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IRSN
INSTITUT DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Fontenay-aux-Roses, 29 November 2024

The Chairman of the French Nuclear Safety Authority (ASN)

IRSN OPINION NO. 2024-00167

Subject:	**Cigéo project construction licence application - "GP2" - Operational Safety Assessment**
Ref.:	Letter ASN/CODEP-DRC-2023-030596 of 7 June 2023. Examination of the Cigéo project construction licence application file - Referral ref. SAISI-DRC-2023-0093

In its letter in reference, the French Nuclear Safety Authority (ASN) requested the opinion of the Institute for Radiation protection and Nuclear Safety (IRSN) regarding the construction licence application file of Cigéo, the French deep geological repository for high-level waste (HLW) and long-lived intermediate-level waste (ILW), submitted by the French national radioactive waste management agency (Andra).

ASN requested a technical review of this construction licence application, structured around three thematic groups:

- the baseline data used for the Cigéo safety assessment ("GP1" review, subject of IRSN review no. 2024-00051 of April 12, 2024);
- the safety assessment related to the operational phase ("GP2" review);
- the safety assessment related to the post-closure phase ("GP3" review).

ASN also identified several cross-cutting themes to be incorporated into the review of these three thematic groups. These include the elements used to define the industrial pilot phase, the preliminary specifications for waste package acceptance, the reversibility (including disposal adaptability and waste package retrievability), as well as the consequences of climate change.

This opinion concerns the GP2 technical review for which ASN asked IRSN to examine the relevance of the design provisions that led to the disposal facility's reference configuration, as well as the construction and operating provisions adopted, in relation to:

- the operational safety approach until closure of the disposal, including in particular the safety objectives, the important activities and elements for the protection as well as their qualification, the identification and classification of incidental and accidental scenarios, the definition of operating domains, the monitoring strategy for the underground facility;
- the assessment of nuclear-related risks (exposure of workers, criticality, dissemination of radioactive substances), as well as internal hazards (fire, explosion, handling of waste packages, internal flooding,

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loss of auxiliary power, co-activity related risks) and external hazards (earthquake, meteorological hazards, aircraft crash, impact of industrial activities, external flooding, etc.);
- the methodology and results of the assessment of radiological and chemical impacts on human health and the environment associated with the various operating situations.

Topics related to the development of Cigéo, such as the organizational principles for the transitioning from the design to the construction phase, the closure strategy, the flexibility and the adaptability studies, which are also mentioned in the ASN referral, are included in this review. The analysis of the provisions related to the preservation of the memory is deferred to GP3.

In addition, this technical review was the subject of a technical dialogue organised by the National Association of Local Information Committees and Commissions (*Association nationale des comités et commissions locales d'information - ANCCLI*), the Local Committee for Information and Follow-up of the Bure Laboratory (*Comité local d'information et de suivi du laboratoire de Bure - CLIS de Bure*) and IRSN, with the dual aim of taking the concerns of civil society into consideration in order to make IRSN's review more robust, and to allow civil society to form its own opinion and therefore to participate in the process leading up to the public decision.

The topics addressed below are based on IRSN's technical review of the submitted safety case and the information provided by Andra during the review. The resulting recommendations, as well as the commitments made by Andra to ASN in light of this review, are listed in the appendices to this opinion, and some of them are mentioned in this opinion. Most of the associated deadlines relate to later stages of the project and are conditional on the promulgation of the Licensing Decree. The commissioning of the facility, which will enable the first package of radioactive waste to be received, is a major step from a safety point of view. As it is planned by Andra by 2050, the preliminary safety report could be revised before the update required to support the commissioning application; according to IRSN, progress on the work required for commissioning could then be documented during these revisions. The construction of the facility (of the "first concrete" for the surface nuclear buildings, the start of excavation of the surface-to-underground links, first HLW cell and first ILW-LL cell) forms a set of other important milestones in terms of safety, mentioned in this opinion.

This IRSN technical review will be presented to the members of the Advisory Committee of Experts on Waste (GPD) at their meeting on December 10 and 11, 2024. Members of the Advisory Expert Committees on Laboratories and Plants (GPU) and on Radiation Protection for workers, the general public, patients and the environment (GPRP), will also attend this meeting.

1. SAFETY AND RADIATION PROTECTION APPROACH

Andra's operational safety and radiation protection approach, adopted to protect people and the environment from the risks associated with the release of radioactive substances and toxic chemicals, is based on the safety functions that the facility must perform and the definition of objectives for the protection of both workers and the public. As a first step, Andra analyzes the internal risks of nuclear origin and internal or external hazards (cf. chapter 2 below) to identify undesired events that could lead the facility to deviate from normal operation and jeopardize a safety function; Andra then defines the technical and organizational measures to manage these risks, notably by applying the principle of defence-in-depth. Among these means, Andra identifies the activities and elements that are important for the protection of interests[1] (AIP, EIP), notably in relation to safety functions, and establishes specific requirements for them. In a second step, Andra classifies the undesired events likely to

[1] Interests that aim to "*protect public health, safety and security, as well as the environment, from the risks or inconveniences resulting from ionizing radiation*" (article L.1333-7 of the French Environment Code).

lead to a radiological risk into families of so-called operating situations[2], according to their estimated likelihood, and then verifies, for each family of situations, that the adopted provisions are adequate to meet the protection objectives. IRSN considers that Andra's safety approach, which is consistent with the state of the art, is satisfactory in terms of principle. The protection objectives adopted by Andra, which are broadly similar to those defined at the stage of the safety options report, do not call for any particular comment from IRSN.

Regarding the implementation of this approach, IRSN considers that the unlikely character of certain accidental scenarios within the design basis extension domain, and the absence of reasonable additional provisions to address them is not sufficiently justified at this stage. Furthermore, the exclusion of a scenario must be based on design, implementation and operational requirements that ensure it remains extremely unlikely, with a high degree of confidence. IRSN therefore considers that Andra should consolidate the classification of scenarios along these lines (commitment 2024-E17). Additionally, with regard to the ability of EIPs to perform their assigned functions, the qualification strategy for inaccessible EIPs must be presented before the excavation of the surface-to-underground links begins (commitment 2024-E21). More generally, given the progressive deployment of Cigéo, it is essential that the criteria and methods for qualifying these EIPs be clearly defined and presented before their implementation (commitment 2024-E22).

Andra has established an approach for identifying operations to manage accidental and post-accident situations, including package retrieval, which is satisfactory. However, although Cigéo's design aims to exclude any situation involving significant contamination of the underground facility, IRSN considers that, as part of the defence-in-depth principle, Andra must postulate such a scenario to identify any additional provision, to ensure that such a situation would not prevent the resumption of operations under appropriate safety and radiation protection conditions. This aspect is addressed in recommendation No. 1 appended to this opinion.

Regarding facility monitoring, Andra's strategy relies on the use of different redundant and complementary measurement methods as well as, for the disposal cells, for indirect measurements in "witness" cells. IRSN considers that this strategy, as well as the identification of parameters to be monitored have reached a sufficient level at the construction licence application stage. However, Andra is expected to further specify the monitoring provisions for the first structures before their construction, as well as its strategy for indirect monitoring in witness cells (commitments 2024-E18 to E20).

2. OPERATIONAL SAFETY ASSESSMENT

Civil engineering design and dimensioning

For the civil engineering of surface facilities, Andra has adopted seismic-resistant measures (e.g. simple, regular reinforced concrete structures founded on slab), along with provisions to ensure concrete durability (e.g., formulation, reinforcement). Additional measures have been taken to protect the structures against the consequences of an aircraft crash, such as an "aircraft shell", and to prevent damage from falling loads. For the underground facilities (reinforced or unreinforced concrete structures), the design includes provisions to foster structural stability over a secular period, particularly in relation to seismic risks and the mechanical behavior of the host rock. IRSN considers that these provisions are appropriate and sufficiently described at the construction licence application stage. However, further justifications are required, primarily before the first concretes are poured for the nuclear buildings, concerning the effects on civil engineering of accidental load drops (commitment 2024-E39), aircraft crashes (commitments 2024-E47 to E49) potentially followed by fires (commitment 2024-E37), and earthquakes.

[2] (i) normal and degraded situations in the design basis domain, (ii) incidental and accidental situations in the design basis domain, (iii) accidental situations in the design basis extension domain and (iv) excluded situations.

Internal nuclear-related risks

Regarding radiation protection of workers, IRSN notes that Andra has conducted preliminary calculations to define the order of magnitude of the required radiation protection thicknesses in the facility premises accessible to workers, which is satisfactory at the construction licence application stage. Additionally, radiation protection rules have been defined in accordance with the future operation of the facility. However, the practical implementation of the radiological delimitation of premises, of the optimization of worker exposure, and of radiological monitoring of workers will need further elaboration.

Concerning the risk of radioactive substance dissemination, the first static containment system is ensured by the HLW and ILW-LL packages[3]. For HLW packages, the performance of this system depends notably on the dimensioning of the disposal containers with respect to corrosion. Andra has provided additional information on corrosion processes and rates following the GP1 review, in view of the GP3 review. Furthermore, dynamic containment (ventilation) is employed in surface nuclear buildings and ILW-LL cells in operation. IRSN considers the overall design basis and the dimensioning of this system (classification of areas, filtration levels, flow rates, etc.) appropriate but emphasize potential challenges in managing transitional phases, in terms of adapting ventilation flow rates at each step of deployment of the underground facility, in particular when new ILW-LL cells or HLW disposal sub-zones are commissioned (commitment 2024-E24).

Regarding criticality risk management, IRSN considers the studies presented by Andra generally satisfactory at the construction licence application stage. The analysis conducted by Andra, along with the measures for controlling fissile material masses, will need to be completed and consolidated (commitments 2024-E26 and E27). However, in IRSN's view, these complements do not call into question the assessments of acceptable fissile material masses in the surface facility and in the disposal cells, nor the margins relative to the fissile material masses contained in the waste packages.

Internal hazards

IRSN considers that the elements presented by Andra to manage the risks associated with fire, internal flooding, handling of waste packages, loss of auxiliary systems and co-activity related risks are generally satisfactory for this stage of the project's development.

Regarding the management of fire-related risks, IRSN considers that Andra's risk analysis approach needs further refinement, particularly concerning the provisions selected as EIP (commitment 2024-E31) and, before the first concrete is poured for the surface nuclear buildings and the excavation work begins, with regard to the conservative feature of the selected hazards (commitment 2024-E34). The compartmentalization provisions presented by Andra to limit fire consequences in the underground facility (e.g., isolation of certain surface-to-underground links through structural provisions, twin-tube with cross-connections[4], etc.) require further study, especially concerning the isolation of the exhaust air shaft from the operational zone and the justification for the absence of compartmentalization for the ramps (commitment 2024-E33). Additionally, IRSN considers that Andra's plans for fire response in the event of a fire in the underground facility (e.g., location of emergency teams on the surface, distances to be covered on foot given potential challenges for intervention vehicles to make headway) do not currently guarantee a rapid and effective response (commitment 2024-E35). As the evolution of compartmentalization and intervention arrangements could lead to design or layout changes, they must be presented before excavation work commences.

For the specific case of the disposal of bituminous waste packages in their current state, Andra has outlined the design provisions for the disposal containers and cells dedicated to this waste type, aiming to meet the 100°C

[3] Primary package(s) placed in a disposal container, or primary package alone in the case of direct disposal.

[4] For example, two parallel ramps, two parallel "nuclear process" galleries, connected by crosscuts.

surface temperature criterion[5] for the waste package. Tests and modelling have been carried out by Andra to verify compliance with this criterion under "reference" scenarios[6] and "extreme" scenarios that assume a runaway of a package. Given the uncertainties related to the behavior of bituminous waste and in line with the defence-in-depth principle, preventing propagation to neighbouring packages must be guaranteed. Preliminary assessments have also been made by Andra regarding detection and response times following a temperature increase in a disposal package. IRSN considers that the compliance with the 100°C criterion can be demonstrated for the reference scenarios selected by Andra. In contrast, the extreme scenarios do not sufficiently incorporate phenomenological knowledge of bituminous waste package behaviors, and their conservativeness has not yet been demonstrated; the detection and intervention strategy needs further development based on envelope scenarios. IRSN therefore considers that the elements presented are insufficient to establish the accessibility of the safety demonstration (e.g., prevention of runaway propagation) for the disposal of bituminous waste packages in their current state. Andra has committed to continuing studies to address these issues (commitment 2024-E36).

Regarding the management of explosion risks in the ILW-LL cells due to gases production by radiolysis in the ILW-LL packages, the cells will be ventilated to evacuate the gases. The transfer hood is designed to prevent the formation of an explosive atmosphere during package transfers; Andra also plans compensatory measures in the event of the hood being blocked during transfer. IRSN considers that these provisions are satisfactory in principle. When cell ventilation is halted, particularly during closure operations, radiolysis gases may accumulate. At this stage, Andra presents preliminary studies on the evolution of the internal atmosphere of an unventilated ILW-LL cell and on the consequences of a potential explosion. However, IRSN considers that these initial findings do not provide sufficient assurance regarding the management of explosion risks during and after the ILW-LL cell closure. Therefore, these aspects need to be further addressed before excavation work begins (commitment 2024-E57), as design modifications may be necessary to demonstrate effective risk management.

Explosion risks in HLW cells arise from hydrogen production due to anoxic corrosion of metal components (liners, disposal containers). Andra plans a system to monitor and, if necessary, inert the atmosphere in the HLW cells with nitrogen to limit corrosion by maintaining near-anoxic conditions and to prevent the formation of an explosive atmosphere. Andra has presented initial results for this system, obtained from partial demonstrators in its underground laboratory. However, IRSN considers that there are significant uncertainties regarding the technical feasibility of the HLW cell design at this stage, particularly concerning gas exchange limitations at the cell head, as well as concerning the sampling and inerting system. Additionally, scaling the system to industrial level, including connecting nitrogen production plants to several hundred HLW cells, presents further challenges. IRSN notes that Andra is planning a new in situ test program in its underground laboratory to assess the feasibility of the abovementioned provisions. In any case, the safety demonstration for HLW package disposal must be completed before excavation of the Cigéo's HLW pilot zone (commitment 2024-E28).

External hazards

IRSN considers Andra's safety assessment regarding external hazards, including external flooding, meteorological events, lightning strikes, accidental aircraft crashes, and the industrial environment, to be sufficiently mature at the construction licence application stage. However, IRSN considers that the seismic hazard level adopted by Andra for facility design during operations does not adequately cover all uncertainties, particularly at high frequencies. Andra has committed to providing an updated seismic hazard level by the end of 2024 to address this issue (commitment 2024-E41).

[5] Criterion for preventing runaway of exothermic reactions within a bituminous waste package.

[6] Fire of equipment in handling cells or in the waste emplacement zone of ILW-LL cells.

Impact assessment

IRSN considers Andra's methodology for assessing the radiological impact on workers, the public, and the environment during normal operation, particularly through the identification of the releases, to be generally appropriate, though it requires further formal justification. IRSN agrees with Andra's calculation of a very low radiological impact. However, in assessing the impact of liquid releases of toxic chemicals, Andra uses values from environmental quality standards for its analysis, assuming that releases will remain within these values. These standards limits do not constitute release authorization. IRSN points out that the future operator must define its releases and reduce them as much as possible. Therefore, IRSN recommends that Andra provide as soon as possible a quantitative assessment of the health and environmental impact of liquid releases of toxic chemicals from Cigéo, based on an estimation of concentrations released into the environment. (recommendation No. 2 appended to this opinion). In incidental and accidental scenarios, IRSN agrees that Andra's assessment of radiological and chemical consequences for nearby populations aligns with the protection objectives. The same conclusion applies to radiological consequences for workers.

Preliminary waste acceptance specifications

Based on the risk analyses mentioned above, Andra has defined preliminary acceptance specifications for primary packages, including criteria such as radiological and toxic chemical inventories, thermal power, fissile material mass, radiolysis gas release and drop resistance. IRSN considers the criteria associated to these preliminary specifications to be consistent with operational safety demonstration. However, the criterion related to the durability of static containment for primary packages must be further consolidated. This requires consideration of the environmental conditions and the properties of the materials used for the first containment barrier, and ensuring an operational character (commitments 2024-E50 and E51). Andra has also developed a list of systematic controls to be carried out upon receipt of primary packages, along with a preliminary list of sampling-based "out-of-flow" controls that are still under development. IRSN considers that these two types of controls, combined with Andra's existing knowledge of the primary packages, should ensure compliance of the packages with the acceptance specifications.

3. CIGÉO DEVELOPMENT

Andra has presented its recent provisions related to the evolution of its organizational structure, specifically to optimize the preparatory phase leading up to the construction and subsequent operation of Cigéo. IRSN considers these provisions generally satisfactory, with the aim of anticipating risk management at each phase of the Cigéo program. Certain provisions, particularly those relating to the integrated management system, configuration management, resource and skills management, the integration of organizational and human factors, and the formalization of experience feedback, remain less mature and require further development (commitments 2024-E53 to E55).

Regarding the retrievability of disposed packages, Andra has identified two types of scenarios involving the retrieval of packages: "operational retrievals", which are part of the day-to-day operation of Cigéo, and "hypothetical retrievals", studied as part of post-accident management or reversibility. The studies carried out by Andra on the basis of these scenarios represent a step forward at the construction licence application stage. In particular, IRSN notes that the design of retrievability provisions (e.g. robotic systems, surface handling of packages, etc.) has progressed since the safety options report and notes that these provisions will be tested during the pilot phase. Nevertheless, IRSN reiterates its concerns expressed above regarding the corrosion of metal components in HLW cells and the management of the internal atmosphere in both HLW cells and sealed ILW-LL cells. These issues must be resolved in order to demonstrate the safe retrieval of disposed packages form the cells.

Regarding the plan for dismantling, closing and monitoring the facility, the strategy envisaged at this stage and the main dismantling operations identified by Andra are broadly appropriate. With regard to closure operations, the reference scenario adopted by Andra consists in the partial closure of the facility by disposal zones once they have been filled. In this respect, IRSN highlights the need for Andra to pay particular attention, before the excavation work begins, to ensure that the facility's architecture is capable of managing flows related to both nuclear activities and closure operations, without compromising risk management (commitment 2024-E56). This is in addition to the management of explosion risks, which remain to be demonstrated (see above).

Andra has also presented information on the flexibility of Cigéo, which refers to its ability to accommodate variations in the reference inventory, delivery schedules, closure strategies, and the integration of new knowledge, technologies and operating modes. Given the uncertainties identified in GP1 concerning the reference inventory, particular regarding the volume of waste packages whose packaging has yet to be defined, IRSN emphasizes the importance of this flexibility to ensure the safe management of all waste included in this inventory. More generally, IRSN considers that this principle of flexibility must be translated into concrete organizational and material provisions, to manage risks during operations, particularly those sensitive to spatial and temporal variations; it is essential that these provisions do not compromise safety once the facility is closed (commitment 2024-E59).

Regarding Cigéo's adaptability to manage waste from the reserve inventory, Andra has indicated that the design principles for the disposal spent fuel and low-level long-lived waste are similar to those for HL and IL-LL waste respectively. Based on the preliminary risk assessment provided by Andra, IRSN has not identified redhibitory issue related to the disposal of reserve inventory waste. However, criticality and pyrophoricity risks associated with spent fuel disposal, as well as ventilation management and fire response, will require particular attention in updated adaptability studies. These studies must also take into account the conclusions of the present review concerning the reference inventory, which can be transposed to the reserve inventory waste. IRSN also points out that the disposal of reserve inventory waste would extend the operational lifespan of Cigéo, with the main issue being the durability of civil engineering structures. In this respect, the performance-based approach envisaged by Andra for the development of concrete formulations appears relevant in order to guarantee concrete performance over longer periods than those associated with existing prescriptive standards. Andra has also mentioned additional measures which could be implemented to enhance durability, such as the use of non-metallic fibres, geometric reserves for possible reinforcements and optimized support/cladding phasing. However, IRSN stresses the importance of selecting these provisions before building the concerned structures (commitment 2024-E58).

Finally, Andra plans to initiate Cigéo with an industrial pilot phase, in accordance with article L.542-10-1 of the French Environment Code. This phase comprises a period of construction and inactive testing (with no radioactive waste packages), followed by a period of start-up testing and subsequent waste package disposal. During this expertise, Andra has presented preliminary technical objectives for this phase, which will need to be further developed, with particular attention paid to defining success criteria, in order to provide a basis for the program of work to be carried out to complete and consolidate the safety demonstration (commitment 2024-E52). In this respect, IRSN reiterates that the number of packages to be disposed during the pilot phase, as well as the rate of disposal operations, must be evaluated based on the active testing program covering all stages of package disposal and retrieval. Additionally, any disposal cell constructed for the subsequent phases of the facility during the pilot phase must benefit from the feedback gained during the construction and operation of initial disposal cells.

4. CONCLUSION

IRSN considers that the demonstration of risk management during the Cigéo operational phase has reached the level of maturity required at the licence application file stage for most of its components, in particular with regard

to internal risks of nuclear origin, risks of external aggression linked to flooding, meteorological events, the industrial environment and aircraft crashes, as well as risks of internal aggression associated with fire, internal flooding, handling of waste packages, loss of auxiliaries, and co-activity. The waste acceptance specifications and the controls foreseen when packages are received at the facility are generally satisfactory. The design principles and dimensioning approach adopted by Andra for the civil engineering of surface and underground facilities also meet the level expected at the construction licence application stage. All of these points will need to be consolidated during the next stages of the project, particularly with regard to fire risk management. Similarly, the monitoring provisions for the first structures still need to be specified before they are built. On this basis, and given the overall very low level of estimated radiological consequences, IRSN considers that the design, construction and operating provisions adopted at this stage for the reference configuration are on the whole appropriate for demonstrating the operational safety of Cigéo surface facilities, underground infrastructure and ILW-LL disposal zone. In addition, the organizational changes initiated by Andra to transition from the design phase to the industrial phase of construction and operational are, in IRSN's view, likely to strengthen the anticipation of risk management.

However, the accessibility of the safety demonstration remains difficult to assess for HLW cells, as well as for closed ILW-LL cells, given the uncertainties concerning the feasibility and adequacy of the provisions for managing their internal atmosphere, particularly with regard to explosion-related risks. Nor does the information presented allow IRSN to conclude on the accessibility of the safety demonstration in the specific case of disposal of bituminous waste packages in their current state. Changes in operating methods or in the design of disposal cells may be necessary. Consequently, IRSN considers that it is now important to complete and consolidate the assessment of the safety of Cigéo in the operational phase, by taking full advantage of the industrial pilot phase, based in particular on disposal test cells constructed *in situ* in the underground facility, under environmental and industrial operating conditions that take account of the changes in scale compared with surface tests or those carried out in the underground laboratory. In this respect, a duration for the industrial pilot phase duration of around thirty years from the issue of the Licensing Decree, as currently planned by Andra, seems reasonable to gather the necessary complements and confirm the facility's ability to operate safely.

In addition, IRSN emphasizes that the flexibility of the facility, which is a fundamental issue in its deployment in order to preserve the capacity of safe management of HL and IL-LL waste from the reference inventory, must be supported by concrete organizational and material provisions. Finally, based on the preliminary operational safety analysis presented by Andra as part of the studies on the adaptability of Cigéo to the reserve inventory waste, IRSN does not identify any redhibitory issue relating to the safe disposal of spent fuel and LL-LL waste included in this reserve inventory waste.

This technical review will be supplemented by that of the post-closure safety demonstration, as part of the GP3 review.

IRSN
Director General
By delegation
Delphine Pellegrini
Deputy Head of the Environment Division

APPENDIX 1 TO IRSN OPINION NO. 2024-00167 OF 29 NOVEMBER 2024

IRSN recommendations

Recommendation No. 1

IRSN recommends that Andra should present, in the next revision of the Cigéo safety report, the accident and post-accident management operations following a situation leading to significant contamination of the underground facility, as well as the associated provisions.

Recommendation No. 2

IRSN recommends that, for the update of the construction licence application scheduled before the public inquiry, Andra should provide a quantitative assessment of the impact on health and on flora and fauna of liquid releases of toxic chemicals from Cigéo, based on an estimate of the concentrations released into the environment, in order to assess the impact of these releases.

APPENDIX 2 TO IRSN OPINION NO. 2024-00167 OF 29 NOVEMBER 2024

Commitments made by Andra through its letter CG-AMOA-LET-24-0033 of 18 November 2024

Commitment no 2024-E17

In the next revision of the preliminary version of the Cigéo safety report, Andra will refine the justification for the exclusion of scenarios with regard to the design, construction and operating provisions adopted.

Commitment no 2024-E18

Andra will provide:

- before the start of the excavation of underground structures, all the key parameters associated with each CIP planned to be monitored;
- depending on the timing of the realization of the structure concerned, the associated monitoring provisions.

Commitment no 2024-E19

Before the start of excavation work, Andra will present measures enabling it to characterize the initial state before and after excavation of the "Callovo Oxfordian" CIP [component important for the protection] and to monitor its evolution.

Commitment no 2024-E20

Prior to excavation of the ILW-LL test cell, Andra will specify its strategy for indirect monitoring from the ILW-LL witness cell, specifying the parameters actually monitored of the normal operating domain and the monitoring provisions that will ultimately be adopted in this cell.

Commitment no 2024-E21

Andra will specify its strategy for the qualification of the inaccessible EIP [elements important for the protection] in the next revision of the preliminary version of the Cigéo safety report.

Commitment no 2024-E22

In the next revision of the preliminary version of the Cigéo safety report, Andra will present the criteria and methods used to justify the qualification of the EIP with regard to the compliance with their defined requirements.

Commitment no 2024-E23

Andra will demonstrate, at the latest for the Cigéo commissioning application, that the last filtration level in the EP1 building keeps its the required performance in the event of a fire in the C2 containment class fire zones or in fire sector premises, after closing the fire dampers where present, to enable the filtration of smoke taken up by the adjacent C2 containment class premises.

Commitment no 2024-E24

Andra will consolidate, at the latest for the Cigéo commissioning application, its strategy for adapting the underground facility's extraction and supply ventilation (fan sizing, flow rate adequacy, management of transient phases, etc.) for each phase of the facility's development, with the aim of maintaining pressure ranges and

renewal rates, as well as the tests and modelling planned to demonstrate the achievement of aeraulic performances for the entire facility.

Commitment no 2024-E25

Andra will confirm, initially during commissioning tests and then after each unit opening, the effectiveness of the solutions adopted to compensate for the loss of supply ventilation, particularly with regard to the minimum ventilation flow rates to be maintained.

Commitment no 2024-E26

Andra will consolidate its criticality-safety analysis in the next revision of the preliminary version of the Cigéo safety report, by presenting all the assumptions relating to the demonstration of acceptable fissile material masses and their justifications.

Commitment no 2024-E27

In the next revision of the preliminary version of the Cigéo safety report, Andra will specify the primary packages for which the maximum masses of fissile material assessed by the waste producers are close to those authorized for Cigéo, and will quantify the margins in abnormal situations where the limits are exceeded, if necessary using modelling assumptions that are as realistic as possible and necessary.

Commitment no 2024-E28

Before excavating the HLW pilot zone, Andra will present the results of the HLW test cell program, and on this basis complete the demonstration of the safety of the disposal of HLW packages.

Commitment no 2024-E29

Andra will justify, at the latest for the Cigéo commissioning application, the classification of scenarios relating to the failure of fire compartmentalization or sectorization. In particular, Andra will identify cases where the failure is covered by the failure of an element important for protection.

Commitment no 2024-E30

Andra will justify the classification of the scenario of a fire resulting from a collision between a package transfer vehicle and another type of vehicle in the next revision of the preliminary version of the Cigéo safety report.

Commitment no 2024-E31

Andra will consolidate, at the latest for the Cigéo commissioning application, the requirements assigned to the provisions implemented to manage fire-related risks. Among these provisions, Andra will identify those with a classification as EIP, in accordance with its EIP identification approach.

Commitment no 2024-E32

Before construction of the EP1 building, Andra will complete the justifications of the provisions planned to limit the consequences in the event of a fire in a cell containing a bitumen waste package in the EP1 building.

Commitment n°2024-E33

Before excavation work begins, Andra will consolidate the justification of:

- the fire protection measures adopted for the surface-to-underground links, in particular the absence of any need for compartmentalization of the ramps and the effectiveness of the compensatory measures in relation to the intervention and smoke extraction performances expected of these structures;
- the adequacy of drift compartmentalization provisions with regard to potential fires in these areas.

Commitment n°2024-E34

Before the start of excavation work and the first concretes of surface nuclear buildings, Andra will take into account, for the verification of fire resistance requirements for civil engineering structures, envelope thermal solicitations that could occur during the operational phase.

Commitment n°2024-E35

Before the start of the excavation work, Andra will assess the need for any additional measures to be taken in the underground facility in relation to those presented in the construction licence application, to enable a sufficiently rapid and effective response in the event of fire. Prior to the start of construction of each unit, it will incorporate feedback from experience.

Commitment n°2024-E36

In the next revision of the preliminary version of the Cigéo safety report, Andra will consolidate the envelope runaway scenarios based on phenomenological considerations of the reactivity of bituminous waste packages and the behavior of bituminous waste packages under thermal stress. On this basis, Andra will consolidate its detection and intervention strategy presented in the construction licence application and justify its sufficiency to exclude the propagation of a runaway of exothermic reactions to neighboring packages in the disposal cells dedicated to bituminous waste packages.

Commitment n°2024-E37

In the next revision of the preliminary version of the Cigéo safety report, Andra will justify compliance with the requirements assigned to the civil engineering structures of the surface nuclear buildings constituting the final containment barrier with regard to the effects induced by the crash of an aircraft followed by a fire. In the absence of justification of the requirement not to introduce kerosene, Andra will define the calorific loads whose combustion is to be added to that of kerosene in the event of an aircraft crash.

Commitment n°2024-E38

In the next revision of the preliminary version of the Cigéo safety report, Andra will justify the fire resistance of the archstone and the lining, by a state-of-the-art method applicable to underground structures, taking into account the risks of concrete bursting and over a period of time that allows the structures to cool down.

Commitment n°2024-E39

Before the first concretes of the surface nuclear buildings, Andra will:

- carry out additional calculations for all the load-drop cases selected, taking into account inclined load-drop configurations on an angle or corner;
- systematically carry out sensitivity studies for structure behavior studies, based on non-linear fast dynamics numerical calculations, with regard to aircraft and load drop impacts;
- demonstrate that the non-chipping and non-perforation of slabs for each case of load drop, using standard empirical formulas. Failing this, Andra will justify the absence of reinforcement failure using a

more complete numerical approach dedicated to the justification of non-perforation, based on sensitivity studies.

Commitment n°2024-E40

In the commissioning application file at the latest, Andra will provide further evidence of its ability to control fire and explosion risks during the transitional phases of cell delivery and closure.

Commitment n°2024-E41

By the end of December 2024, Andra will draw up a new design-basis seismic spectrum (SDD) based on an update of its exploration of uncertainties at safe shutdown earthquake (SMS) level, taking into account a 0.5 increase in Mw on the one hand, and propagating all the spectra explored to construct the distribution on the other hand.

Commitment n°2024-E42

Andra, to complete the assessment of the risk of flooding from local rainfall will:

- before the first concretes of the surface nuclear buildings, study alternative solutions to those presented in the construction application file, to limit the accumulation of water near entrances n°5 and n°6 of the EP1 building;
- before the first concretes of the surface nuclear buildings, justify the roughness coefficient values adopted for the rainwater drainage system with regard to the maintenance program adopted, or, failing that, take into account conservative values for drainage system design;
- at the latest for the commissioning application, update the modelling of the rainwater and runoff drainage system after construction of the system in order to verify that the developments carried out do not call into question the elements presented in the safety demonstration.

Commitment n°2024-E43

Before the first concretes of the surface nuclear buildings, Andra will carry out a robustness analysis of the facility with regard to the recommendations of the "Wind and Snow" working group.

Commitment n°2024-E44

Andra will justify, before the first concretes of the nuclear surface buildings, that the measures planned to protect the EP1 surface building against the direct effects of lightning provide a high level of protection. The suitability, with regard to the targeted level of protection, of the characteristics of the structural elements that may be accounted for will be justified.

Commitment n°2024-E45

Before the first concretes of the nuclear buildings, for the design of safety-related equipment on the surface, Andra will take into account a pressure wave whom envelope nature is justified with regard to the risks associated with industrial activities and communication routes in the Cigéo environment.

Commitment n°2024-E46

Before the first concretes of the surface nuclear buildings, Andra will take into account the impact trajectories of military aircraft in line with the state of the art. At the construction licence application stage, this state of the art corresponds to an impact trajectory of military aircraft normal to the outer walls (roof slabs and peripheral walls).

Commitment n°2024-E47

Before the first concretes of the surface nuclear buildings, Andra will develop further the assessment of aircraft crash presented in the construction licence application file with the following:

- a functional analysis to identify the EIPs required in the event of an aircraft crash and their potential aggressors;
- vibratory spectra induced by aircraft crashes representative of military aviation on the EP1 building and general aviation on the VVE shaft emergence, as well as shaking studies associated with EIPs designed for aircraft crashes.

Commitment n°2024-E48

Andra will demonstrate, before the first concretes of the surface nuclear buildings, the non-perforation of external slabs and walls for military aircraft impacts, using simplified, proven methods. Failing this, Andra will justify the absence of reinforcement using a more comprehensive numerical approach dedicated to the justification of non-perforation, based on sensitivity studies.

Commitment n°2024-E49

Andra will install couplers in the external slabs and walls of the EP1 building, related to the risk of aircraft crash.

Commitment n°2024-E50

Prior to ASN approval the waste acceptance specifications, Andra will justify thicknesses chosen for the "sufficient thickness" option in the waste acceptance specification for maintaining static containment, based in particular on the environmental conditions of the disposal cells and the properties of the materials making up the primary packages.

Commitment n°2024-E51

Prior to ASN approval of the waste acceptance specifications, Andra will ensure that the criteria for static containment are operational.

Commitment n°2024-E52

In the next revision of the preliminary version of the Cigéo safety report, Andra will specify the program of work to be carried out in the "inactive" pilot phase in order to confirm the safety demonstration.

Commitment n°2024-E53

By the end of 2024, Andra will complete its project reference system related to the integrated management system, particularly regarding the technical configuration management and the management of modifications to the Cigéo program.

Commitment n°2024-E54

By the end of 2025, in order to strengthen the organizational modes of risk management for the Cigéo program, Andra will:

- present a roadmap for apprehending the challenges of operation and the associated organizational arrangements;
- present a roadmap for the integration of human factors;
- will justify that its organization enables radiation protection requirements to be taken into account in a cross-functional manner during the detailed design of the Cigéo for its construction, with a view to its future operation.

Commitment n°2024-E55

By the end of 2025, Andra will present a roadmap for formalizing its feedback of experience, including its organizational and human dimensions.

Commitment n°2024-E56

Andra will justify, before the start of excavation work, the possibility of conciliating flows relating to nuclear activities and those relating to closure activities without impacting on risk management.

Commitment n°2024-E57

Prior to the start of excavation work, Andra will complete the safety demonstration for the closure of the ILW-LL cells with regard to explosion risks, based in particular on an assessment of (i) the fate of gases in the ILW-LL cells, taking into account exchanges with the access gallery, and (ii) the consequences of an explosion in the part of the cells containing the disposed ILW-LL waste packages.

Commitment n°2024-E58

Before the start of excavation work and the first concretes of the nuclear buildings, Andra will present its assessment of the evolution of the performance of civil engineering concretes over time, based in particular on the results of the performance-based approach, with a view to a potential extension of the project's lifespan, and will modify the constructive provisions of the structures concerned if necessary.

Commitment n°2024-E59

For its first reversibility review, Andra will present (i) the organizational and material provisions taken to ensure the flexible nature of Cigéo, and (ii) the changes in the levels of flexibility and adaptability in relation to possible stages in the facility's deployment.