet requirements concerning the controllability of processes and ensuring operational and nuclear safety. With regard to the issue of the efficient potential removal of waste containers, this project offers an ingenious solution which does not disrupt the overall stability of the original disposal complex.

## REFERENCES

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