
A rationale for the safety of a long-lived low-level waste disposal facility

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Abstract:

The French Law of 2006 on radioactive waste management requires in particular implementing solutions for the elimination of graphite waste from the dismantling of first generation reactors as well as some radium containing waste. The rationale for the safety of a facility designed for the disposal of such waste, which has led to the recent publication by the French Safety Authority of a guidance document on safety issues to be accounted for during the site selection step, is summarised.

1 INTRODUCTION

The safety of a disposal facility must be commensurate to the potential danger of the waste for which it is designed. Consequently, every disposal facility must meet two general objectives:

- its design must be based on a clearly defined industrial need and thus on eliminating well-identified categories of waste;
- it must prevent the dissemination of radioactive substances while waste undergoes radioactive decay until a residual level is reached which is unlikely to give rise to unacceptable exposure of humans or the environment, even if a significant loss of the facility's confinement properties occurs.

To reach these objectives, it must be provided for a set of measures appropriate to the inherent risks caused by the waste. In general, the design of a disposal facility must be based on the favourable properties of the geological formations on or in which the waste is placed, the depth of burial, the safety functions of multiple physical barriers (waste packages, engineered barriers, covers or seals), and the limitation of the radioactivity stored. Organisational provisions are also required so as to allow for appropriate surveillance of the facility. However, the use of some or all of these measures depends on the waste categories to eliminate.

2 PRINCIPLES FOR THE SAFETY OF RADIOACTIVE WASTE DISPOSAL FACILITIES

2.1 Very Low Level Waste disposal

France has decided to dispose of the lowest-level category, known as very low-level waste (VLLW), in dedicated surface facilities. VLLW waste is of sufficiently low radioactivity such

that the potential consequences resulting from the dissemination of the radionuclides contained in the waste are of no significant concern for radiological protection purposes; furthermore, no surveillance period is necessary to ensure enhanced containment while waste decays to residual levels (these levels are already sufficiently low at reception of the waste in the facility). Thus, rather light safety measures are legitimate for VLLW disposal, the critical point being effective sorting upstream.

2.2 Short Lived Low and Intermediate Level Waste disposal

Surface disposal has also been chosen for short-lived low and intermediate level waste (LILW-SL), but to ensure the safety of this disposal option, the waste must be effectively confined until most of the radioactivity contained has decayed. The estimated duration of this confinement is 300 years. Multiple physical barriers (packages, structures, cover) are set up between the waste and the environment to preclude radioactive dissemination for the required period, and institutional control is maintained for at least 300 years to correct any disturbances and prevent intrusion. Beyond that time, discontinuation of institutional control is postulated and, by correlation, a significant loss of the facility's confinement properties. In this case, the residual radioactivity may be mobilised by natural phenomena and by a set of inadvertent intrusion scenarios (resulting from human activities such as agriculture or urban development). Consequences from these events remain acceptable if a strict limitation of the amount of long-lived radionuclides contained in the waste is applied. The radioactivity within the facility should also be distributed as uniformly as possible, to avoid hot spots which might undermine the demonstration of the facility's long-term safety.

2.3 High Level Waste disposal

Deep geological disposal is the solution currently under study to eliminate long-lived intermediate and high level waste (IL/HLW-LL). The levels of radioactivity in this type of waste are such that a significant loss of the overall confinement properties of the disposal system would not be acceptable until after several hundreds of thousands of years. Furthermore, the highest-level waste emits heat for several thousands of years due to its very high radioactivity, requiring specific safety measures to prevent possible adverse effects from this phenomenon. To manage IL/HLW-LL risks, the recommended disposal method is based on isolating the waste from human activities and climate variations by installing the facility at a depth of at least 200 m. It is also based on confining the waste in a stable geological medium and in a host layer characterised by particularly slow water flows. The safety of this type of facility will also depend on high performance packages and seals capable of limiting radioactive dissemination if the geological barrier fails. Thus, IL/HLW-LL geological disposal is quite logically the elimination method requiring the most effective and robust dispositions, for safety reasons.

2.4 Long Lived Low Level Waste disposal

The design of disposal facilities for long-lived low-level waste (LLW-LL) should primarily aim to eliminate graphite waste and radium-bearing waste, as stipulated by the Law (Law on radioactive waste management No. 2006-739 of 28 June 2006). Most of the long-lived radioactive inventory of graphite waste consists of carbon-14, which needs a few tens of thousands of years to decay significantly. Radium-bearing waste, if containing radium-226

well in excess of Uranium-238, will also undergo considerable decay during a few tens of thousands of years, similar to graphite waste. Consequently, the objective of this type of disposal facility must be to effectively confine the waste during the above-mentioned decay period (around 10^4 years) in order to reach a residual level of radioactivity which could not cause unacceptable exposure, even if there was significant loss of the facility's confinement properties. Given the time during which the waste must be confined, most of the general objectives and long-term safety principles mentioned above for the geological disposal of IL/HLW-LL are applicable. However, a LLW-LL disposal facility should differ substantially from a geological disposal facility in terms of adapting the safety provisions needed to the inherent risks caused by the waste. More specifically, given the low risk of LLW-LL compared to IL/HLW-LL, it is legitimate to consider that performance requirements for the various barriers and equipments aimed at ensuring the safety of a LLW-LL disposal be less stringent than those required for a geological disposal facility. It is of course the designer's responsibility to specify these requirements according to the results of its safety assessment. Nonetheless, it appears at this stage that the main differences would involve the depth and required performance over time of the geological medium, the performance of the packages, and the design provisions aimed at ensuring the facility's safe operation. However, the long-lived radioactivity disposed of in the facility will obviously need to be limited, as in surface facilities, particularly for radionuclides not likely to decay in a few tens of thousands of years. It may also be necessary to examine setting rules on the distribution of radioactivity within the facility, to limit local activity concentration that would induce a risk increase once the site is no longer protected from ordinary human intrusion. The radioactivity limitations will thus be fundamental elements for defining the waste categories that could be accepted in a LLW-LL disposal facility.

The LLW-LL disposal facility is therefore an "intermediate" facility between a surface facility and a deep geological facility which, if designed upon the above-mentioned principles, may contribute to the overall optimisation of the solutions for radioactive waste elimination in France.