

SIMILARITIES OF DESIGN AND OPERATION BETWEEN WIPP AND ANDRA'S FRENCH UNDERGROUND REPOSITORY PROJECT

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ABSTRACT

On initial observation, the Waste Isolation Pilot Plant (WIPP) in New Mexico, USA, and the ANDRA underground repository project in Bure in Eastern France seem to have little in common. For example, WIPP is constructed in a salt formation while the ANDRA project is constructed in argillaceous rock. WIPP is dedicated to defense-generated transuranic (TRU) waste while the ANDRA project is considering a comprehensive inventory of radioactive waste including vitrified high-level waste and spent fuel. Finally, WIPP has been in waste disposal operation since 1999, and the ANDRA project is still on the drawing board.

Despite these obvious differences, WIPP and ANDRA staff noted several years ago that there were many similarities in term of design and operation. These similarities have been compared and evaluated through a program of cooperation that promotes sharing of experience in deep geologic repository design, operation and safety.

Through the program of cooperation, which began in 2001, WIPP participants shared the experience gained and lessons learned during the design, construction, testing and operational phases of the repository. This cooperation is the first of its kind insofar as it focuses on engineering, operation, and operational safety while most international cooperation programs emphasize scientific matters. This paper describes the merits of this cooperation and the resulting benefits to both projects.

INTRODUCTION

The WIPP and the ANDRA repository projects have many interesting differences. The WIPP repository is constructed in a salt formation while the ANDRA project is in argillaceous rock. WIPP is dedicated to defense TRU waste while ANDRA is considering a wide comprehensive inventory of radioactive waste including wastes from reprocessing (vitrified waste) as well as spent fuel. Most of the waste disposed of at WIPP is contact-handled TRU waste, with a surface dose rate below 2 mSv/hr. All of the French waste considered for disposal at the ANDRA repository has a dose rate level which requires specific radiological shielding. The period of time taken into account by the US Department of Energy (DOE) for long-term safety analysis is 10,000 years, while ANDRA carries out its computation over a period of 1,000,000 years. WIPP

has been an operational facility since March 1999, and the ANDRA project is still on the drawing board.

Despite these differences, there are many operational and design similarities between the WIPP repository and the ANDRA project:

- Underground drift layout and the associated logic of operation and ventilation – both projects are based on disposal panels consisting of a U-shaped drift and a network of four parallel access drifts constructed in the central axis of the disposal area;
- Number, function and location of the shafts – both projects have four shafts (waste transportation, rock or salt handling, air intake, and air exhaust), all at locations separated from the waste disposal area;
- Waste transportation between surface and underground – both projects use a vertical shaft, equipped with a Koepe pulley system, to transport waste from surface to underground; and
- Nuclear safety analysis and management – both projects include operational safety analysis (based on deterministic identification of risks and quantitative analysis of accident scenarios) in the design of facilities and processes.

Through the program of cooperation between WIPP and ANDRA, WIPP staff have shared the experience gained and lessons learned during the design, construction, testing and operational phases of the repository. This cooperation, focusing on engineering, operation and operational safety, has resulted in significant benefits to both WIPP and ANDRA.

Underground Drift Layout - Same Logic of Operation and Ventilation

In both projects, the logic of the underground layout (Fig. 1) is based on two categories of elements:

- The disposal panels, which consist of a U-shape drift, and
- A network of four parallel access drifts constructed in the central axis of the disposal zone.

The logic that has prevailed in both cases in such a design is based on the necessity of carrying out mining activities and waste emplacement operations simultaneously.

Figure 2 shows the logic used at WIPP and under consideration at ANDRA as well: among the four parallel access drifts, two are used for the ventilation of the panel under construction and the other two are used for the ventilation of the panel in which the waste is being emplaced. These two circuits (construction and operation) are separated by ventilation doors. The green arrows represent the logic of progression of the panel construction and operation; the first panel to be constructed is the closest from the shaft zone. Then a second panel is constructed while the first one is operating. When the full row of panels is completed on one side of the disposal zone, the reverse order is adopted on the other side.

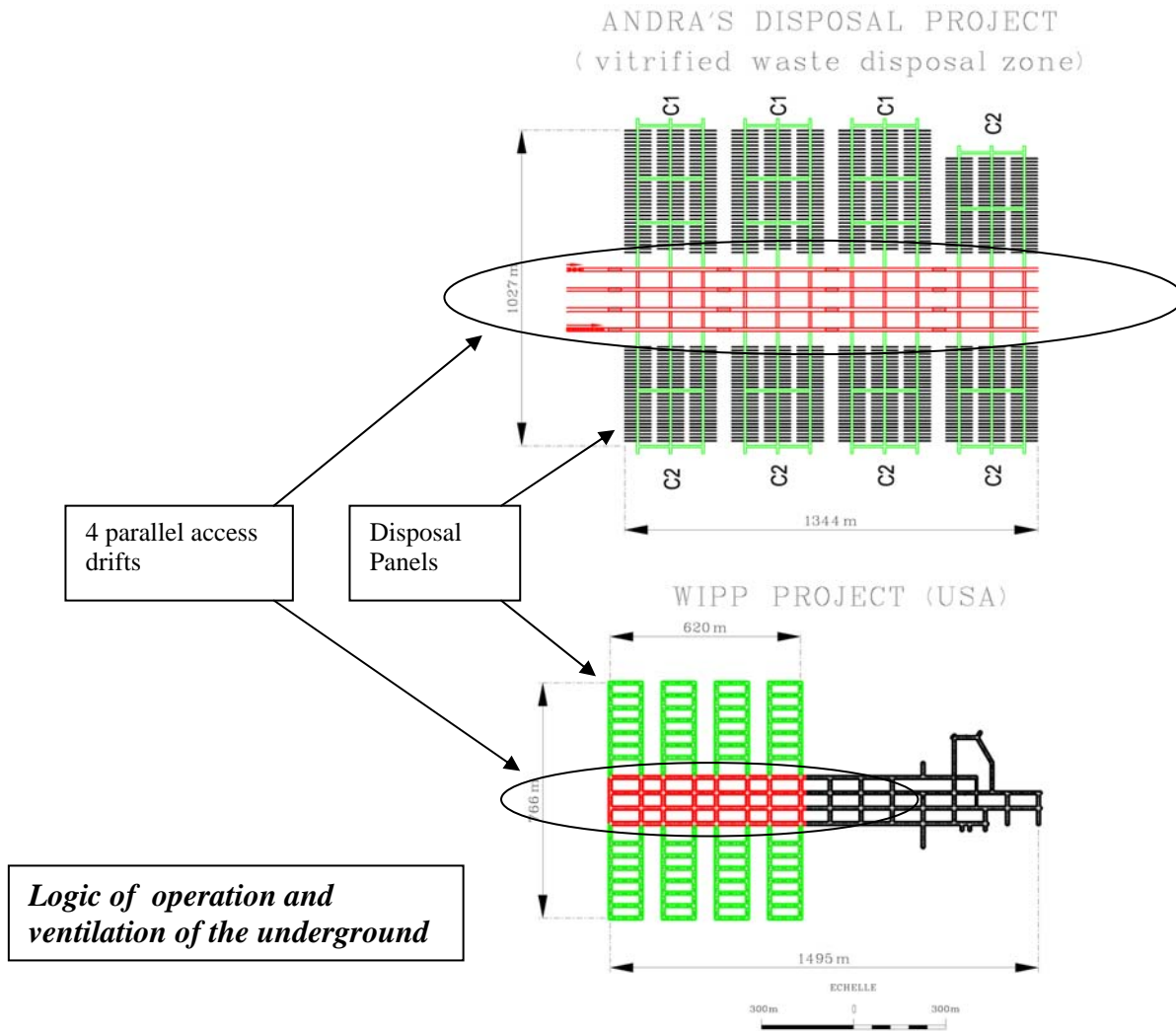


Fig. 1 WIPP project and ANDRA concept: a similar layout

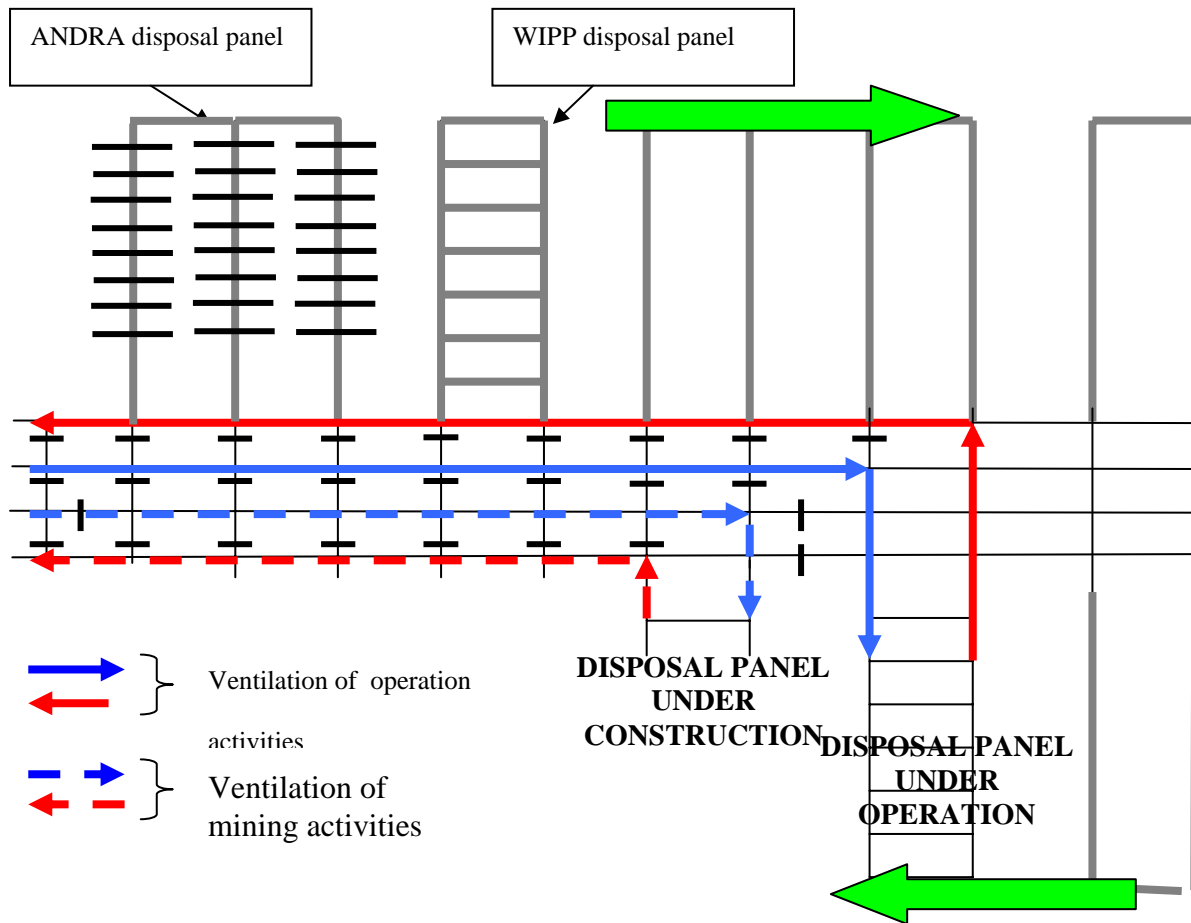


Fig. 2. Logic of construction and operation of the underground facilities implemented at WIPP and considered at ANDRA.

Based on this logic, the waste handling ventilation circuit is separated from the mining circuit. The dust generated by the excavation activity does not affect the area in which waste handling and emplacement operations are carried out. This measure also constitutes a mitigation measure in that contaminated air from a radioactive release generated by an accident during waste emplacement would not affect the mining zone.

Moreover, the method of first constructing the disposal panel nearest the shaft zone allows the initial capital investment to be kept to a minimum. As a matter of fact, the length of the access drifts which are constructed at the same time is adapted to the requirement of the panel. In addition, this principle allows flexibility for the operator: since no drifts or disposal panels are constructed in advance, design modifications can be made based on lessons learned during the first phase of operation.

Figure 3 shows how this logic is applied to the ANDRA disposal concept for vitrified waste.

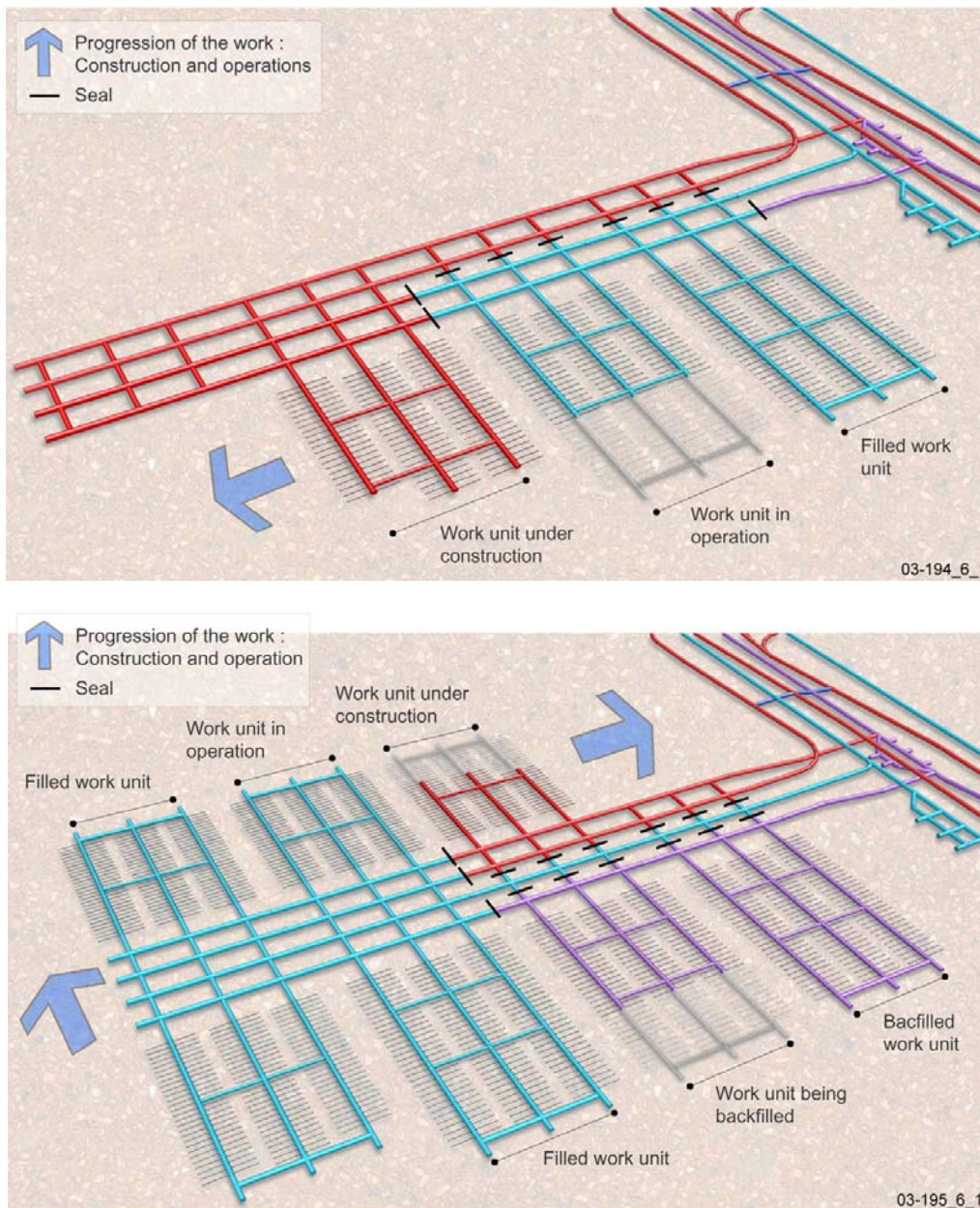


Fig. 3 Construction and operation of the ANDRA disposal concept for vitrified waste (Top: Phase 1, Bottom: Phase 2).

ANDRA is considering three disposal zones: B type waste (intermediate level long-lived waste -- notably bitumen and hulls and endpieces), C type waste (vitrified waste), and spent fuel (MOX). In each zone the principle of four central parallel access drifts is also adopted in order to separate the ventilation dedicated to the mining work area from that dedicated to the operations area.

Number, Function and Location of the Shafts

The location, function and number of the shafts are similar in both projects.

- Location of the shafts

In both cases the shafts are located in an area separated from the disposal zone (Figure 4). In the case of ANDRA, the rationale is twofold:

- locating the shafts area at the hydraulic upstream, and
- avoiding any advection phenomenon between two shafts which could occur (even if very unlikely) if the distance between them were sufficient.

In the case of WIPP, the shafts are strategically located to provide optimum ventilation, ease of operation, and contamination control.

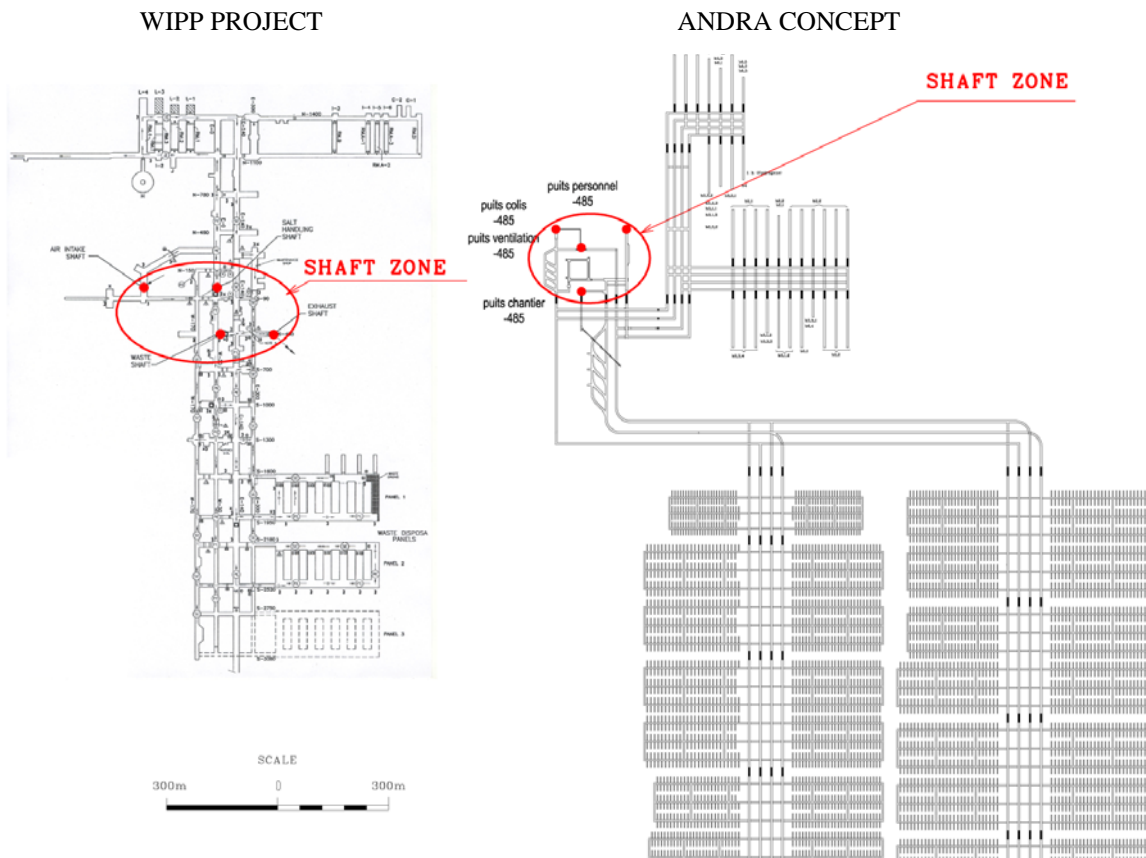


Fig. 4 Location of the shafts in the WIPP project and in the ANDRA concept.

- Functions and number of the shafts

In both cases the following functions are dedicated to four specific shafts:

- Waste transportation,
- Air intake,
- Air exhaust, and
- Rock (ANDRA)/salt (WIPP) handling.

In the case of WIPP, personnel transportation occurs either in the waste shaft or in the rock handling shaft. In the case of ANDRA, only one shaft is used for legal reasons. Table I summarizes the functions and the number of the shafts in both cases.

Table I Function and number of the shafts in the WIPP and in the ANDRA Project

	Waste transportation	Air intake	Air exhaust	Rock handling	Personnel transportation
WIPP (4 shafts)	Specific shaft	Specific shaft	Specific shaft equipped with HEPA filters	Specific shaft	No specific shaft
ANDRA project (5 shafts)					Specific shaft

Waste Transportation Process on the Surface and in the Underground

In both cases, the method used to transport waste between the surface and the underground is a shaft equipped with a Koepe pulley system. Koepe system consists of two mobile units suspended by several independent and redundant hoisting ropes in equilibrium on a friction pulley (the Koepe pulley). Below the mobile units, tail ropes balance the weight of the hoisting ropes. The pulley is installed at the top of the headframe.

The mobile units include the conveyance which contains the waste to be transported, and a counterweight. Table II shows the features of WIPP and ANDRA equipment.

Table II Comparison of WIPP and ANDRA equipment

	WIPP equipment	ANDRA equipment considered
Inside diameter of shaft	5.8m	11 m
Number of hoisting ropes	6	8
Number of tail ropes	3	4
Loading capacity	45 t	110 t

Operational Safety Analysis

In both cases, the operational safety analysis is fully included in the design loop process. This process consists of the following steps:

- “Design,” including tentative protection and mitigation measures,

- “Risk identification and classification,” which is a comprehensive list of the risks and their associated characteristics whatever their probability of occurrence,
- “Quantitative Hazard Analysis,” the goal of which is to quantify the consequences (radiological and nonradiological) of the main risks identified (notably operational risks), and
- “Design classes identification,” the goal of which is to identify the important components for the safety.

Then the design and the associated prevention and mitigation measures are modified according to the findings of the quantitative hazard analysis. According to this logic, unlikely and extremely unlikely events are considered.

In this regard, the consequences of a waste hoist failure during waste transportation in the shaft have been studied and quantified, although the probability of occurrence is estimated at about 10^{-6} per year.

One of the common mitigation measures (existing in WIPP and adopted by ANDRA as well) addressing this event is a HEPA filtration building located at the top of the exhaust shaft. It must be emphasized that waste hoist failure is not the single case which justifies this measure. This system is also designed to mitigate the consequences of other events such as waste container puncture or waste drop in the underground.

In normal operations, the air coming from the underground by the exhaust shaft does not go through the HEPA filtration building. In case of an accident, the air flow can be diverted towards the HEPA filtration manually or automatically, thanks to a specific manifold.

CONCLUSION

The WIPP and the ANDRA underground repository projects have many common features, most notably in term of underground layout, operation, ventilation, shafts and waste transportation processes between the surface and the underground. The logic adopted in the framework of the operational safety analysis is similar as well. It is based on a deterministic identification of risks and on a quantitative analysis of the significant events including the extremely unlikely ones. Lessons learned by WIPP from waste handling and disposal operations have been shared through the cooperative program between ANDRA and WIPP.