INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

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Accidents at the WIPP in February 2014

Summary of the actions carried out

WIPP[1], a deep geological repository for radioactive waste located in New Mexico (USA), has been designed to accommodate, within cavities dug in the salt at a depth of about 660 meters, 176,000 m^3 of transuranic waste (including Americium and Plutonium), from American defense-related nuclear activities (military research and the production of nuclear weapons). After fifteen years of operation, the repository experienced, in February 2014, two significant events: a fire in the northern part of the underground facility and then, 9 days later, a release of radioactive material in the southern part of the facility.

This overview updates the one published on March 12, 2014, available in French on IRSN's website [1], and takes into account the major investigations carried out on the causes of the accidents. The information assembled here comes from, among others; documents issued by the Accident Investigation Boards (AIB[2]) and by the Technical Analysis Team (TAT[3]), mandated by the organization responsible for this facility, the Department of Energy (DOE[4]) to investigate the cause and consequences of the events, as well as from articles published in the press.

For IRSN, the analysis of these events highlights the need:
- to require waste packages to constitute a robust containment barrier, which implies, in particular, knowing in detail their contents, especially in terms of chemical reactivity;
- to foresee provisions of monitoring to detect anomalies early enough in order to act before a release of radioactive material occurs;
- to take into account in the safety case that unforeseen circumstances in the operations and control of the facility may occur and to include provisions in the facility design which would mitigate the potential consequences. These provisions must aim, in particular, at making an intervention possible and at restoring acceptable conditions of safety and radiation protection for the resumption of operations.

Fire

On February 5, 2014, a truck used to remove excavated salt caught fire in the northern part of the WIPP underground facility, near the salt handling shaft. The waste disposal panels are located several hundred meters from the site of the fire (see Figure 1); no waste packages were in the vicinity of the fire. The entire staff was evacuated from the underground facility. Six employees were transferred to the hospital due to possible smoke inhalation. The AIB attributed the causes of the accident and the events leading up to it [2] to multiple instances of negligence on the part of the DOE and its contractors, in particular concerning the maintenance of the salt haul truck, the inadequacy of the fire emergency procedures, the lack of fire extinguishing equipment of the underground facility and the training of personnel. The recommendations of the

[1] Waste Isolation Pilot Plant
[2] Accident Investigation Board
[3] Technical Assessment Team
[4] Department of Energy

Accident Investigation Board, issued at the end of its inquiry, are in its Accident Investigation Report [2] published shortly after the fire.

Release of radioactive material

On February 14, 2014, a release of radioactivity set off the Continuous Air Monitor (CAM) located in the vicinity of Panel 7 in the underground facility [3]. Approximately 3.7 10^7 Bq (1 mCi) of Americium 241 and Plutonium 239 and 240 were released outside of the facility during a period of about fifteen hours (data from CEMRC[5], [4]). This release was detected outside the site, at levels that reached a little more than 80 µBq/m^3 of plutonium 239 and 240 and 5 µBq/m^3 of Americium 241 at a distance of several hundred meters [4]. Among the workers present on the surface of WIPP facility during the release, 22 people were found to have internal contamination by Americium 241. On the basis of modeling, the DOE [4] estimated that the maximal individual dose that an exposed worker could have received to be 100 µSv. The medical examinations carried out on those contaminated did not contradict this estimate. Beyond the site, the DOE [4] estimated that the maximal potential dose for the most exposed person (located at the edge of the site to the northwest of the exhaust shaft) was not more than 10 µSv. The US EPA[6] [6], the authority of radiation protection, confirmed this estimate. For their part, the CEMRC [4] has indicated that the release had "no measurable effect" on the population living in the vicinity of WIPP.

Robots and then successive expeditions of DOE intervention teams, outfitted with devices protecting against the inhalation of radioactive particles (see Figure 2), were sent into the underground facility beginning on April 2nd, 2014 in order to progressively approach the assumed source of contamination while, at the same time, providing for the essential maintenance of the facility (replacing the bolts to ensure the mechanical stability of the corridors, for example) [3]. During one of these expeditions in May 2014, a damaged waste drum (see Figure 3) was identified in Room 7 of Panel 7 and several samples of materials were taken between May and August 2014. Photographs have shown that certain materials had melted, which attests that a high temperature (on the order of hundreds of degrees around the offending drum and up to 1 000 °C on contact) was reached in this room [7].

The damaged drum is part of a waste stream from the Los Alamos National Laboratory (LANL). These wastes were deemed inconsistent with the acceptance criteria for WIPP if they did not undergo a pre-treatment, notably because of the suspected presence of liquids [7]. Also, in 2007, LANL developed a specific procedure describing the process of repackaging of such wastes. In 2012, a modification of this procedure led to mistakenly prescribe the use of an organic absorbent (cat litter) instead of the usual absorbent, which proved to be chemically incompatible with the nitrate salts contained in waste [7]. The damaged drum had been repackaged according to this procedure on December 4, 2013 and then sent to WIPP where it was finally emplaced on January 31, 2014 in Panel 7. The AIB [7] and the TAT [8] have concluded, on the basis of experiments and modeling, that exothermic chemical reactions between the organic absorbent and the nitrate salts resulted in a rise in the temperature and the pressure of the drum which ruptured the container's lid and released a part of the radioactive substances contained within. The possibility of a link between the fire on February 5th and the radioactive release has been eliminated by the AIB [7] and the TAT [8] on the basis of simulations testing several hypotheses (direct thermal pulse, spread of combustion products, reduced ventilation for fire management).

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[5] Carlsbad Environmental Monitoring & Research Center (division of the College of Engineering at New Mexico State University)

[6] Environmental Protection Agency

The DOE [9] attributed the portion of radioactivity released into the environment to insufficient performance of the filtration system of the exhausted air, located on the surface. This system had leaks in two dampers which were probably exacerbated by the phenomenon of corrosion related to the saline quality of the air exhausted from the underground facility and which had not been detected as a result of the lack of prior controls of maintenance of the ventilation system. According to the AIB [9], the DOE relaxed the constraints regarding the control of the ventilation system, because it no longer considered, beginning in 2008, that the system should be classified as important for the safety of the facility. The DOE [3] announced that they had sealed the leaking dampers with high density foam on March 10, 2014.

Leaks of residual contamination to the atmosphere were observed by the CEMRC [10] on several occasions since the February 14, 2014, during maintenance operations (four releases of three orders of magnitude lower than that of February 14, 2014, according to the readings taken at the exhaust shaft). The DOE [3] indicated that they could be due to particles remaining blocked in the filtration system since the accident on February 14, 2014 and could have been released during these operations.

Facility's recovery program – work in progress and in the future

Since the fire on February 5, 2014, the delivery of waste to WIPP has been suspended. The drums from LANL which would have been transported to WIPP have either remained at this laboratory [11], or have been taken to a temporary storage center in Texas [3]. Among these drums, those with similar contents as the drum implicated in the radioactive release are currently the subject of a monitoring program (notably temperature measurements, gases emitted, etc.).

Beyond the revision of the safety documentation (controlling fire hazards, emergency procedures, worker training, etc.) to take into account the recommendations issued by the AIB [2] [7] [9], the main themes of the Recovery Program [12] published by the DOE in September 2014 are as follows.

Decontamination of the underground facility

In the course of expeditions in the underground facility, the DOE has identified and characterized the contaminated areas and has undertaken to decontaminate some of them (see Figure 4) [3]. The decontamination is carried out by projection of water on the walls in order to dissolve the salt on the surface and trap the radionuclides in the salt crystals which reform on the ground (see Figure 5). A polyethylene textile (brattice cloth) is then placed on the ground, and covered with uncontaminated crushed salt. This allows, according to the DOE [13], to reduce the contamination of the walls by 95 %. A spray-on fixative is then applied on areas of higher activity [14]. The DOE has no plans to clean up Panel 6 and Room 7 of Panel 7, due to their excessive contamination; these rooms will be therefore closed without being decontaminated (see below) [3]. The exhaust shaft will not be decontaminated either because of the technical difficulties of the operations [12]. The DOE [15] specifies that, for future operations of the facility, which need to take into account the presence of both contaminated and uncontaminated areas, this implies permanently maintaining air filtration (since the air is exhausted by the contaminated exhaust shaft) and supplementing the ventilation (see below).

Expedited closure of disposal areas

The DOE [16] presented a plan for initial closure of the parts of the disposal (Panel 6 and Room 7 of Panel 7) where the drums of the same waste stream as the offending drum have already been disposed of, in accordance with the request of the New Mexico Environment Department [17]. The operations provided for in the plan include the installation of a metal bulkhead coupled with an impermeable textile (brattice cloth) (see Figure 6) [16], located at the entrance of the Panel 6 and at the entrance of the Room 7 of Panel 7, isolating these spaces (see Figure 7); the DOE intends to emplace waste in the rest of Panel 7, which is currently contaminated [16]. These closure operations were completed in the beginning June 2015 [3]. According to a press article [18], the New Mexico Environment Department (NMED) indicated that a more durable closure system, such as an explosion-isolation wall, will be constructed.

Modification of the ventilation system

The DOE [12] reported that the actual airflow in the underground facility (about 100,000 m^3/h), reduced because of the filtration of the exhausted air, is unsuitable for the resumption of operations. Also, the installation of additional ventilation systems in several stages is planned in order to restore the airflow required for waste storage operations and salt mining (approximately 722,000 m^3/h of total airflow). The installation of a first set of fans should, according to the DOE [12], allow an increase in airflow (up to 194,000 m3/h); the separation of airflow circuits of the contaminated and the uncontaminated parts of the facility will be ensured by partitions erected in the facility's galleries [15], the design of which has not been specified in available documents. A "final" ventilation system, undefined at this stage, should be able to achieve the total airflow necessary.

Currently, the DOE plans to resume waste emplacement activities at WIPP in 2016 [3].

Initial lessons learned by IRSN

The improvement of the safety of nuclear facilities is a constant priority, which includes the analysis of events which take place in them. It is important for IRSN to take into account the operational feedback emerging from these two accidents at WIPP in the safety assessment of radioactive waste management operations, in particular those concerning deep geological disposal facilities. IRSN [19] has thus taken into account the initial lessons learned from the accidents at WIPP in its report of expertise of the safety evaluation of the operational phase, at the preliminary design stage of the Cigeo project, the geological repository project currently being developed in France by the national agency for radioactive waste management (Andra). The design of Cigeo presents significant differences (argillaceous rock, types of waste, safety principles, etc.) in comparison to WIPP, which leads to focusing the analysis of the accidents on transposable elements.

First and foremost, the importance of the waste package as the first containment barrier is clearly reaffirmed. Concerning this subject, efforts should focus, above all, on the knowledge of the waste (characterization, controls) in order to evaluate in particular the chemical reactivity of the waste. In this respect, the control of reactions that may cause a rise in temperature of the waste packages, which is the cause of the accident of the WIPP, is particularly important. Furthermore, the packaging must be designed in such a way as to limit the dissemination of radioactive substances outside of the waste package in the event of an incident or accident during operations.

Furthermore, monitoring remains, in addition to other preventive measures taken (starting with the design of the disposal facility), one of the fundamental safety provisions to be implemented. In this respect, IRSN recommended for the Cigeo project that a monitoring program be put in place to enable the earliest possible detection of a gradual rise in temperature of emplaced waste packages presenting a risk of exothermic reactions (notably the case of bituminous waste packages). This early detection, followed by the implementation of corrective actions, should make it possible to avoid reaching the temperature threshold beyond which exists the risk of a runaway exothermic reaction.

The two accidents that occurred at WIPP show that, despite the safety provisions which may be put into place and the willingness of the various actors in the operations of a geological repository to implement them, the relaxing of these provisions over time cannot be excluded, and even more so considering that the duration of operations envisaged for such a facility is long. The safety approach to be applied for this type of facility must include scenarios involving combinations of failures of these provisions, even if they appear unlikely, so as to reinforce the capacity of the disposal, beginning with its design, to withstand the unforeseen circumstances of operation. This might lead to considering extreme scenarios. In this respect, IRSN recommended that Andra postulate a scenario of runaway exothermic reactions within several bitumen containers and, on this basis, identify appropriate additional measures necessary to avoid the occurrence of a release outside the facility or to limit its consequences.

If an accident situation should occur in spite of all the preventative measures adopted, the case of WIPP has shown that there are particular difficulties associated with intervention and the characterization of the accident itself in the underground environment, especially if the structures are contaminated : this can lead to a significant period during which operations are halted with consequences that may be important to both the safety of the facility and the entire system of waste management before the disposal stage. IRSN considers that, in the design of a geological disposal for radioactive waste, it is necessary to identify accident scenarios which are likely to profoundly alter the subsequent operations of the facility (in the case, for example, of the contamination of connecting galleries or the entries to disposal vaults in Cigeo), and to implement all possible provisions to prevent this type of situation. Beyond the prevention of accidents, the intervention and rehabilitation of the facility must be anticipated as early as the design stage, notably to preserve possibilities to undertake tried and tested actions that would have been evaluated beforehand. Defining an action plan which allows the retrieval of damaged containers and the containment of the contamination in the facility, and then to rehabilitate the affected area is important to leave a range of choices open to decision concerning the future of the disposal in case of a serious accident.

References

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[3] DoE News Release & Updates: http://www.wipp.energy.gov/wipprecovery/recovery.html

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[8] Technical Assessment Team report: http://www.wipp.energy.gov/Special/TECHNICAL_ASSESSMENT_TEAM_REPORT.pdf

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[16] Waste Isolation Pilot Plant - Nitrate Salt Bearing Waste Container Isolation Plan – revision 1: http://www.wipp.energy.gov/library/Information_Repository_A/Responses_to_Administrative_Order/14-2614_WIPP_Nitrate_Salt_Bearing_Waste_Container_Isolation_Plan_2014%20_Redacted.pdf

[17] New Mexico Environment Department Administrative Order: https://www.env.nm.gov/wipp/documents/NMED_AO_2_27_14.pdf

[18] Article from the Albuquerque Journal of June, 2nd 2015: http://www.abqjournal.com/555711/news/roof-collapses-pose-safety-risk-at-wipp.html

[19] The IRSN webpage – « Esquisse » Dossier of the Cigeo project: http://www.irsn.fr/FR/expertise/rapports_gp/gp-dechets/Pages/GPD-GPU_Rapport-IRSN-Cigeo-exploitation_122014.aspx#.VbXqfhDQtoE

Figures

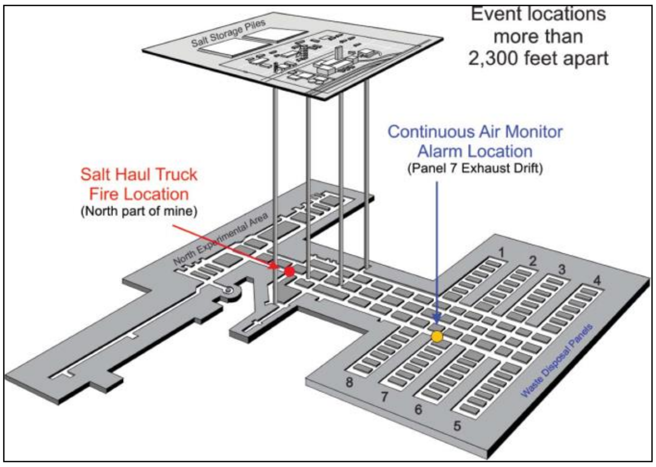

Figure 1: WIPP overview. In red: fire location (north experimental area). In yellow: location of the CAM which triggered on February, 14 2014 [http://www.wipp.energy.gov/special.htm]

Figure 2: DOE personnel in the underground part of the facility in March 2015 [http://www.wipp.energy.gov/wipprecovery/townhallmeeting.html]

Figure 3: picture taken above emplaced waste containers. The offending drum is in the middle, on the left of the picture [http://www.wipp.energy.gov/pr/nr.htm]

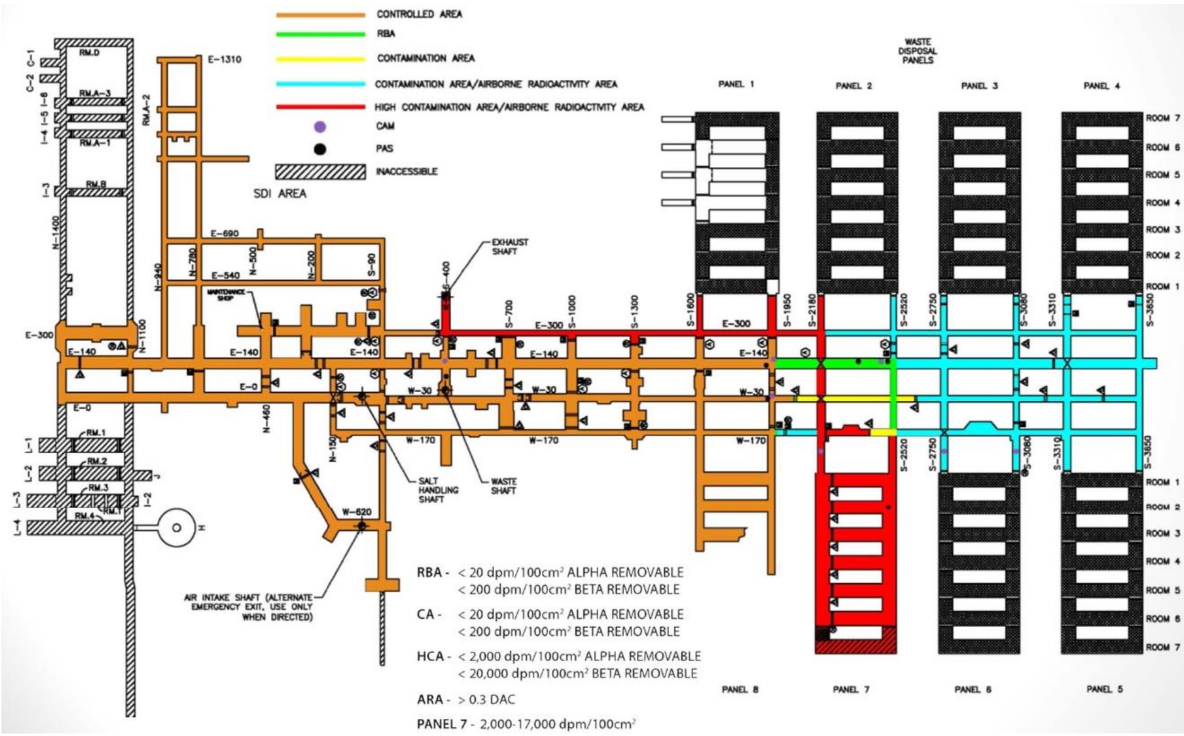

Figure 4: extent of the contamination of the underground of the WIPP, August 2015. In yellow, blue and red: contaminated or highly contaminated areas. In brown: controlled areas. In green: radiological buffer zone. [http://www.wipp.energy.gov/wipprecovery/townhallmeeting.html]

Figure 5: water sprayed on the ribs of the facility, picture taken from a video [http://www.wipp.energy.gov/Video/Mitigating_Contamination.mp4]

Figure 6: pictures of the bulkhead doors at the entry of Panel 6 (on the left) and Panel 7, Room 7 (on the right) [http://www.wipp.energy.gov/pr/nr.htm]

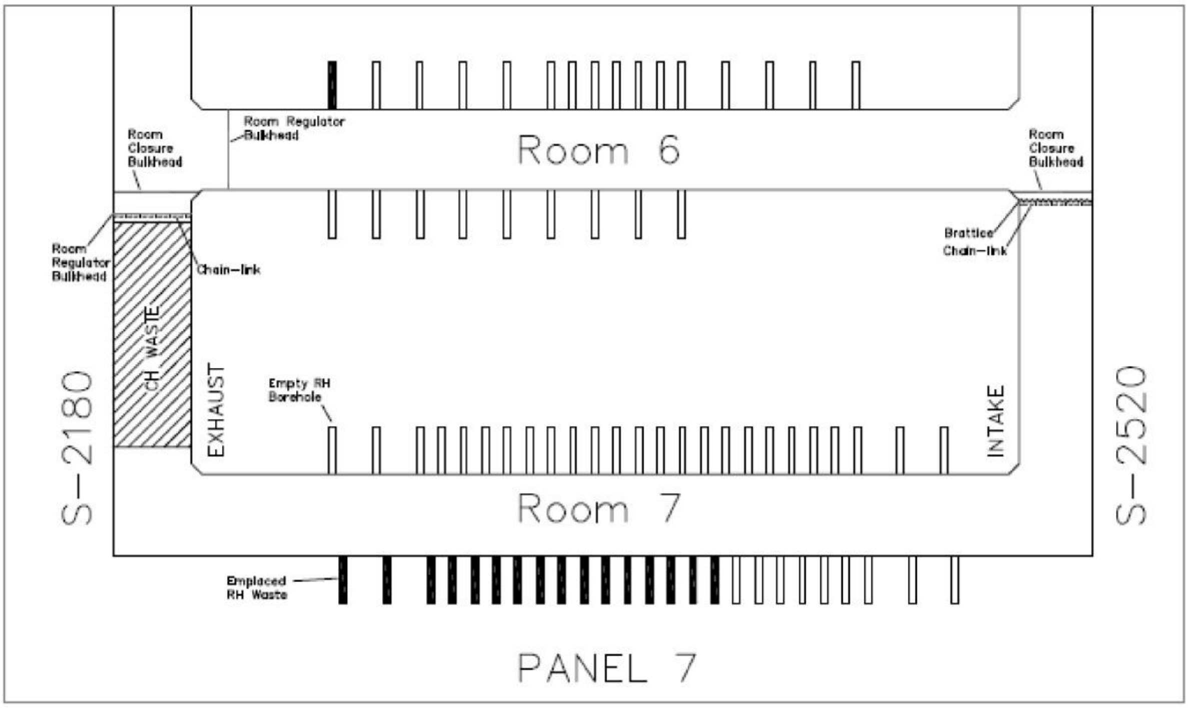

Figure 7 : bulkhead door locations as part of the closure process of the Room 7 of the Panel 7 [http://www.wipp.energy.gov/library/Information_Repository_A/Responses_to_Administrative_Order/14-2614_WIPP_Nitrate_Salt_Bearing_Waste_Container_Isolation_Plan_2014%20_Redacted.pdf]