2022 Edition

Status of safety in nuclear facilities

General Inspectorate Annual Report

orano

◀ *Cover photo: Operator in action, Tricastin*

A glossary of abbreviations and key main technical terms is provided on pages 58 to 62 of this report.

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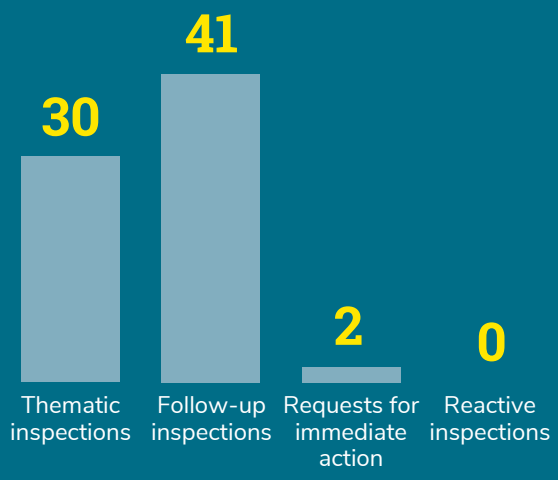
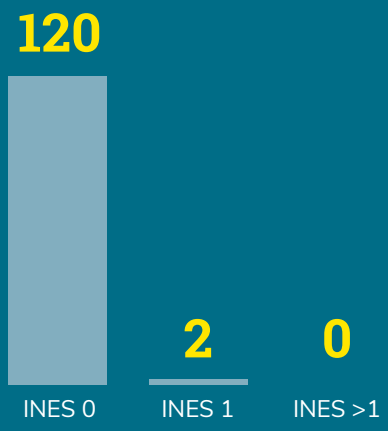
KEY FIGURES

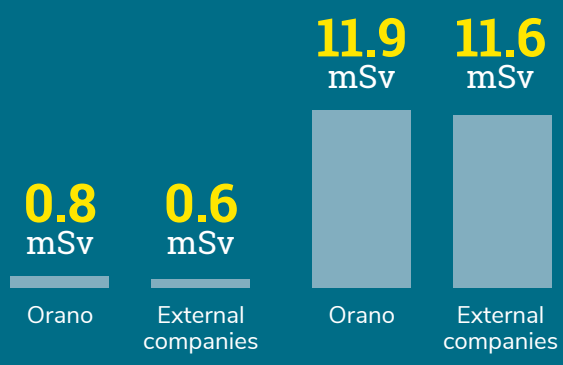
Number of inspections



Number of events declared to nuclear safety authorities or included in experience feedback



Worker dose



Maximum radiological impact of nuclear sites

0.0113 mSv

MESSAGE FROM THE CEO,
Philippe Knoche

« In an uncertain context, Orano continued to operate its nuclear facilities with a good level of control of nuclear safety, environmental protection and radiation protection ».

After two years of pandemic, the year 2022 will again have been singular in many ways and rich in lessons learned.

With a view to the development of nuclear energy, three very distinct realities call for reflection and action today. First of all, the conflict in Ukraine and its impact on the safety and security of the country's reactors raises the question of the long-term resilience of our facilities and operating teams in the face of exceptional situations. The very unusual weather conditions this year, with events of a magnitude rarely experienced leading to fires, droughts and torrential rains in France, Europe and other parts of the world, require us to anticipate these developments in view of their potential impacts. Finally, the cracks observed in the circuits of French power reactors are a reminder, if one were needed, of the exacting standards required by the nuclear industry.

All these considerations underline the primacy of nuclear safety and industrial security over all other factors.

In this context, we must continue to be exemplary in the day-to-day operation of our industrial facilities, with a safety approach that is as close to the ground as possible, practical and focused on the most critical issues.

For Orano, the 2022 results are satisfactory.

The number of significant events declared to nuclear safety authorities or included in experience feedback in relation to nuclear and industrial safety remains stable. This reflects a good level of feedback of these signals which, once analyzed, contribute to the continuous improvement process. The severity of events is also decreasing significantly. The occurrence of certain repetitive events is falling as a result of the actions taken by the teams within the facilities.

I note, however, that the deviations concerning radiation protection, although of low severity and without consequence for personnel, have increased significantly. This confirms the trend seen last year. Many analyses have already been carried out to explain the causes; action plans are being deployed to remedy them. It is up to us to maintain the momentum so we can measure the effects. In this regard, the radiation protection modernization project initiated in 2021 is also a real opportunity to enhance the attractiveness of the radiation protection disciplines, which are crucial, and to strengthen their performance.

Beyond observing the rules, we must continue to work collectively on our behaviors - operators and managers alike - to consolidate our culture. I should also, in connection with this point, highlight the initiative launched in 2022 with our managers to strengthen their ability to influence and shape the behavior of their teams through their postures and their practices. Safety is about all of us.

I therefore encourage you to examine this annual report by the General Inspectorate which allows us to measure the progress made and to identify the areas for improvement on which we still need to work.

VISION OF THE INSPECTOR GENERAL, **Pascal Wilz**

« Based on a review of key indicators, an analysis of reported events, the lessons learned from inspections and various observations, it is clear that 2022 was satisfactory in terms of nuclear safety, industrial safety and radiation protection ».

This annual report of the General Inspectorate deals with industrial risk prevention and presents the status of the control of nuclear safety, industrial safety and radiation protection for 2022 within the scope of Orano's activities and facilities.

Key results

1 **Radiation protection, 122 significant events** were declared by Orano, or Orano was responsible for their cause. Two of them were declared at level 1 of the INES (International Nuclear Event Scale) and 120 at level 0.

No events at or above level 2 were declared.

These results highlight a **clear decrease in the number of level-1 events**, the lowest in 10 years. **At the same time, the number of events remained constant. This led to a prevention rate**[1] **(or IPR) that is the lowest in 6 years, significantly lower than 0.1.**

The number of significant events involving **radiation protection**, even if these events did not impact personnel, has been **constantly increasing over the last 3 years**. They should be considered in relation to the good results in the area of dosimetry and the very large number of interventions in regulated areas (e.g., 850,000 per year at the La Hague

1 *Ratio of the number of events of 1 or higher on the INES scale to the number of level-0 events.*

site). Given the challenges regarding the group's specific activities with untransformed radioactive materials, these minor deviations are indicative of a flaw in the personnel's radiation protection culture and must therefore be corrected. The group has thus made ambitious action plans. According to the site, they include technical measures (additions to and modifications of equipment), organizational measures (poster campaigns) and training actions for the personnel. The subcontracting companies are associated with this work. It is important to sustain momentum so that these plans produce their effects.

A detailed analysis of the events is presented on page 26 of this report.

The most illustrative events, with regard to operating feedback, which had no significant consequences for the personnel, the environment and the nuclear safety of facilities, concern:

- in the area of preventing the criticality risk:
  - an error in composition of a package load during train transportation, classified as level 1 on the INES scale,
- in the area of fire risk prevention:
  - a fire during a cutting operation using a plasma torch,
  - electric arcing in a facility being dismantled,
- in the area of material confinement:
  - one-time releases beyond the authorized administrative limits,
  - incorrect use of a materials container support,
- in the area of radiation protection:
  - repeated deviations in personnel dosimetry, including one by a specialized operator, classified as level 1 on the INES scale,
  - a pinhole in a glove box during a handling operation.

The actions identified in 2021 for improving the **performance of the operating feedback process** were progressively deployed. The participation of the sites in the 2nd level analysis of events is a sign of progress, enabling us to make the feedback more relevant and to favor the sharing of lessons learned.

The deployment of this action plan will continue into 2023. We paid particular attention to **recurrent events and in-the-field monitoring of the action plans associated with these events and the internal communication** supporting the operating feedback.

In the area of industrial risks, for which the reporting of events is the most recent, 2021 was considered as a reference year. In 2022, the observed trends are similar to those involving nuclear safety.

Thus, after a significant increase in the number of events, the past year shows a clear increase of these events both in number and severity: **245 level-0 and level-1 events and 5 level-2 events** on the ASSESS scale led to an **industrial risk prevention rate (or IPR RI) of 0.02** at the end of the year.

The most significant events concern:

- effluent spills at two mining sites abroad,
- a fire in a mobile device, and
- exceeding a regulatory limit for an air-cooled exchanger.

In the areas of nuclear and industrial safety, the low prevention rates regarding the stated objective (0.02 for an objective of 0.1) led to a change in measuring this performance through finding deviations considered as weak signals. This new indicator will be tested in 2023 and will play a role in updating the Nuclear Safety-Environment policy for 2024–2026.

2 **Dosimetric results** are satisfactory, with low values for group employees and employees of outside companies.

While the French annual regulatory limit is 20 millisieverts (mSv), **the average exposure levels for employees and external workers were 0.8 mSv and 0.6 mSv respectively**, lower than last year.

At the end of the reference period, **no employee had received a cumulative dose above 14 mSv over 12 consecutive months**, the internal alert criterion for the group. This result is an improvement compared to last year.

3 **Radiological impacts on the environment at the sites remain at very low radiological levels:** less than 13 microsieverts per year (for a regulatory limit of 1,000 microsieverts for members of the public).

4 In 2022, **30** inspections and **41** follow-up inspections were carried out. These inspections led to 100 recommendations and as many action plans to be implemented by the inspected entities. This result should be considered relative to the **112 recommendations that are confirmed to be resolved.**

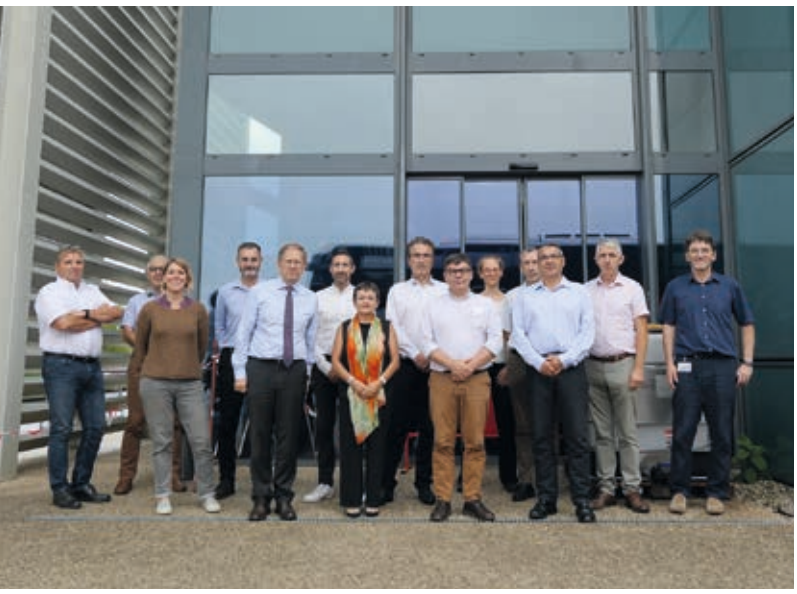
The inspection program was carried out except for three missions that were rescheduled to take place in 2023. We paid particular attention to **acquiring a cross-cutting view of nuclear safety management processes and risk control related to handling**, a topic identified as a priority for the group in 2022. **Verification of fire risk control**

and industrial safety issues is ongoing. For the first time, the following were inspected: a site newly integrated in the group, former mining sites in France, the TNF site (Kenersville, North Carolina, USA) and an operation known as Pool to Pad (USA).

In keeping with the operating feedback from events in 2022, the General Inspectorate took action in 2023 to control access to regulated areas and provide radiation protection training.

Joint inspections with CEA (French Atomic Energy and Alternative Energy Commission) were carried out in facilities where CEA is the nuclear operator and Orano the industrial operator. This regular practice provides a complete overview of nuclear safety and radiation protection control in facilities. It also promotes the exchange of methods, best practices and nuclear safety issues between both nuclear operators. In 2022, radiation protection was highlighted with the observation of two facilities and the associated operating teams.

The conclusions of the inspections carried out are described in detail on page 16 of this report.



▲ CEA and Orano inspection teams

Processing recommendations within a controlled timeframe had been identified as an area for improvement in the reports for previous years. The collective effort to compensate for liabilities confirmed the positive trend observed since 2019. We paid particular attention to complying with timeframes for responding to recommendations and conducting action plans, but also to processing the oldest recommendations.

The results, while not yet totally as expected, are satisfactory. Reducing the number of in-progress recommendations is ongoing (-10% over the past year and -23% since 2019).

The older recommendations (beyond two years) are currently limited to a few units. For the first time in 4 years, the number of in-progress recommendations at the end of the year is less than the number of recommendations issued. This positive trend should continue in 2023.

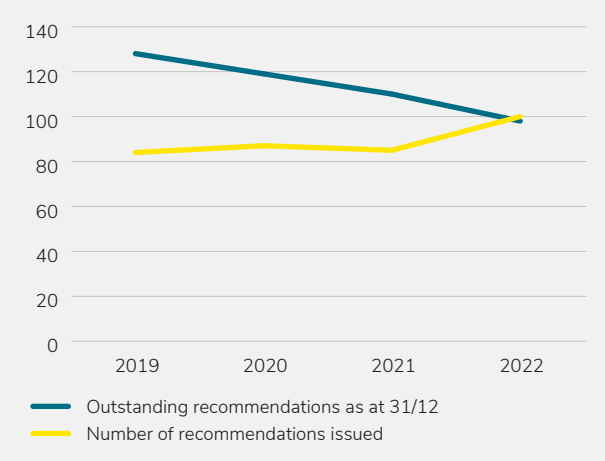


Figure 1: Trend for numbers of recommendations since 2019

Control of nuclear safety issues

PERIODIC INSPECTIONS AND TESTS

Controlling periodic inspections and tests had been identified in 2020 as a point to pay attention to due to the high number of significant events. While the situation has improved in terms of the number of events declared in 2021, the last accounting period shows a slight increase in the number of deviations. While these deviations remain acceptable regarding the number of inspections performed, we must continue to bear in mind the specific action plans deployed on the various sites since 2020 and the underlying analyses.

FIRE RISK

While there were no significant fire events, operators must constantly keep the few fires that did occur top-of-mind and do this at all levels.

The observations of the independent nuclear safety organization (General Inspectorate, internal inspection and first-level inspections) show good awareness of this risk and a good level of training among the specialized teams and the operator in case of intervention. Areas to improve have been identified. These include, according to the site:

- operational management of the fire load, in particular for waste storage facilities,

- condition of fire doors,
- make-up of first response teams,
- operational discipline in performing hot work and the completion of fire permits, even though there have been past efforts to improve this prevention,
- risk analysis prior to a specific operation, as shown by the event described on page 36,
- cross-cutting analysis of weak signals, and
- on certain sites, lack of awareness of reports issued periodically by the Insurance Department, which are important documents regarding prevention.

SUBCONTRACTOR CONTROL

The subcontracting of safety important activities requires the operator to be able to control all assigned tasks with a high level of confidence and to ensure surveillance by qualified personnel working directly in the field.

The observations of the independent nuclear safety organization are a continuation of last year. They show that the INB Order[2], which defines the acceptable requirements, is properly incorporated in the processes and procedures but implemented heterogeneously.

The application of these requirements in the purchasing process, particularly by performing checks to detect deviations, is clearly improving. Surveillance in the field must continue to check for proper application of nuclear safety requirements.

In this regard, the manager of surveillance of subcontracted activities plays a key role in this system. 2022 saw the deployment of an e-learning training module on surveillance basics. The coming year will see a campaign to assess the skills of surveillance managers and an overhaul of training modules on surveillance tools.

HANDLING

Handling is a sensitive activity relative to nuclear safety but also to industrial and occupational safety. It thus concerns all the group's facilities and activities.

This topic was identified in 2022 as a priority action at the group level. Numerous efforts were made to capitalize on best practices and identify improvement areas.

The safety of operations is based on a coherent whole bringing together a documentary baseline, trained personnel and compliance with rules.

The sites have responded to this issue by deploying large-scale initiatives to ensure its control. However, the observations of the independent nuclear safety organization remain mixed.

While the organization of the sites is generally well defined, based on a complete baseline, in the field the practices can be improved even more. This mainly concerns:

- the presence and identification of foremen, when called for by the situation,
- the use of reliability enhancement practices,
- risk analysis prior to interventions,
- updating the instructions for use.

Two distinct initiatives contributing to controlling this risk should be highlighted.

The first consists **of identifying the best practices** implemented on the sites, by referring to WANO[3] requirements. Combining observations and analyzing the expected benefits regarding the necessary effort enabled choosing the applicable best practices in addition to the regulatory requirements to which the operators are already subject. It is the responsibility of the sites and the General Inspectorate to check the proper implementation of these additional requirements.

The second initiative concerns **developing and deploying** a telephone application called Manut', which enables everyone (operator or manager):

- to validate the various points of the checklist presented on the screen (one-minute pause),
- by superposing the smartphone view on the handling equipment connected to a load, to rapidly and simply ensure the proper measurement of their slinging angle (a function of the handling sextant).

▲ *Handling sextant*

▲ *Handling of a container, Malvési*

2 *Modified French Order of February 7, 2012, setting the general rules concerning regulated nuclear facilities.*
3 *WANO: World Association of Nuclear Operators.*

Implementing the Nuclear Safety-Environment policy

The 2021–2023 Nuclear Safety-Environment policy is an integral part of the group's CRS approach. It covers all interests protected by French law, namely nuclear safety, environmental protection and crisis management. It also takes industrial risks into consideration.

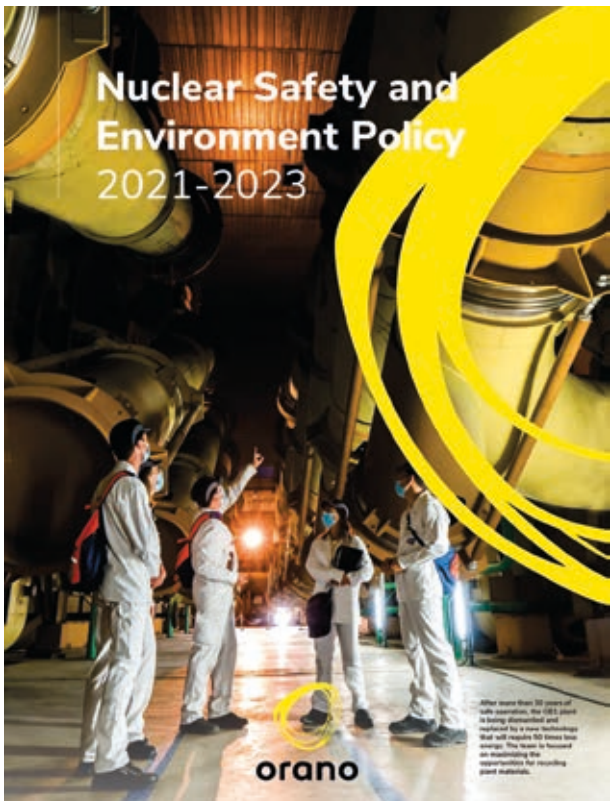
It includes 21 action priorities, 11 for nuclear safety and 10 for the environment. Its operational application and its effectiveness will be monitored through the inclusion of its priorities in the master plans of concerned entities, through an annual implementation plan and through a set of indicators to be periodically presented to the executive committee.

For the second year the policy was implemented, nearly 80% of the actions decided on were carried out during the period. These results remain satisfactory. Three major actions that are part of the deployment of the policy should be highlighted:

The development and first deployments of a training module called "Managers as nuclear safety leaders". Through their behavior in the field, managers are essential links for achieving a solid nuclear safety culture and a high level of performance in nuclear safety, industrial safety, but also for occupational safety. The feedback on these first training sessions appears to be very satisfactory, particularly due to the commitment of managers to the approach. Continuing the deployment of this module for the 700 employees identified and the capacity to measure an improvement in behavior are the main challenges for the next 3 years.

The control of subcontracted activities is one of the important challenges in maintaining nuclear safety on a daily basis. This control is based, in part, **on the capacity of surveillance managers to check, in the field, compliance with the requirements** that apply to outside companies.

▲ *Collaborative work during "Managers as nuclear safety leaders" training*



For this purpose, an ambitious training program was implemented for the 750 surveillance managers identified. It is aimed at establishing fundamentals in the areas of nuclear safety culture; knowledge of regulations and, in particular, of the INB Order; surveillance of subcontractors; and the risk of fraud. This training program also covers implementing surveillance tools. It is mainly based on an e-learning module. In 2022, nearly 600 employees were trained.

▲ *Opening page of the e-learning module on control of subcontactors*

Maintaining a strong nuclear safety culture is an important and permanent part of the nuclear safety-environment policy. In addition to an awareness-raising module for employees, campaigns where entities conduct self-assessment campaigns, at the level of the workshop or the team, remain the flagship tool for identifying strong points and progress points.

global leadership in **nuclear safety**

WANO

WORLD ASSOCIATION OF NUCLEAR OPERATORS

10 WANO characteristics	
Individual commitment	**PA** = personal responsibility
	QA = questioning attitude
	CO = communication about nuclear safety
Management commitment	**LA** = leadership accountability
	DM = decision-making
	WE = respectful working environment
Management system	**CL** = continuous learning
	PI = problem identification and resolution
	RC = environments enabling the escalation of concerns
	WP = response process

In 2022, the campaigns were continued enabling nearly 2300 employees (including nearly 700 internationally) to assess themselves. Each entity has the responsibility to implement a pragmatic action plan to improve its performance and communicate with concerned employees.

In the framework of GIFEN[4], the self-assessment questionnaire on nuclear safety culture was reviewed. It currently includes 61 questions in 3 categories: individual commitment and managerial commitment, and organization and system. The questions are classified according to the 10 characteristics of the WANO standard.

The cross-cutting analysis of the various campaigns conducted in 2021 and 2022 highlights the strengths and improvement points at the group level.

The strengths concern the commitment of individuals regarding nuclear safety, such as personal responsibility and a questioning attitude.

The improvement points are broken down according to the management system and the management commitment relative to nuclear safety. They are part of response processes and of identifying and resolving problems. One of the main topics is improving the processing of deviations.

Implementing an approach to decrease the processing of recorded deviations, of a collection of weak signals and short-loop processing, and of a deployment of field rounds by management illustrates the actions taken by the entities following this campaign.

We would like to highlight the energy that went into deploying these self-assessment campaigns. It will be continued in 2023. The end of the Nuclear Safety-Environment Policy is an opportunity to make a more complete assessment of this period and, if necessary, to stipulate the specific actions for further strengthening our safety culture.

INDEPENDENT NUCLEAR SAFETY ORGANIZATION

Strengthening the independent nuclear safety organization (FIS) was recommended in the peer review of Senior Management and its support functions for La Hague activities. This review was conducted at the end of 2017 by WANO.

We have continued with the actions initiated in 2019. The inspection unit introduced under the responsibility of the Deputy Director of La Hague implemented its annual inspection program. Regular exchange with the General Inspectorate and cross-participation of the inspectors optimized inspection activities.

In 2021, the Decommissioning & Services BU improved its internal control capacity by performing audits of control of the main nuclear safety issues within its scope. The audit plans and their results have been exchanged with the General Inspectorate.

The systematic transmission to the General Inspectorate of the results of the first-level inspections of the Melox, Tricastin and La Hague sites allows for a more complete internal evaluation of the level of nuclear safety of the sites, while also making inspections more accurate and guiding the annual inspection program. Some of these observations are included in this report.

The 2022 program of the General Inspectorate made it possible to perform a cycle of verifications of nuclear safety management, the main conclusions of which are covered on page 16 of this report.

SKILLS DEVELOPMENT

In 2022, we continued with actions to develop skills, an important strategic driver in guiding and supporting the group's development and in controlling nuclear safety and radiation protection. These actions are organized around subject matter specialists at the group, BU and site levels.

4 *GIFEN: Association of French nuclear industry groups.*

The annual skills review process (or RAC) is now well established. In 2021, for the first time, it incorporated industrial risks in the scope of safety-environment disciplines. It provides an accurate map of these disciplines with a medium-term outlook and makes it possible to specify the necessary actions to control their criticality. These disciplines, which includes nearly 500 employees, are characterized by a significant influx of young engineers.

The plan to strengthen the nuclear sector, though it represents a real opportunity, is no less a risk factor in terms of the capacity to train enough engineers in these fields and to maintain the necessary attractiveness.

The *Safety Excellence* training plan for facility managers, project managers and nuclear safety engineers (around 600 employees) has maintained its focus: 8 sessions enabled training nearly 100 employees, making it possible to train more than 75% of employees registered for the 2022 training plan, a figure higher than the targeted objective.

We made adjustments to enhance the effectiveness of this system, which has been recognized. In particular, this involves the addition of practical role-plays to work on in teams. It should be noted, however, that this represents a significant workload in a tight time period of 7 months, at the limit of the capacity of the team in charge of organizing and deploying this training program.

For more than ten years, the group has implemented **a periodic system of self-assessment of skills** for the members of the Executive Committee, management committees, facility managers, project managers and nuclear safety engineers. This exercise was conducted **in 2022 for the nuclear safety engineers**, of which the renewal rate was around 40% in 4 years, making it possible to identify strengths and improvement areas. Globally, skills appeared to be maintained, despite the renewal of nearly half the concerned population in 4 years. Clear progress was observed for compliance with the standard path to support new nuclear safety engineers and the training on nuclear safety fundamentals. Some points remain in the background, such as internal and external risk control and interactions with supervisory authorities. Given these observations, improvement actions will be implemented. They concern strengthening the intern pipeline and training in the fundamentals of nuclear safety, defining specific actions for experienced engineers and improving the discipline network.

CONTROLLING THE REGULATORY BASELINE

Updating the group's internal nuclear safety baseline, in application of general regulations, remains a constant challenge requiring significant mobilization of a large number of experts, centrally and at the sites.

The **nuclear safety methodological committee** (or COMET) makes it possible to have internal methodologies that are shared and developed with support from the sites and the engineering teams. The deliverables consist mainly of methodology data sheets and guides. This committee also functions as a preferred structure for specialists in operational entities, engineering specialists and corporate specialists to exchange information on these technical and methodological subjects.


Fiche COMET

Approche proportionnée aux enjeux

Version : 22/11/2022

The main texts released during the past year, not including the documents produced by the sites, represent a workload that remains very significant in this nuclear safety field:

- updating internal guides related to periodic reviews, the nuclear safety demonstration approach, and the preparation and contents of safety analysis reports,
- updating or publishing 8 thematic data sheets, which address the impact of the climate risk on fires of external origin, precipitation, sea level and temperatures, as well as the proportionate approach to challenges. Each data sheet refers to the applicable regulations and the associated definitions and physical phenomena, makes a comparison of hazard levels and indicates actions to take in various timeframes.

In addition to what has been described above, it is worth underlining the important work done internally to annotate international draft texts (from the IAEA in particular) concerning fuel cycle facilities and transportation, which will have an impact on national regulations at a later date.

PERIODIC REVIEWS

Given the operating feedback from the first series of periodic reviews within the scope of fuel cycle facilities, since 2017 the group has set up a reference center to provide consistency in the approaches and methods in order to continuously improve processes and performance.

Thus, in 2022, the activities of the group's advisor cluster continued with the following objectives:

- **provide operational assistance** to operators and engineers in applying guides updated in June,
- **optimize global processes** for developing reviews,
- **share the methodological development needs** arising from operating feedback on examinations, and
- **capitalize on operating feedback** from the reviews by promoting information exchange between the various sites and outside the group.

This operational assistance was applied at the La Hague, Tricastin and Melox sites for around ten periodic reviews in progress, at different stages of completion.

The files are currently prepared with the support of guides incorporating the lessons learned from past examinations and

the most recent methodological work. These changes made it possible to improve risk control while maintaining enhanced effectiveness within equivalent scopes. The computerization of content and the consistency of approaches remain in place and are documented in the group's guides, which were updated this year.

The methodological assistance focused on improving:

- **the data collection process**, via the use of digital tools, redefined the methods for accessing and archiving data; processing these data enables optimizing the preparation of assessments necessary for preparing review files,
- **the process for examining continuous conformity**, by reusing the methods tested on the La Hague site and by applying this process to the Tricastin site with the objective of deployment in the INB no. 168 (Georges Besse 2 plant).

The review training sessions, which further the digital training deployed in 2021, enabled targeting an operator population in a specific way.

We should also highlight **the operating feedback approach applied to documenting action plans and making commitments**, which enabled identifying difficulties and planning improvement areas that sharing best practices brought to light.

Currently, internal work enables robust participation in sharing activities with the other French nuclear operators and international organizations. This took concrete form with the center's participation in various activities.

We organized experience sharing with French nuclear operators on the practices of reviews at facilities being dismantled.

▲ *Vienna International Center, headquarters of the IAEA (Austria)*

As part of the work of the Nuclear Energy Agency (NEA), the center contributed to developing a document on applying the graduated approach principle regarding risks in fuel cycle facilities. This work should be finalized at the end of 2023 with the publication of this document, which will constitute an initial opinion of international experts on this topic.

Finally, in support of the International Atomic Energy Agency (IAEA), which wishes to publish a document on periodic reviews in fuel cycle facilities, the center presented the group's approach in this area.

USING HOFS TO ENHANCE THE RELIABILITY OF OUR FACILITIES

Incorporating human and organizational factors (HOFs) in our operating, maintenance, modification and design activities remains one of the group's priorities. This is apparent in its Nuclear Safety-Environment policy, through actions aimed at improving this dimension.

In 2022, the work to incorporate HOFs was mainly focused on changes in the documentary baseline in this area, applicable to all group entities.

A "best practices" guide regarding HOFs, to be implemented as part of an organizational modification or one involving equipment, was produced and will be presented in 2023 to the group's main actors concerned by this publication.

In addition, a working group was set up to change the internal directive, which lays out the missions and organization of the HOF function. This led to defining the frame of performing HOF analyses for periodic nuclear safety reviews. The revised version of the directive will be published in 2023 and will be applied at the INB no. 155 (TU5) on the Tricastin site.

Beyond these actions, in 2022 a reflection was conducted on the need to define "best practices" relative to HOFs in the area of subcontractor management. This work will undergo consolidation in 2023 and will lead to a guide aimed at supporting these activities.

Finally, more generally in 2023, an assessment will be conducted on Orano's full HOF baseline. Improving specialized skills in the HOF scope within the nuclear industry, and particularly the French Nuclear Safety Authority, will lead to anticipating the resultant future changes. More than ever, HOFs must serve our facilities and enhance the reliability of our activities.

2022 HIGHLIGHTS

▲ New evaporator, La Hague

At all its sites, Orano has continued with the modernization of its industrial facilities and is implementing the necessary organizational changes to deal with future challenges in a tense context.

TRICASTIN SITE

GEORGES BESSE 2 ENRICHMENT PLANT

To be an actor that strengthens western sovereignty in the energy domain, Orano plans to increase its enrichment capacities by nearly one third through extending the current Georges Besse 2 plant.

A request file was submitted to the French National Committee of Public Debate (CNDP) in September to validate the conditions of consulting the public, which apply to all large-scale nuclear projects. The opinion issued by the committee led to defining the conditions of a prior consultation, which was held from February 1 to April 9, 2023.

FLEUR PROJECT[5] (INB no. 180)

After the building permit was obtained, and following a public inquiry and the favorable opinion of the inquiry committee in January 2021, two important milestones were reached in 2022 and early 2023:

- French Decree No. 2022-391 of March 18, 2022, authorized the creation of the INB FLEUR,
- Decision no. 2023-DC-0750 of January 3, 2023, of ASN authorized Orano Chemistry-Enrichment to commission the INB no. 180 called Fleur ("local recycled uranium storage").

Parallel to these administrative milestones, inactive tests continued with the operator, particularly to validate the access of emergency service vehicles and the capacity of response by the site's response teams.

MALVÉSI SITE

HYDROFLUORINATION WORKSHOP

Work augmented and accelerated in the hydrofluorination workshop, requiring close coordination during the production outages. After the replacement of the UF_4 pneumatic transfer airlocks came the replacement of an important piece of equipment called a helicoidal elevator and the launch of a work phase, in addition to those conducted in 2019–2020. This new phase aims to improve fire risk management, ensure the building's structural compliance relative to natural hazards, strengthen the primary confinement of materials and enhance the safety of handling operations.

UO_2 WORKSHOP

Last May 12, a significant milestone was reached with the transfer of the project's workshop to the future operator, enabling active tests with materials. The complete finalization of the project now includes lifting all remaining reservations (suppliers and engineering) and the complete delivery of project documentation.

ACID EFFLUENT TREATMENT WORKSHOP

Designed to reduce its environmental footprint, the acid effluent treatment workshop makes it possible to decrease the volume of solid conversion residues and nitrate effluents stored in the settling or evaporation ponds. At the end of 2021, the inactive tests at the TEA facility ended and the facility was transferred to the commissioning department of the Malvési site.

LA HAGUE SITE

CONVERGENCE PROJECT

The CONVERGENCE project, initiated in 2020, is decisive for the site. Several steps were taken in 2022:

5 *FLEUR: Providing local recycled uranium storage*

▲ *TN®17Max in transit to the Valognes rail terminal*

- construction continued on the ATLAS building, which will serve to bring the support functions under one roof, with the objective of fully regrouping in the second semester of 2023,
- after the agreement of ASN following the publication of the corresponding decision on August 23, 2022, a new organization of the site was deployed in September, without any major difficulties,
- since September, the first teams of the T2 workshop moved into their new control room, next to the T3 control room, which was remodeled for them. This is the first step. It will eventually lead to sharing the T2, T3 and R2 control rooms.

In parallel, the exhaustive review of the nearly 12,000 documents liable to be impacted by this organizational change is ongoing.

ACTIVE COMMISSIONING OF PIT 50

In mid-September, ASN agreed to the active commissioning of pit 50. This new pit provides additional storage capacity for French vitrified waste containers (CSD-V). It was industrially commissioned at the end of October with the arrival of the first CSD-V.

THICKNESS MEASUREMENT IN ZONE 4

Last October, a drone was introduced in a cell in zone 4. The objective was to measure thicknesses in contact with the pipes located at an evaporator heater. A drone was also sent to inspect a nozzle on this evaporator.

In total, around thirty contact measurements were performed, without any collision with the cell equiplment.

FISSION PRODUCT CONCENTRATION EVAPORATORS

The renewal of evaporators or the NCPF project is ongoing.

For the first concerned workshop, the operations to connect new evaporators to the rest of the process started in September in accordance with the plant's scheduled outage. In parallel, cold then hot tests were conducted.

In addition, the first tests on the new evaporates of the second workshop started in view of a connection in 2024.

CASKS AND TRANSPORTATION OPERATIONS

FIRST TRANSPORTATION CAMPAIGN USING TN®17Max

In November 2022, three TN®17Max casks from a nuclear power plant transited for the first time through the Valognes Rail Terminal, before being brought to the Orano La Hague site to be unloaded for recycling.

This initial transportation operation inaugurates the commissioning of a new fleet of casks initiated in 2011. This TN®17Max fleet replaces that of TN®17-2, in compliance with the latest regulatory requirements.

CASK IDENTITY SHEET

Mass:
- Maximum authorized mass in transportation configuration: 82 metric tons
- Empty mass in transportation configuration without fuel assemblies: 75 metric tons

Dimension:
- Overall length: 6.8 meters
- Overall cask diameter: 2.15 meters
- Cavity diameter: 1.02 meters
- Cavity length: 4.57 meters

Capacity:
- 9 irradiated PWR type 15*15 assemblies

MELOX SITE

CRISIS MANAGEMENT COMMAND CENTER

This facility constitutes the final step in a cross-cutting program of the group to build crisis management facilities designed to resist the most severe hazards. The site work ended and operational commissioning will take place in 2023.

GoMox PROJECT

The main objective of the GoMox project, initiated at the end of 2021, is to find innovative and operational solutions to make the plant last, reduce maintenance delay for the machines, and decrease dosimetry around glove boxes.

One focus of this project is to double the machines for the most critical functions.

LESSONS LEARNED FROM THE INSPECTIONS

The General Inspectorate conducted 30 inspections, supplemented by 41 follow-up inspections, indicative of the effort made to comply with recommendations.

Observations

Aligned with previous years, the inspection program was structured around four main objectives:

- maintaining a high level of control over nuclear and conventional safety during changes to organizations, and over the capacity of existing organizations to deal with unplanned situations,
- management of key nuclear safety challenges (fire, radiation protection, confinement of nuclear substances, criticality and removal of residual power),
- daily management of nuclear and conventional safety through rigorous application of operating processes and procedures, and
- complying with the requirements of nuclear safety authorities around surveillance and supervision of activities.

Overall, **30 thematic inspections**, evaluations and observations were performed along with **41 follow-up inspections** relating to recommendations.

▼ *Inspection of operational waste management, La Hague*

In total, these inspections resulted in **100 recommendations** and as many action plans issued by the inspected entities, compared to the **112 recommendations** whose close-out was checked.

REACTIVE INSPECTION

No reactive inspections were performed in 2022.

ORGANIZATIONAL CHANGES AND MANAGING SPECIFIC SITUATIONS

Project management - NCPF

The project to replace evaporators, or **"new fission product concentration project (NCPF)"** is reaching its end. The inspection performed at

La Hague on the equipment in one of two workshops showed that the organization and commissioning measures are under control. Progress indicators with regard to updating the operating and maintenance documentation and training teams allow for confidence on commissioning of the facility in compliance with the applicable nuclear safety baseline. Transfer of equipment between construction and testing is organized according to a functional whole and is prepared by a dedicated team. Operators are part of the test teams and the process to enter operation is mature. However, processing test reporting sheets relative to nuclear safety should be improved.

Nuclear safety management

In October 2019, the group issued a procedure that formalized the standard and the guiding principles for nuclear safety management. An inspection program for 2022 involved a cycle of inspections on this topic at the **Melox, La Hague, Tricastin and Malvési sites**.

These inspections were part of the group's 2021–2023 Nuclear Safety and Environment Policy, whose stated objectives are to continue developing nuclear and industrial safety culture, to strengthen management, and to develop leadership in nuclear safety and skills in industrial safety.

The results for this cycle of inspections are positive. Management of nuclear safety is structured. The sites took on the major challenges and strategic focus areas of the group's policy and incorporated them in their master plans. The site and BU policies define the challenges and action principles for continuous improvement of their performance in nuclear and industrial safety as well as the reduction of their environmental footprint. The organization and responsibilities for protecting interests have been defined and documented. Managing resources and skills in the safety & environment domain is organized, critical skills are monitored and action plans are implemented to correct any difficulties. Weak signals from internal inspections are taken into account and progress on developing action plans is monitored. Compliance with commitments is managed in a proactive way. Finally, the annual review of the risk control process makes it possible to assess the integrated management system and to identify the progress actions for the following year.

Improvement points have been identified at some sites. They mainly concern:

- practices around **delegating signature authority by the facility manager**, which may differ from one site to another,
- **deploying cross-cutting training programs**, grouped under the headers Safety Excellence (for the operational line) and Safety Focus (for the nuclear safety teams). Support path standards were defined to assist new hires in taking up their duties and in completing the associated missions. Other programs have been deployed for the project leaders and the supervisory managers of subcontracted activities. However, these paths were not used at some sites and the expected rigor was not applied; the required training before new hires take up their duties must be defined and the manager must formally validate the employee's capacity to meet the demands of their position at the end of the training path.
- **deploying the independent nuclear safety organization.** Each of these sites has one or more teams linked to the independent nuclear safety organization; at La Hague, it was strengthened in 2018 by implementing a site inspection department, linked to one of two assistant directors. It is the responsibility of each site to analyze the sufficiency of the inspections carried out with regard to the independent organization, since the training paths of nuclear safety engineers and inspectors lead to first-level inspections and the objectives and methodology of various inspection types can be deployed.
- **strengthening safety culture and nuclear safety leadership**, which constitutes one of the priorities of the 2021–2023 nuclear safety-environment policy. Self-assessment of nuclear safety culture is a key element of this improvement since it enables identifying strengths and weaknesses and developing progress actions based on them. While the objective of having a complete vision of the group has been reached, presenting the results of each team assessment in the field and performing some progress actions remain to be systematically implemented.

Impact of changes to group organization

On January 1, 2021, the group changed its organization to make the operational structure coincide with the legal structure. This change in organization highlighted some operating configurations assigned to industrial operators.

The inspection conducted at **Tricastin** was aimed at verifying in the field that the operational provisions were applied according to this organization.

For the end-of-cycle activities, the choice to select a platform organization bringing together the operator, the industrial operator and the prime contractor must not block implementing requirements with regard to subcontracting, surveillance of outside companies and the quality management system.

▲ *Glove box work, LEA, Tricastin*

MAJOR RISKS ASSOCIATED WITH NUCLEAR SAFETY FUNCTIONS

Radiation protection

Controlling radiation protection was one of the challenges for 2022.

The General Inspectorates of CEA and Orano performed **a joint inspection at the CEA centers** of Cadarache and Marcoule. More specifically, for both facilities it focused on sharing responsibilities and the interfaces between actors as well as the surveillance performed by CEA as a nuclear operator.

CEA assigned the operation of these facilities to Orano. Interviews prior to the facility visits made it possible to check that the responsibilities of the operator, the employer and the head of the utilizing company, as well as the interfaces between both companies, were correctly defined and broken down in the operational documentation. They also made it possible to check the incorporation of recent changes in the regulations on preventing radiological risks. On these points, it is necessary to check, on one of the two facilities, the consistency of the applicable radiation protection rules that are CEA's responsibility and those applied that are Orano's responsibility and to update the internal radiation protection baseline. The conditions of the surveillance exercised by the nuclear operator comply with the regulatory and contractual requirements. However, they should be adapted to the scheduled activities to improve radiation protection risk control.

On the **Tricastin site**, the control of operational radiation protection is satisfactory. The baseline is robust. The radiation protection organization has been described; the roles and responsibilities have been clearly defined. The plant manager is the guarantor of risk control within his/her scope. He/she relies on the "worker protection" department for which the presence of radiation protection technicians in the field is being boosted. This project also plans for strengthening the central team in charge of radiation protection and safety methods. In addition, in 2022, significant work was done to define and set up a "center for radiation protection skills," in application of the regulatory provisions of the French environment code and the French labor code.

Optimizing the exposure level of employees and subcontractors to ionizing radiation as part of the Files for Work in Radioactive Environments constitutes a progress point. The same goes for the awareness among operators of the radiological risks and the protection measures to be complied with during work in demarcated zones. Finally, radiological cleanliness in an inspected workshop and the definition of response conditions and site demobilization must be improved.

Controlling the fire risk

In 2022, controlling the fire risk led to an inspection on each of the main nuclear sites.

The department responsible for protecting nuclear materials (PMN) at the **Melox plant** has been sized and organized to control the fire risk. The action of this department is strengthened, if needed, by the resources of the adjoining CEA center at Marcoule and by the departmental unit of intervention and emergency response (SDIS). Exercises are regularly conducted. Controlling the fire risk in the plant's rooms is satisfactory. Employees understand the rules of prevention and response. Response equipment is suitable for the risks, accessible, and available. Few fires have been observed since 2018 and none of them were due to hot work. The fire safety baseline was updated as part of the nuclear safety re-examination, currently being assessed by ASN.

Given the size and preponderance of the PMN department in fire response, there are ambiguities around the role and size of first- and second-response teams made up of operating personnel. This point must be clarified by taking into account the presence of operators on the premises and their knowledge of the facilities.

The organization of the **La Hague site** to control this risk is satisfactory overall. The checks performed by surveying the conditions of compliance with the technical operating specifications and nuclear safety requirements and by surveying the detection and response provisions, and the provisions aimed at avoiding the propagation of a fire and limiting its consequences, did not reveal any anomalies. The observed exercise involving the site's response teams and the operator's local response group took place in a satisfactory way, reflecting the teams' solid knowledge of the field and the response sheets. The main areas of

▲ *Fire-fighting exercise, La Hague*

improvement involve qualifying the personnel who perform technical inspections of the equipment for this function and updating maintenance operating procedures, as well as managing modifications to the fire files.

Two inspections were conducted on the **Tricastin site**. The organization and provisions for controlling this risk were defined. The site department have been organized to control the fire risk, as its action is strengthened if needed by the SDIS. There are numerous exercises involving site and workshop personnel, making it possible to ensure regular participation of the various first-response teams. The observed exercise showed that the actors know their role and apply the planned provisions. Control of the fire risk in the visited rooms is satisfactory; prevention and response rules are understood, the response equipment is suitable for the risks and is accessible and available, and the workshops are kept tidy and clean. Emergency access points are identified and available. In addition, data is available to enable managers to anticipate the necessary training and refresher modules. The checks performed by sampling regulatory inspection reports on fire protection equipment and those performed on the application of the modification process did not bring any non-conformities to light. However, the overview of the number of fires in recent years shows a significant increase in 2021, which was confirmed in the first two months of 2022. This change must be analyzed and appropriate prevention actions defined. More specifically, for one facility, the improvement points concern monitoring hot work, the role of first-response team members and making the diagrams of the fire monitoring cabinets available. For one unit, implementing the compensatory measures requested following the prohibited use of sandwich panels must be brought to completion. Finally, despite deployment to date, progress must still be made on the operational discipline involving hot work and the completion of fire permits, notably in relation to lifting fire detection inhibitions.

Confinement

Inspection made it possible to observe the progress of the **Malvési site** in terms of confinement. This corresponds to work performed at several facilities. It results reducing releases and the number of internal contaminations.

However, progress remains to be made in preventing dissemination risks; for the facilities that have the status of an environmentally regulated facility (ICPE), this involves taking into account the constructive provisions in the instructions and for the PERLE worksite through better control of radiological zoning.

Removal of thermal power

The **Melox plant** teams in charge of operating dedicated facilities for the removal of thermal power have been trained. They rely on a baseline of operational documents that is structured and available in the control room. Degraded operating situations are regularly tested, notably the emergency control operation which undergoes testing every year. Remediation equipment in case of an incident outside the design basis is available and subject to periodic inspections and maintenance operations.

However, consistency must still be established to identify the various temperature thresholds whose compliance is necessary to comply with the nuclear safety baseline and to define the lists of elements important for the protection of interests and their requirements. Finally, relative to controlling subcontractors, the establishment of maintenance requirements and the inspections and periodic tests of equipment associated with this nuclear safety function must be improved, as well as the surveillance of suppliers to whom the services concerning this function are assigned.

Criticality

Control of the criticality risk in the **Melox plant** is satisfactory for operating and maintenance operations, as well as for modifications. No breaches were observed in the application of criticality instructions or in practice. In 2021, following the multiplication of deviations concerning provisions for managing manual movements and mass, and for managing hydrogenated materials, two projects were deployed. The missions and responsibilities of the personnel involved in managing the criticality risk have been defined.

▲ *McClean site (Canada)*

A recent change in organization, introducing the position of Engineer Qualified in Criticality, makes it possible to strengthen operational control of this risk by providing a precise framework for engineers carrying out technical missions similar to those assigned to criticality engineers at the plant.

However, this organizational modification was not handled via the modification management process. In addition, there are already various training modules on controlling the nuclear safety-criticality risk. Proper monitoring of training and refresher modules has been checked. The obligation to attend the criticality training is indicated in the specifications for the services. However, for facility managers, the content of the criticality training and its traceability must be better documented.

OPERATIONAL MANAGEMENT OF NUCLEAR AND CONVENTIONAL SAFETY

Industrial safety

Further to the inspections in Niger and of KATCO (Kazakhstan) carried out in 2021, the inspection of the McClean plant (Canada) enabled assessing the deployment of the industrial risk management system. Some technical measures, such as setting up automatic closure valves, are now operational.

Even though significant work was carried out to update some of the risk analyses, the hazard study has not yet been finalized. Progress on setting up the safety management system (SGS) is still insufficient. Elements for managing major accidents must be implemented for the most significant hazard potentials (such as ammonia or propane).

Handling

Control of handling and lifting operations was a priority in 2022. Several inspections were conducted in this area.

The inspection conducted at La Hague highlights that the organization and practices for the management of handling and lifting operations are well defined in the documentary baseline. Numerous tools have been developed to improve the operational control of handling operations. However, it was observed in the two visited workshops that the main operational document governing the handling and lifting operations is not always applied. The presence of personnel in the hazard cone must be better analyzed. In addition, the implementation of practices to enhance the reliability of interventions as well as the observations by management staff must be strengthened.

The organization of the **Valognes platform** and the practices for the management of lifting and handling operations contribute to controlling this risk and complying with safety and radiation protection requirements. The safety instructions are displayed at the workstation. The instruction sheets clarify the roles for major operations. The coactivity books enable designated managers to document their work authorizations for outside companies. Monitoring training and the issuance of authorizations makes it possible to anticipate renewal and refresher modules. Monitoring periodic regulatory inspections enables conducting inspections according to schedule.

However, pre-job briefings and, more generally, practices to enhance the reliability of interventions must be adapted to the operations. Appropriate personal protective equipment must be worn. Finally, operating feedback from a damaged lifting beam used in 2021 must be brought to completion.

The organization and practices deployed on the **Malvési site** for the management of handling and lifting operations contribute to controlling

▲ *Package handling operation, Valognes*

this risk and complying with safety requirements. Safety instructions are displayed at the workstation and applied by the operators in charge of handling operations. The implementation conditions of the anchor relating to handling are globally satisfactory.

However, assessments to determine whether the assembly of temporary handling equipment is suitable for performing work above pipes containing hazardous products must be improved. There is a need to consolidate the application of provisions for bringing a handling and lifting equipment item back into service as provided for in the French Order of March 1, 2004, on the verifications of lifting equipment and accessories. Finally, the management of non-conformities identified following regulatory periodic checks must be developed.

Risk control for handling and lifting operations performed at the **TEMIS facilities in northwestern France** and compliance with safety requirements are satisfactory. The missions relative to safety have been defined. Visits in the field have been conducted and the associated corrective actions have been monitored. Best practices were noted, such as the anticipation of handling situations involving compacted baskets, during studies of the future production line. No deviations were observed in the monitoring of training and refresher modules or in the regulatory periodic inspections of the lifting equipment. However, self-propelled handling carriages must be checked daily and systematically. The role of labeling lifting accessories and the notion of danger zones must be clarified. In addition, the responsibility of supervisors, preparers, and actors, for the preparation and execution of handling, must be defined.

External transportation

Transportation of uranium tetrafluoride (UF_4) **between the Malvési plant and the Tricastin site** is carried out with satisfactory control. The teams in charge of the expedition and reception of tank-containers are skilled and make use of a baseline of operational documents. The department in charge of scheduling transportation to Tricastin ensures the coordination of the transportation flows for full and empty containers according to the production requirements of both sites.

However, the interfaces between the various actors in the road transportation process (sites, transporters and the NPS BU) must be better defined, following the example of what exists for rail transportation. In view of the future flow increase, a strategy as to the use of rail or road must be defined to control risks. Finally, as part of the preparation for managing an accident that could lead to a loss of confinement in a tank-container, the use of mitigation means during a representative exercise must be defined.

Waste management

The **TRIADE facility** carries out its waste treatment activities satisfactorily in compliance with its baseline and the acceptance requirements of outlets. Improvement actions were implemented to strengthen the robustness of the waste management process and risk control. Thus, activities important for the protection of interests have been defined and are applied operationally. They concern radioactive waste conditioning operations and preparation of waste to be shipped to treatment or storage centers. In parallel, a plan to enhance skills and manage training and certification is currently being deployed. The site also initiated actions to improve identification and monitoring of waste packages, the presence of operational documentation in the field and control of fire risks associated with waste storage.

However, improvement areas have been identified concerning the strengthening of incoming and outgoing waste traceability. The conditions enabling long-term compliance with the treatment and storage timeframe imposed by prefectorial order must be improved. Finally, the control of waste zoning and storage must also be improved.

▲ *Asbestos waste storage, La Hague*

The organization of operational waste management on the **La Hague site** makes it possible to comply with the regulations in force and internal directives.

The missions and responsibilities have been defined. The waste baseline is complete and robust.

The activity important for the protection of interests known as “Waste Conditioning” has been operationally defined and implemented. In the field, the collection, conditioning and storage zones are well managed overall in the visited workshops. The workers met on site are strongly invested and conscious of the importance of their role. Innovative practices were observed and progress areas are under consideration However, to ensure the consistency of the actions at the site and to promote synergy around operating feedback and best practices, interfaces between the site’s waste teams must be improved. Operational waste management must be fleshed out, notably for preserving the history of zoning changes, managing areas for storing waste and old equipment, and taking chemical risks into account. Finally, applying the AIP previously mentioned in the relevant baseline must be continued.

Safety and radiation protection

The **Creutzwald site (Moselle, France)** joined the group in 2020.

The first inspection of this site brought to light the positive initiatives deployed by the workshop's management since its inclusion in the Nuclear Fleet Operations Department of the DS BU. However, the safety culture of operators and technicians should be strengthened. The improvement points identified concern disabling safety devices on machine-tools, tidying workstations, measures to prevent fire risks (notably to compensate for the absence of automatic fire detection), managing handling operations and managing chemical products.

▲ *Inspection of protective devices on a machine-tool, Creutzwald*

The first inspection of the TNF site (Kernersville - North Carolina) by TN Americas, part of the NPS BU[6], shows that action plans, adapted to the main challenges of occupational safety, are used to consolidate risk management, in particular for the escalation of best practices and improvement points from the field. Safety in the workshop will be improved by creating links between the employees to augment the actions of the safety manager. However, the group's internal HSE baseline must be transmitted to TN Americas and its compliance checked. Workstation risk analysis must be updated and revised during pre-job briefings; HSE documents must referenced and tracked. Finally, the "5S" approach must be supplemented by identifying emergency entrances and exits and eliminating unnecessary fuel materials.

The first inspection of a *Pool to Pad* operation (unloading and dry storage of used fuels), conducted by TN Americas teams, took place at the St Lucie power plant (Florida) operated by Florida Power Light (FPL). The safety and collective dosimetry results of the ongoing campaign are satisfactory.

However, the safety and radiation protection baseline for each Pool to Pad campaign must be more clearly defined, indicating the references of the documents of the operator (FPL), the TN Americas documents, and the Orano documents to be applied for compliance with US regulations and Orano's safety and radiation protection policies. Performing inspections documented by a safety and radiation protection specialist at TN Americas must ensure implementing these points and applying them in the field for each campaign.

Safety and environment

For the first time, the Inspectorate General proceeded with an inspection of the **Mining Closure France department** at the Bessines site. Control of regulatory radiation protection compliance, prevention of accidental spills and outage processes for mining work were satisfactory. In terms of safety, individuals on site had good knowledge of safety provisions, notably regarding the use of chemical products, fire protection, and the need to have an operating authorization for some operations. The work areas were tidy and the traffic areas unobstructed.

However, the process of deviation handling following regulatory inspections must be improved. Training for personnel who use overhead cranes and gantry cranes and training for preparing fire permits must also be strengthened.

Dismantling

The inspection conducted at Tricastin on **dismantling the INB no. 105** showed a satisfactory and controlled situation. All actors were aware of the facility's context and the regulatory baseline. The responsibilities around conventional safety, nuclear safety and radiation protection were identified. Field visits enabled checking and noting that the industrial safety, nuclear safety and radiation protection requirements were applied at all levels and complied with by outside companies in charge of conducting dismantling operations. Finally, the site is well run.

▲ *Mining Closure France, inspection of a tank, Lavaugrasse*

6 *BU NPS: Nuclear Package & Services Business Unit*

However, this inspection brought to light the need to improve training by subcontractors and its traceability, control of mandatory training by the operator, and assessment and surveillance of subcontractors. Finally, a point was highlighted concerning the application of a provision of the "SISERI" Order regarding the prior agreement of subcontractor employers before the utilizing company transmits the operational dosimetry.

SPECIFIC SUPERVISION AND SURVEILLANCE

Waste recovery and conditioning (RCD)

In 2022, the inspection focused on RCD projects and was conducted by the Programs and the End-of-Cycle Activities (DAFC) departments of the site under the supervision of the central department DPS2D. It made it possible to observe the updating process for the RCD program strategy document, its application by various entities and the changes to binding regulatory milestones. Following organizational changes, the documentation related to managing the Programs Department's projects was updated in the first semester of 2023. The management of RCD projects by the Programs Department is satisfactory. However, the basic and control data for phases 2 and 3 of silo 130 must be updated and the rescheduling of binding regulatory milestones must be handled using a deviation management process. For projects having the least nuclear safety issues and led by the DAFC, project management processes and procedures must be updated. In addition, assumptions related to the operating schedule of silo 130 must be documented. Finally, the DPS2D department must make its missions around control and basic data consistent with the practices observed during the inspection.

ROLE-PLAY EXERCISE FOR FINA AND INTRA GROUP EQUIPMENT

As an extension of the observation conducted in 2021, the General Inspectorate assessed the role-plays for FINA and the INTRA group equipment in May 2022 at La Hague. The operating feedback highlighted the professionalism and commitment of the various actors. The main improvement areas involve the deployment of electrical and radiation protection equipment as well as the operation of radios in the field.

Requests by the General Inspectorate

After each inspection, the General Inspectorate issues a report that includes one or more recommendations. If a situation calls for rapid correction without waiting for the circulation of the report, the General Inspectorate issues a request for immediate action (or DAI) whose effects are expected within a few days.

IMMEDIATE REQUESTS FOR ACTION

Two immediate requests for action were submitted in 2022. They exclusively concern occupational safety (safety provisions in a workshop and processing of non-compliant regulatory inspections).

This number remains comparable with that of last year.

RECOMMENDATIONS

The inspections conducted in 2022 led to the issuance of 100 recommendations, a number notably higher than that of last year. Their detailed breakdown in the following two figures is consistent with the inspection subjects.

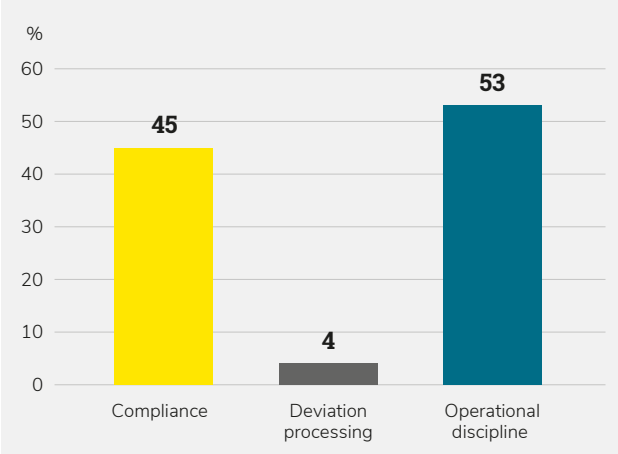


Figure 2: Breakdown by field of the recommendations issued (in %)

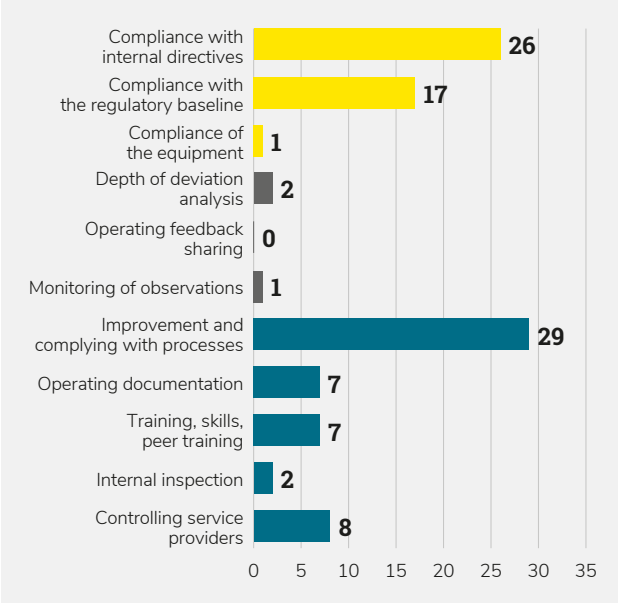


Figure 3: Breakdown by subfield of the recommendations issued (in %)

As of January 1, 2023, **there were 98 in-progress recommendations, a clear decrease over several years**. Their breakdown, shown in the following two figures, remains the same overall as the breakdown of the issued recommendations.

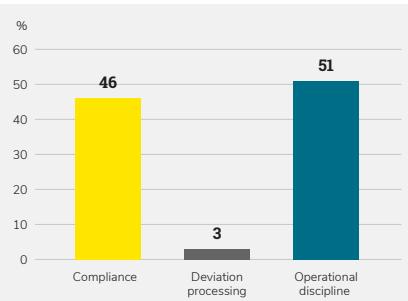


Figure 4: Breakdown by field of the recommendations to be processed (in %)

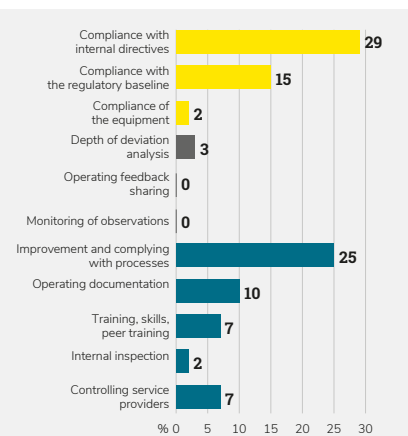


Figure 5: Breakdown by subfield of recommendations to be processed (in %)

The change in the number of recommendations that remain to be processed has progressively decreased over the last 4 years, reaching for the first time, at the end of 2022, a value below the number of issued recommendations.

A cross-cutting vision of handling

From January 2022 to February 2023, the General Inspectorate carried out a cycle of inspections on handling at the group's sites, leading to 19 recommendations.

GENERAL FRAMEWORK AND CONTEXT

Lifting and handling of hanging loads (using cranes, jib cranes, etc.) as well as moving and transporting non-hanging loads (using self-propelled carriages, for example) are part of the group's daily industrial activities. These activities are governed by strict rules set forth in the regulations and partially included in the group's anchor around mechanized handling. Their end goals are to protect people and to control nuclear and industrial safety.

The objective of these inspections was to check that the organizations and the practices at various sites for managing handling and lifting operations guarantee risk control and compliance with nuclear and conventional safety requirements. These inspections also provided an opportunity to examine compliance with safety anchors during field visits and to identify best practices specific to each site.

GENERAL ORGANIZATION

The description of roles, missions and responsibilities for this activity is satisfactory for large sites and should be supplemented for smaller sites.

ANALYSES PRIOR TO OPERATIONS

Prior analyses examine exceptional and common operations. They must be conducted in collaboration with handling experts at each site or, where impossible, in collaboration with the entity's safety department. The results of these analyses must be formalized in the operational documentation.

For exceptional operations, this requirement is correctly applied for large sites. For smaller sites, this approach is documented for cases considered the most significant but not for all handling operations or other exceptional handling operations.

For common operations, in some inspected facilities, the result of prior analyses is not systematically included in operating procedures.

At one site, safety instructions are included in the operating procedures of a subcontractor in charge of handling. At two sites, the common handling operations are described in the process instruction sheets or the SSE workstation instruction sheets incorporating safety guidelines. **These instructions constitute best practices.**

QUALIFICATION OF EQUIPMENT

Site organization must allow conducting and tracking actions for maintaining equipment to comply with regulatory requirements[7] but also, for regulated nuclear facilities (INBs), with the requirements of the chapters of the general operating rules concerning inspections, periodic tests and maintenance.

The checks reveal significant disparities in the organization and management of qualifying handling equipment. At all sites, equipment was used even though regulatory periodic checks were not performed according to schedule. This point also concerns periodic checks as well as checks before return to service.

Technical measures were taken at the sites to meet traceability requirements for operations in the maintenance books for each equipment item. However, the personnel in charge of this activity seem insufficiently aware of these provisions.

PERSONNEL QUALIFICATION

In general, training and operating authorizations are well managed, even though two one-time deviations were observed during crane operator training.

The position of field operation manager exists at nearly all sites. This position, important in all phases of complex operations, deserves to be supported by formal training, to be included among the mandatory training modules at each site.

In addition, we must pay particular attention to monitoring the qualification of personnel performing internal periodic regulatory checks.

CONDUCTING OPERATIONS

▲ *Handling of a cylinder at the Georges Besse 2 plant, Tricastin.*

The deployment of practices to enhance the reliability of operational response operations must be further improved, notably during the authorization of locking/unlocking devices on equipment presenting a risk for the personnel, but also risks in terms of nuclear safety in facilities.

The following main points for improvement were observed:

- compliance issues around wearing a safety belt on board self-propelled carriages,
- conducting suitability examinations, which are obligatory in the same way as periodic general visits (VGP) for all forklift trucks.

CONCLUSION

All sites have an organizational structure and the documentary baseline is in place. The main observations concern operational application, and the application in the field of defined rules, which could lead to risk situations for personnel safety or for nuclear safety of facilities.

Beyond the action plans in response to the recommendations of the General Inspectorate, the prerequisites involve maintaining a good level of training and presence in the field to anticipate and detect all hazardous situations as soon as possible.

7 *French Order of December 2, 1998, on training for the operation of self-propelled mobile equipment and equipment for lifting loads or people.*
French Order of March 1, 2004, on checks of lifting equipment and accessories.
French Order of March 2, 2004, on the maintenance book for lifting equipment.

OPERATING FEEDBACK
FROM EVENTS INVOLVING SAFETY AND RADIATION PROTECTION

▼ *Intervention in a ventilated protective suit, Tricastin*

Two events ranked at Level 1 on the INES scale and 120 at Level 0 were either declared or involved Orano. A significant decrease in Level 1 events, the lowest in over 10 years, comes in contrast with a significant number deviations relating to radiation protection.

Over the course of 2022, **122 significant events**, at Level 0 or 1 on the INES scale, were either declared or voluntarily recognized by Orano for feedback purposes. None of these events had significant consequences for personnel, the public or the environment.

Two events, at Level 1 on the INES scale, relate to situations that failed to comply with regulatory requirements for radiation protection, alongside other anomalies that had no consequences in terms of safety. These were:

- concerning criticality:
  - a configuration deviation on the loading of packages during shipment,
- concerning radiation protection:
  - the failure of a specialist to wear an operational dosimeter when entering a controlled area.

120 events were classified at Level 0 on the same scale. These entailed deviations not impacting safety that are referred to as “soft signals”.

They have been taken into account in the continuous improvement process and in improving risk prevention, resulting in the decreased number of events compared with previous years.

After a steady increase in the total number of events over the past three years, this trend reversed in 2021 to a level comparable to 2018.

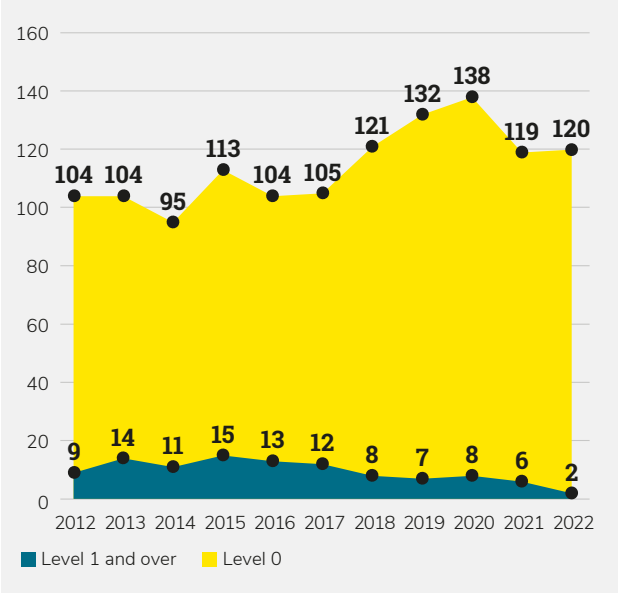


Figure 6: Changes in the number of significant events either reported by Orano or recognized for feedback purposes

The **incident prevention rate for these events (IPR) stood at 0.02** at the end of the year. This result, the lowest in five years, is comfortably in line with the target set at a maximum of 0.1.

Of the total 122 events, 58 related to safety (47%), 38 to radiation protection (31%), 13 to transportation (11%) and 13 to the environment (11%).

Remote handling operator, La Hague

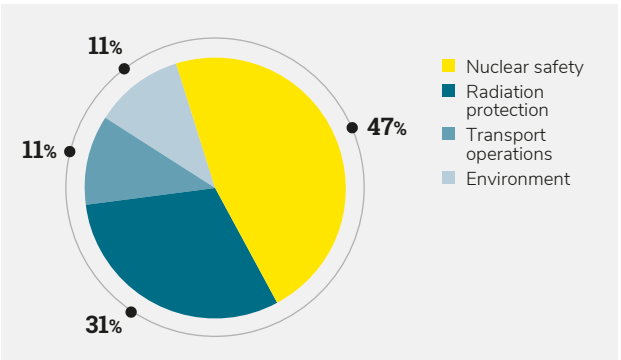


Figure 7: Breakdown of significant events by field of activity (%)

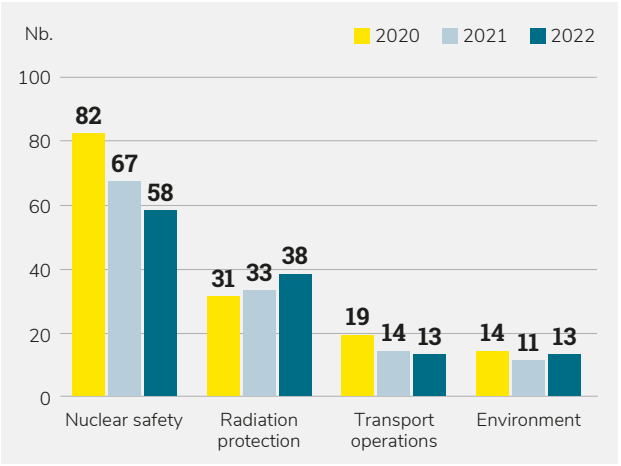


Figure 8: Change in the number of events by field of activity between 2020 and 2022

Although the number of events relating to transportation and the environment remained stable, the year 2022 revealed a continuous increase in events concerning radiation protection over the past three years, accompanied by a decrease in those concerning safety.

Safety of facilities

Of these 122 events, 53 level 0 significant events related to the safety of facilities either owned or operated by Orano. These mainly occurred during routine operations or maintenance activities.

In order to take events relating to periodic inspections and tests into account more effectively, these have been grouped

together under a single heading entitled "CEP" (Contrôles et Essais Périodiques - Periodic Inspections and Tests) within the support roles, whereas previously these events were recorded under the various safety functions.

Safety-related events are broken down by safety function as follows:

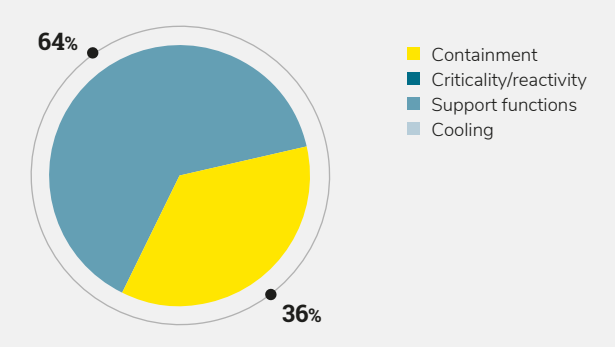


Figure 9: Breakdown of events by safety function

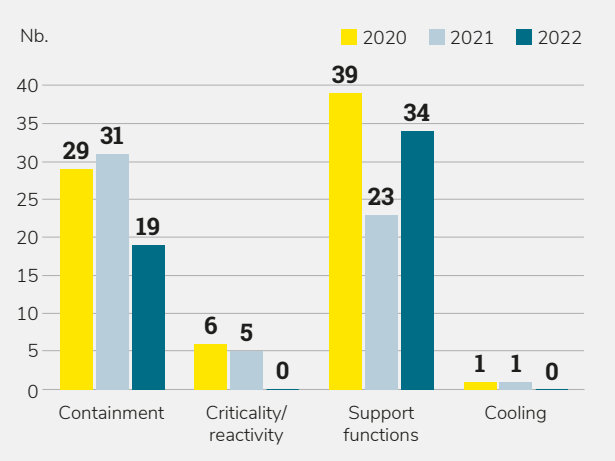


Figure 10: Change in the number of events by safety function between 2020 and 2022 in facilities owned and operated by Orano

Events relating to the containment of radiological material as well as events related to safety functions (criticality and cooling) have decreased. Events relating to support functions are on the rise.

CONTAINMENT FUNCTION

Among the 19 events reported under controlling the containment of radioactive material:

- 9 relate to service deterioration without any real consequences, such as exceeding a maximum period of unavailability for a specific piece of equipment (6 issues occurring at Tricastin),
- 6 concerned the loss of leaktightness on equipment containing radioactive material, although without any environmental impact (including 3 issues at Tricastin).
- 4 were malfunctions in the ventilation of facilities (including 3 issues occurring at La Hague).

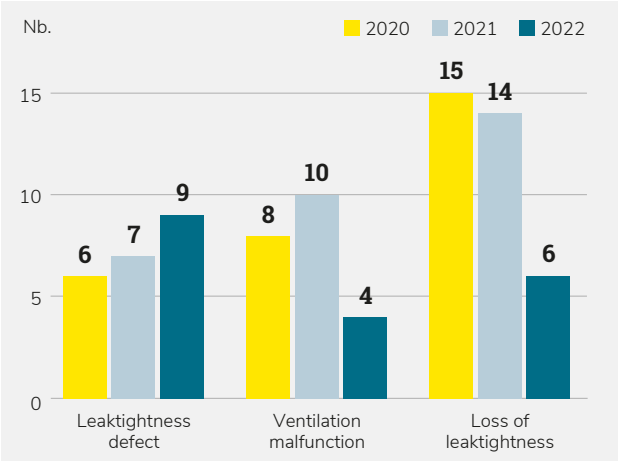


Figure 11: Change in the number of events relating to containment between 2020 and 2022

CRITICALITY FUNCTION

No events concerning the control of fissile material reactivity were reported in our facilities.

SUPPORT FUNCTIONS

Events relating to support functions are up, mainly due to the fire safety operations and periodic inspections and tests.

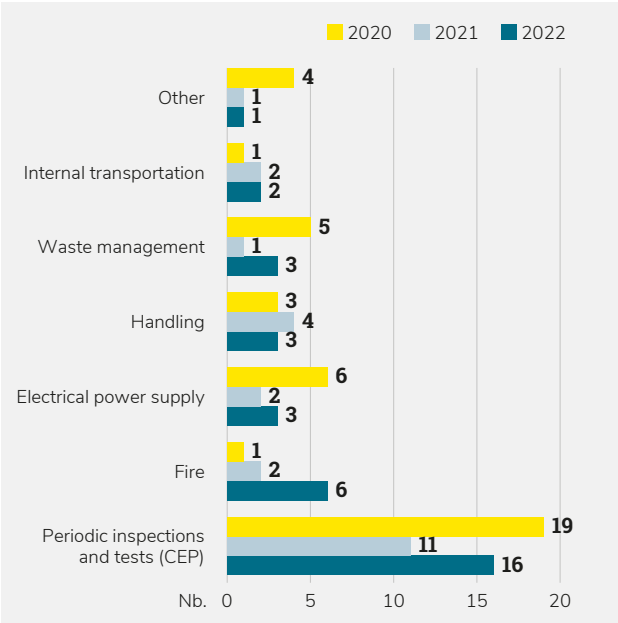


Figure 12: Change in the number of events relating to support functions between 2020 and 2022

Among the 6 fire safety events, 4 related to either fires that had broken out, or the detection of smoke.

Events relating to the failure to complete periodic inspections and tests within the scheduled timeframe set out in the operating procedures increased in 2022 (16 cases in 2022 compared to 11 in 2021).

Radiation protection

There were 38 significant events concerning radiation protection, 37 of which were classified as Level 0 and one as Level 1 on the INES scale. They represent almost one third of the significant events for the year, confirming the increase observed last year (33 in 2021 and 31 in 2020).

The Level 1 event on the INES scale concerns the failure by a radiation protection specialist to wear an operational dosimetry device in a controlled area, although this had no impact on dosimetry results.

As shown in the following diagram, these events mainly relate to the failure to wear dosimeters (lack of personal dosimeters with deferred reading or the failure to activate operational dosimeters), the number of which has doubled in one year:

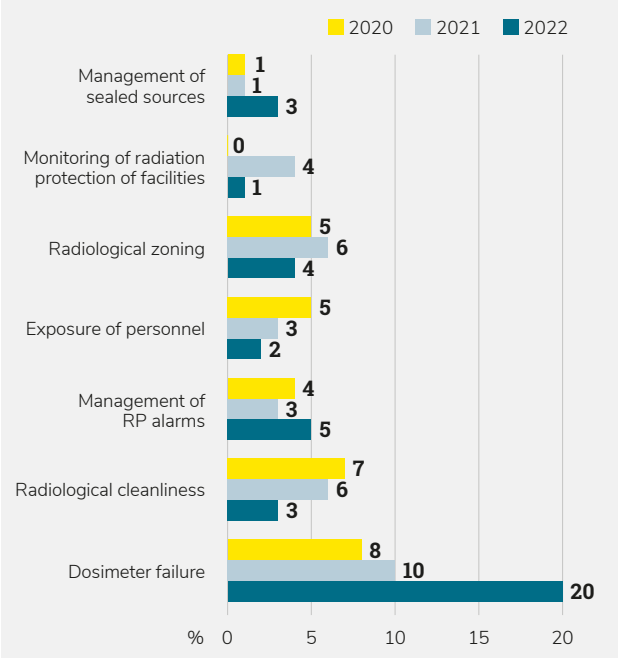


Figure 13: Breakdown of radiation protection events between 2020 and 2022

Transportation safety

Of the 13 transport events reported by Orano, 4 concerned Orano entities or their contractors, the other 9 being the detection of defects at Orano sites upon receipt of shipments dispatched by other operators.

One Level 1 event on the INES scale was reported. It relates to the failure to comply with regulatory requirements regarding criticality risk, although without resulting in any real impact.

The number of drums of uranium concentrate received at Malvési that were damaged during transportation has fallen since 2021.

These events are discussed in more detail on page 53 of this report.

Environmental protection

Thirteen events at Level 0 of the INES scale and 23 other events (outside the INES scale, outside or on the ARIA scale) were reported in relation to environmental protection.

22 events were individual breaches of authorized thresholds for wastewater releases, mainly at the Tricastin site, including six events involving individual fluorine breaches at the conversion plant. This is something which will require attention in 2023.

Four other events were due to the loss of leaktightness in equipment containing refrigerant. This number of events of this kind fell in 2022 (6 events in 2021) due to the studies and actions undertaken by sites to improve their equipment and associated maintenance procedures.

Analysis by facility and by activity

LA HAGUE FACILITY

The La Hague facility reported 36 significant events at Level 0 on the INES scale.

Among these events, 17 related to radiation protection. None of them had any impact on personnel. They mainly concerned the failure to wear or activate dosimeters by personnel in controlled areas due to:

- mostly routine errors, potentially explained by the points of access to controlled areas (location of access terminals, visibility of instruction signs, visual and audible activation signals),
- workarounds permitted by the work environment.

These findings led the facility to implement an ambitious multi-year plan to improve access control in these areas, including the replacement of certain equipment.

Cases of containment failures without dissemination are decreasing. They come as a result of technical defects related to evaporators. The lessons learned from these failures have been incorporated into the design of the new NCPF workshop.

In spite of the progress made in respecting on the respecting the schedule for periodic inspections and tests, 6 deadlines were missed. This can be attributed to a lack of records being kept or a fault in coordination between the inspection bodies and the relevant departments.

The risk of damage to backup generators remains an issue, with two unexpected and short-lived "no load" starts, as these starts do not allow sufficient lubrication of the engine components. Both of these events occurred during operations that required either the power supply units to be tagged and racked out. These came as a result of the failure to keep proper records. In one case, the single-line diagrams of the workshop, used for to prepare tagging, were incomplete. In the other case, the maneuver sheet, used for racking out, was not sufficiently detailed about the consequences of the process.

TRICASTIN FACILITY

The Tricastin facility reported 48 significant events at Level 0 on the INES scale.

Nearly half of them relate to the safety of the facilities and a quarter concern breaches of discharge limits.

Leakage losses reported as containment events show clear signs of being on the decrease (3 in 2022 compared to 9 in 2021). This improvement comes as a result of the action plan set in motion by the site alongside a major commitment by facility managers to fully implement the plan.

In addition to these points, the following site-specific issues are of note:

- satisfactory control over periodic inspections and tests, with the number of problematic events remaining limited and unchanging year-on-year,
- electrical arcing phenomena on two occasions in a dismantling facility,
- a fire which occurred in a concrete compartment while a tank set for dismantling was being cut using a plasma torch. Feedback on this event is described in detail on page 36.
- individual discharges above regulatory limits from the Conversion plant, although without significant impact. The occasional overruns of discharge authorizations remain significant, even though they have significantly decreased in number since 2020. These breaches are mainly due to the absence of fluorine filtration devices on ventilation systems being included at the design stage of the facility, with only with uranium purification devices having been provided. These two networks being connected to a further network fitted with a blasting column now enables us to compensate for this. In addition, the implementation of operating instructions that take into account feedback from the first years of operation should help keep these discharges under control.
- finally, two handling events relating to the crane operator's work environment occurred when cylinders were moved with a gantry crane in a storage yard. One of these events is presented in detail in the feedback section on page 38 of this report.

▲ *Repackaging, sampling and inspection workshop, Tricastin*

MELOX FACILITY

The Melox facility reported two significant events at Level 0 on the INES scale. Representing a significant drop in events, these relate to issues surrounding the performance of periodic inspections and tests and the failure to wear dosimeters in controlled areas.

MALVÉSI FACILITY

Like the previous year, the two events at Malvési relate to the detection of a dissemination of uranium-bearing materials at the time of receiving containers for transporting drums of uranium-bearing concentrate. In such cases, the facility systematically alerts the shipper to enable this latter to analyze the causes of the event and take steps to prevent it from recurring. These alerts go some way towards explaining the reduction in the number of events.

Sub-contracting activities

As part of its activities as a subcontractor or technical operator for another nuclear operator (CEA and EDF), the relevant Orano entities report events for which they hold responsibility, thereby enhancing feedback and experience sharing within the group.

The Marcoule facility reported 10 significant events. This number is down from the previous year.

One of them, concerning a circumvention of a controlled area access rule for an employee in the radiation protection department, was reported at Level 1 on the INES scale.

The other events, classified at Level 0 on the INES scale, mainly concern containment issues and a fire that started in an electric motor, which started in an old capacitor.

There were 12 events at Level 0 of the INES scale in operations performed for the nuclear operator EDF. They mainly related to radiation protection among personnel working on EDF nuclear power plants, including the triggering of dosimetric alarms generated by unidentified exposure prior to any operational work being undertaken.

Industrial safety

▲ *McClean plant (Canada)*

Since 2020, in a process comparable to that used for safety and radiation protection, events affecting industrial safety have been reported to the Group's central level and analyzed again at a second level. This mainly concerns events occurring at industrial sites abroad, facilities classified for environmental protection (ICPE - installations classées pour l'environnement) in France and the transportation of hazardous materials.

These events are classified according to a **severity scale, known as the ASSESS[8] scale** *(see definition on page 58 of the report)*.

The number of events reported in 2022 stands at 250 (245 at Levels 0 and 1, and 5 at Level 2).

This number is down significantly from last year (282 events reported in 2021). The number of significant events (ASSESS 2) is also on the downturn (5 events in 2022 compared to 27 in 2021). These mainly concern overspills.

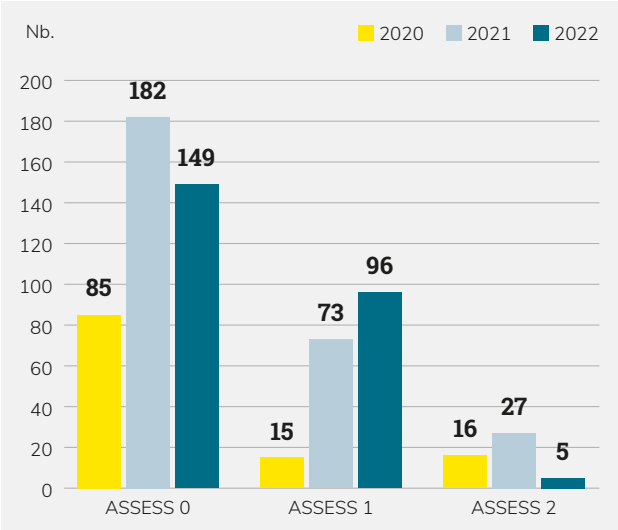


Figure 14: Change in the number of events relating to industrial risks between 2020 and 2022

This distribution led to an **incident prevention rate for industrial risks** (IPR/IR) of 0.02 at year-end. This result is close to the maximum target of 0.1.

Report quality assessment

The significant events reported using the INES scale were subject to a detailed report aimed at identifying the causes behind these events and to set up appropriate and sustainable improvement actions to efficiently prevent them from recurring.

The outcome of this analysis is dependent on the quality of the report in that:

- the description of the event must enable all the identifiable potential causes to be analyzed,
- the depth of the analysis goes back to all initial causes,
- the measures taken cover the causes identified by the analysis and are sustainable.

This quality is assessed based on these three metrics, according to the following principle: assessments A, B, C and D are attributed to reports satisfactorily presenting respectively 3, 2, 1 or 0 of these metrics.

In the end, it appears that the quality of reports on significant events is improving, especially among those deemed to be

8 *ASSESS: Advanced Severity Scale for Events and Soft Signals.*

of very good quality (+6% for A grade). There is a negative aspect to the findings, balancing out the results with an increase in the proportion of reports on significant events that are deemed to be of insufficient quality (+5% for D grades).

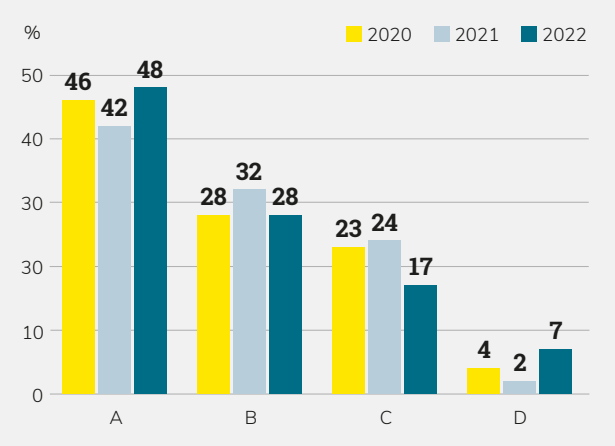


Figure 15: Three-year change in the range of quality in detailed reports

Dips in quality are caused by:

- insufficient research into root causes (especially for workarounds) and insufficient analysis of organizational failures relating to planning operations,
- incomplete or unsustainable measures which do not systematically cover the identified causes.

Analysis of events

The second level analysis of detailed event reports shows that the prevalence of organizational and human factors being behind failures continues to grow, accounting for nearly 90% of them:

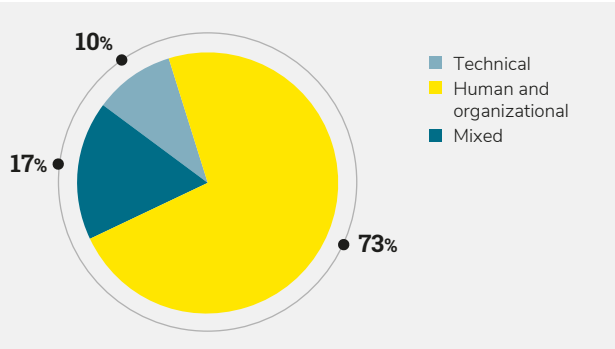


Figure 16: Breakdown of significant events based on initial causes

The trend over previous years for events having exclusively technical causes continues to decrease (-2% in 2022). A decrease in mixed events9 can also be identified (-12% in 2022). Events with only human and organizational causes rose from 59% to 73%, representing a clear increase of 14%.

This observation shows that the Group has been working hard for many years to continuously improve the technical reliability of our facilities. Indeed, the proportion of technical causes - alone or combined with others - has fallen from 41% to 27% for an equivalent total number of reported events.

Without wishing to diminish this progress, it would be worth consolidating the work of bringing organizational and human factors into line, particularly during technical, organizational and document-based changes made within our facilities in order to make these aspects more effective levers for general reliability.

Efforts are already in place to support the development of skills among the people in charge of drafting event reports and analyzing events from a Human & Organizational Factors perspective. The quality of event reports is improving, particularly with regard to identifying organizational failings and human error, as well as the researching the root causes of these failures.

▲ *Operator in control room, Tortkuduk (Kazakhstan)*

FOCUS ON TECHNICAL COMPONENTS

The 24 events analyzed with a technical failure were primarily due to wear/aging and mechanical reasons.

The technical failures of the analyzed events mainly concern leaktightness issues and malfunctions relating to radiation protection, generally due to mechanical causes and wear or aging. To a lesser extent, the failures also involve malfunctions related to the ventilation of the facilities and managing fire risks, essentially caused by these same phenomena.

9 *"Mixed" event: with technical and human/organizational causes.*

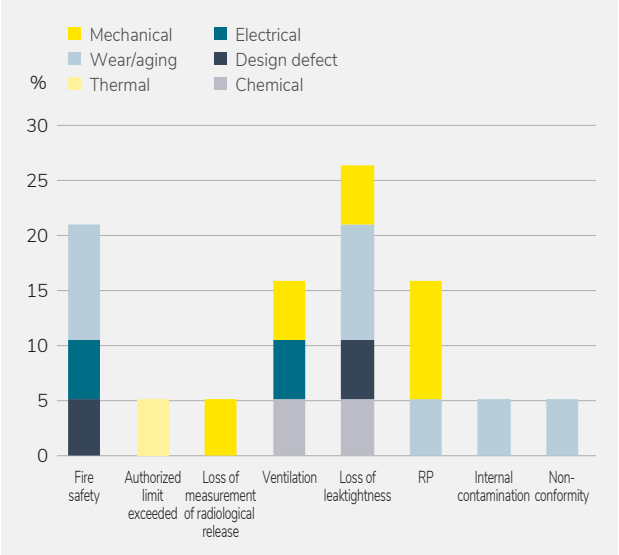


Figure 17: Distribution of functions impacted by technical failures in 2022

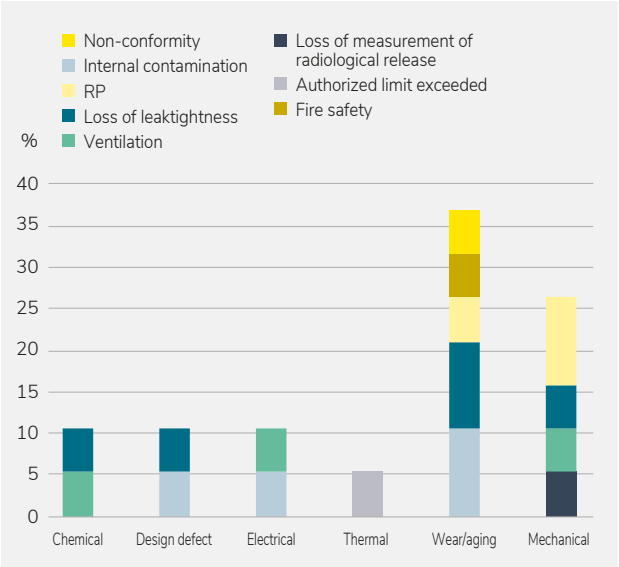


Figure 18: Distribution of technical failures by function in 2022

Additional analyses make it possible to identify human error and causal factors for work situations, at organizational structure level and within processes. They cover 98 significant events analyzed (2 level 1 and 94 level 0 on the INES scale, 2 level 2 on the ASSESS scale).

FOCUS ON HUMAN ERROR

Human error[10] can be broken down as presented in Figure 19:

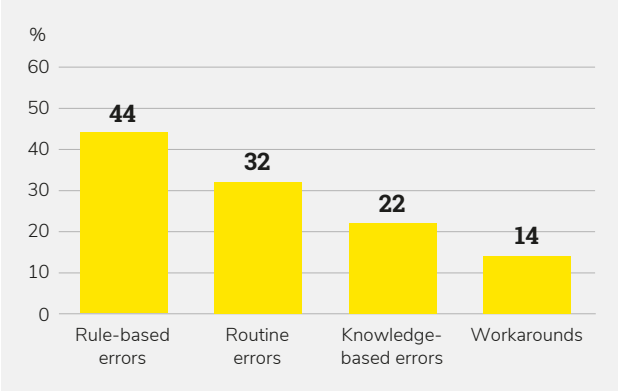


Figure 19: Distribution of human error (in %) identified in the analyzed event reports

Although slightly down (-4%), **rule-based errors** have remained the most commonplace of human errors for several years, accounting for more than a third of the events described. Their root causes are a lack of knowledge of the "correct" rules to apply (45% of cases), or difficulties in applying ambiguous or incomplete rules (35% of cases).

Routine-based errors increase significantly (+8%) in 2022 and require monitoring. This type of error is generally caused by a lack of attention (55%) on the part of operators (either their attention was focused on something else, or they believed someone else was in control of the situation).

Knowledge-based errors have increased slightly (+2%) but their incidence remains stable (20% in 2021). The main cause of this type of error (70%) is related to the absence of rules (instructions, operating procedures, etc.) to manage the situations encountered.

The number of **workarounds** has declined in 2022 from the significantly increased number in 2021. This decrease can be explained by a better identification of this type of human error. Almost all (91%) of workaround situations involved failure to wear a dosimeter. 64% of them came as a result of production constraints (saving time or trying to avoid wasting time). More than half of these workarounds (55%) are performed collectively and recur repeatedly.

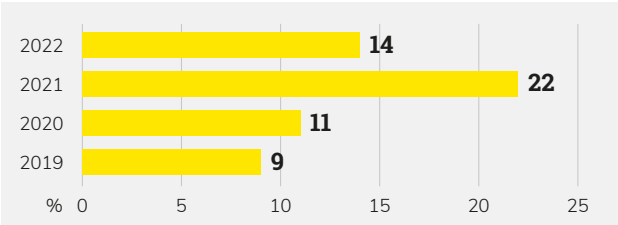


Figure 20: 2019-2022 change in the ratio of workaround situations to human error

10 *Human error includes three types of* ***errors or unintentional actions*** *(see Reason J., Human Error, 1990) and* ***"workarounds"*** *which are* ***intentional*** *deviations from established rules:*
- ***routine errors*** *occur when an action is performed in an "automatic" or routine way,*
- ***rule-based errors*** *occur when an action is performed in a situation that seems familiar, but in reality is not. This situation leads operators to gain an erroneous "representation of the situation" leading to an error either in the choice of rule to apply or in the implementation of the correct rule.*
- ***knowledge-based errors*** *occur when an action is carried out in a situation that is new for the operator, where they are unfamiliar with the rules to be applied and where they have no ingrained, automated responses.*

FOCUS ON THE ORGANIZATIONAL COMPONENT

The causal factors in terms of work situations, organization and processes correlate with the cases of human error analyzed above.

Analysis of causes relating to work situations

With work situations, the main causal factors in 2022 remain the same as in 2021, but in different proportions *(see Figure 21)*.

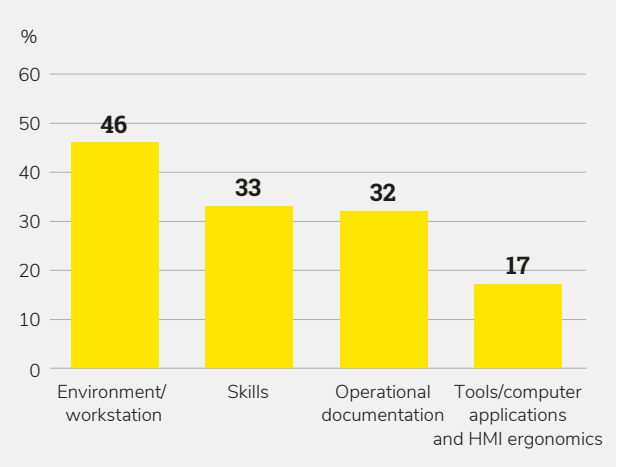


Figure 21: Ratio of causal factors arising from work situations

For the first time since 2018, the “poor work environment” causal factor is the most commonly cited factor, up 25% from 2021. Recurring failures concern:

- missing or erroneous displays and signals (visual and audible) (48%),
- cluttered or obstructed pathways inside and outside buildings, impacting access to premises or tools (31%).

The percentage of events involving a lack of **skills** remained unchanged (-1%). Nevertheless, this causal element remains high, representing a little more than 1/3 of the events analyzed. In concrete terms, the issue boils down to lack of knowledge of the facilities (processes and work tools) or of the applicable documentary references to be consulted, as well as a lack of experience and an insufficiently comprehensive knowledge of the operations to be carried out. As for the failures to apply the documents available for consultation, 50% concern radiation protection rules (wearing or activating Dosicards, performing radiological inspections, access to a controlled area). Moreover, this indicator should be correlated with the "rule-based errors" indicator. A lack of skills and knowledge will naturally prevent operators from correctly understanding the situation in which they find themselves.

Finally, the contribution of **operational documentation** increased significantly, up 8% in 2022, in contrast with the drop-off witnessed in 2020 and 2021 (-5% in 2020, -3% in 2021). This relates to:

- a lack of document updates following technical or organizational changes;
- the use of documents that are incomplete, imprecise or which are not user-friendly, and used by inexperienced personnel. Operational documentation constitutes a genuine learning aid to increase skill levels.

This indicator can be compared with the "knowledge-based errors" indicator. Indeed, one useful element for making actions more reliable, especially when carried out by inexperienced operators, is the use of intrinsically reliable documents (complete and up-to-date).

Analysis of causes linked to processes and organizational aspects

The analysis of causes related to processes and organization highlights the **improvement of subcontracting management** (supervision and support of service providers), which no longer appears in the top five causes of failures. It represents 12% of failures in 2022, in contrast with the 2021 level of 39%.

Other factors contributing to process and organizational failures in 2022 remain unchanged from 2021, except in their proportions. They can be grouped into three different categories:

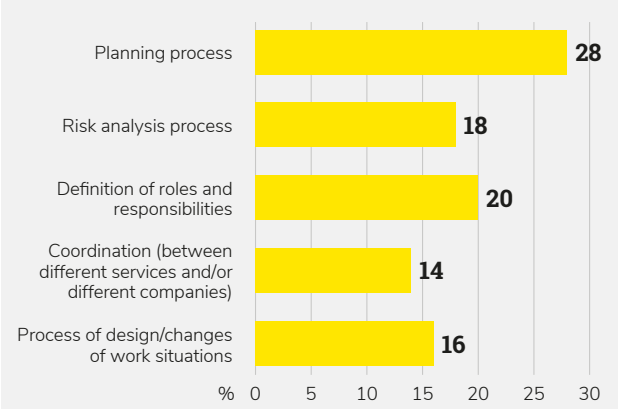


Figure 22: Distribution of process and organizational causal factors (%)

- The **preparation of activities** covers the **processes of planning** (28%, i.e. +12% compared to 2021) and risk analysis (18%, i.e. down 11% compared to 2021). The contribution of these two factors together remains stable (46%), although their weighting is reversed. These interventions are mostly carried out without sufficient preparation, due to a lack of time or resources, or interventions prepared without taking into account changes in the environment or processes.
- **Team coordination and management**, which includes the **definition of roles and responsibilities** (20%, up 2% compared to 2021) and **coordination between departments and companies** (14%, down 4% compared

to 2021), also remains stable (34%). Situations have generally been observed in which task-scheduling is insufficiently well-defined, either within a single team or department or even with other companies.
- The **design and modification** of work situations also remains stable (16%). However, this indicator is not consistent with the proportion of failures relating to the work environment, IT tools and applications and Man-Machine Interface ergonomics (63%).

Analysis of corrective actions taken

The corrective actions taken after each event have also been comprehensively analyzed across four different areas:
- **management,** which covers measures aimed at correcting the organizational structure in place (what is done, by whom? when? and how?),
- **training** of the employees involved,
- **regulations,** which include measures aimed at correcting the written rules,
- **design,** which includes changes to correct the work environment, workstation, tool, equipment or process.

The distribution of corrective actions along these four areas has been monitored since 2018. We witnessed clear improvement in 2022. For the first time since we started measuring this indicator, more than half of the events show at least 3 or 4 areas covered by corrective actions (64%).

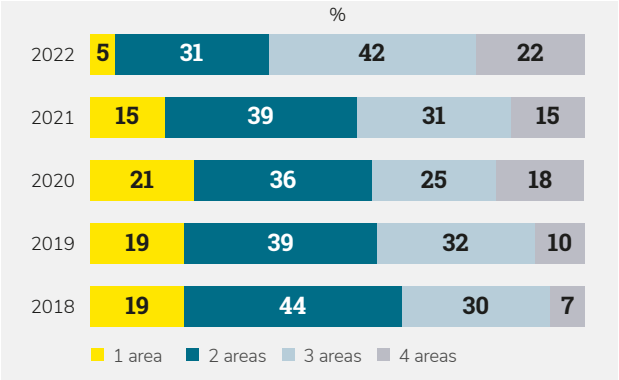


Figure 23: Ratio of the number of areas covered by corrective measures

In 2022, the breakdown of corrective actions was as follows:

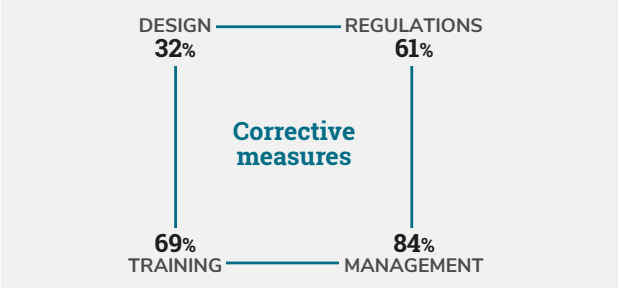


Figure 24: Breakdown of the areas covered by corrective measures

There was a marked concentration of corrective measures relating to **management, training** and **regulations**, with management measures being the predominant area. This is consistent with the distribution of significant events based on the origin of their causes (technical, mixed or human and organizational).

Main areas for improvement

The second-level analysis conducted on the 2022 event reports shows that their quality is improving significantly, even though some scope for improvement has been identified:
- **a more systematic identification of the root causes** of failures, in particular for workaround situations,
- **a better balance of corrective measures** covering all four areas (management, training, regulations and design), considering that when measures concerning management or design are implemented, it is important to back them up with awareness or training initiatives, and by updating operational documentation.

The analysis carried out shows an improvement in the support and monitoring of subcontractors, as seen through the significant decrease in failures involving these initiatives. It remains to be seen if this trend will continue.

The implementation of actions to strengthen the business planning process remains to be explored further. This especially concerns the deployment of the best practices, as described in the guide for the preparation of interventions, issued in 2021. To this end, awareness-raising activities and an analysis of the feedback from its implementation will be carried out in 2023.

Outbreak of fire while cutting a tank with a plasma torch

THE FACTS

A contaminated steel tank to be dismantled was placed in a compartment in order to be cut up.

The plans for the tank, provided before the cutting operations began, did not show the thickness of the resin and the coating present on the internal parts of the tank. Also, a window (approximately 40x20 cm) was made in the body of the tank to determine the thickness of the resin.

The industrial operator in charge of cutting went on to discover that the tank bracing elements (see photo below) were too complex to cut with a sabre jig saw. A fire permit was then drawn up so they could be cut with a plasma torch.

While cutting a bracing element with the plasma torch, the operator noticed flames inside the tank and left the compartment to get a fire extinguisher. He was unable to re-enter the compartment due to the presence of thick, black smoke.

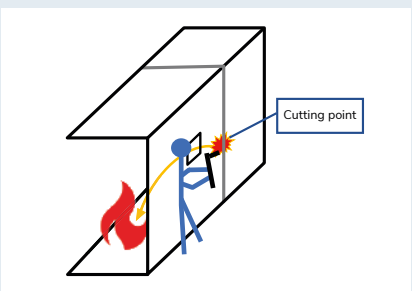
The fire was extinguished by the site's firefighting teams using two 5 kg CO_2 extinguishers that were available at the facility.

Mapping done outside the compartment showed that no contamination had occurred.

▲ View of the tank and of the steel bracing elements to be cut

ANALYSIS OF TECHNICAL CAUSES

The fire came about due to contact between the molten metal generated by the torch and the tank resin, through the window that had been made *(see diagram below)*.



ANALYSIS OF HUMAN AND ORGANIZATIONAL FACTORS

The identified causes were:

- **Routine error:** the fire permit was approved without any specification of the measures to be implemented, even though the tank has a resin coating and the initial cutting scenario had been modified.
- **Rule-based error:** the use of a plasma torch to cut without taking into account the presence of the window.
- A lack of **risk analysis:** the risks relating to the presence of a resin coating, the use of a plasma torch and the creation of a window were not analyzed and no specific measures were identified to manage them.
- Deficiencies in t**he change management process:** the initial cutting scenario was changed without consulting a fire expert, without updating the risk analysis and without including the changes in the operational documentation. Moreover, the change of scenario was not made subject to any formal dialog between the Industrial Operator and the Operator.
- Deficiencies in **operational documentation**, which was incomplete and insufficiently detailed.

This event, classified 0 on the INES scale, had no impact on people or the environment.

LESSONS LEARNED

The main lessons learned from this event are:

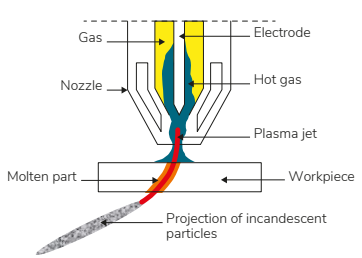
- The importance of clarifying the criteria for seeking advice from fire experts when drawing up fire permits.
- The importance of formal dialog and updating risk analyses in the event of a change in intervention scenarios, due to the fact that any analysis has to be performed on site.

Cutting by plasma torch

Plasma is an ionized gaseous medium operating at temperatures above 3,000°C.

Plasma cutting uses a plasma jet produced by the combined effect of an electric arc and a gas, creating an ionized and conductive gaseous atmosphere producing a high temperature (1,500 to 3,000°C).

The plasma jet melts the metal by thermal effect at its point of impact and ejects the molten metal out of the cut by kinetic energy. Cutting with a plasma torch generates sparks, fumes, slag spatter and droplets of molten metal.



▲ Schematic diagram of plasma cutting

The action of cutting with a plasma torch in the air generates a fire risk through:

- the creation of hot spots due to the heating of the treated support,
- the projection of incandescent particles from the cutting jet onto flammable materials,
- where applicable, the ignition of materials contained within the equipment being cut,
- the carryover of glowing particles to the filtration barriers of the working volume ventilation.

The main ways to prevent the risk of fire are the suitable preparation and analysis of the operation. This form of cutting will always be subject to a "fire permit", taking into account:

- the presence of combustible material, especially inside the equipment to be cut,
- the need for mechanical protection (sheet metal, fireproof tarpaulin, etc.) of the floor or walls exposed to the projection of incandescent particles (as with airlocks, etc.),
- the direction of the glowing particle projections produced by the cutting direction.

During the operation, before leaving the work station and about two hours after the cutting work has been completed (taking into account any remaining smoldering), the situation is primarily monitored by human, rather than any other means. Extra detection methods can also be used, depending on the configuration and possible options.

Measures to limit the consequences of a fire are based on:

- limiting the quantity and reaction to fire of surrounding combustible materials,
- the presence of mobile fire extinguishers of the right category and volume in the vicinity of the operators and, if necessary, the intervention of the facility's firefighting teams.

Removal of a type 48Y cylinder on a transport cart with a type 30B frame

THE FACTS

48Y and 30B cylinders are containers for the storage and transportation of UF_6. The main difference between them is their size.

A 30B cylinder was transferred to a yard on a transfer cart, to be deposited at its storage location using a handling gantry.

The cart cradle was fitted with a frame adapted to this type of container *(see photo)* and handling operations were carried out in the presence of a ground coordinator.

The gantry crane operator placed the 30B cylinder in its intended location, then grabbed a 48Y cylinder to place it on the cart *(see photo)*. He took advantage of the very low speed of the gantry to take time out to record the movement of the cylinder in the site's computer application used for this purpose.

Bearing in mind that the coordinator had removed the frame from the cart, as was customary when packing carts, the gantry crane operator placed the container on the cart and commanded the release of the gantry gripper. This resulted in the cylinder being in an unstable position on the frame, which was not suitable for this size cylinder.

The local crisis center and facility logistics command posts were brought into the situation to organize the recovery of the cylinder.

This event, classified 0 on the INES scale, had no impact on people or the environment.

ANALYSIS OF TECHNICAL CAUSES

There was no technical cause for the event.

ANALYSIS OF HUMAN AND ORGANIZATIONAL FACTORS

The human errors identified include:

- a routine error: the gantry crane operator failed to check for the absence of the frame, believing that this had been done by the coordinator;
- two rule-based errors:
- the gantry crane operator entered data into the computer system ahead of time, while carrying out the task at hand,
- the coordinator did not remove the cart, because he was performing another task at the same time (calculation of masses for weight checks).

Organizational failures were also identified in this case. These include:

- coordination of personnel: there was no dialog between the gantry crane operator and the coordinator to ensure all checks had been carried out and that the cart had been dealt with appropriately;
- management of simultaneous actions: the coordinator was conducting on-the-job training with a new operator. This is an extra task on top of the operating task (hence the concept of simultaneous actions). This provided a distraction for the tasks to be performed by the coordinator;
- the work environment: the identical color (yellow monochrome) of the cradle and its frame made it difficult to determine that a frame was in place;
- operational documentation: the operating procedure did not specify the methods for removing the frame, which ultimately affected the definition of the roles and responsibilities of the people involved;
- definition of roles and responsibilities: responsibility for the removal of the frame was not clearly established.

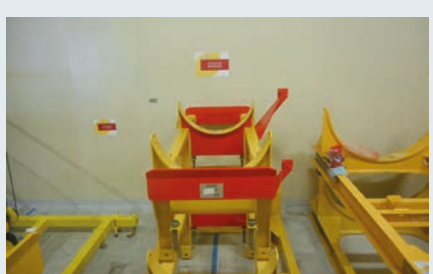
LESSONS LEARNED

In addition to modifying the operating procedure to take into account feedback from this event, a hold point (pop-up type) was added to the container movement management program: this requires the gantry crane operator to check the consistency between the cradle of the cart and the cylinder before proceeding with moving it.

In addition, it was determined that frames should be painted a different color from the cart *(see photo)*.

▲ Cart cradle frame for a 30B cylinder

▲ Cart with a 48Y cylinder requiring removal of the frame



▲ Repainted frame

RADIATION PROTECTION

▼ *Radiation protection measures, La Hague*

The average dose to employees of the group and to personnel of external companies remains low. The implementation of the new regulatory provisions concerning the provision of radiation protection has involved all the sites concerned.

The Group's activities are very diversified, offering products, technologies and services in mining, uranium chemistry, enrichment, spent fuel recycling, logistics, engineering and dismantling.

This range of activities generates a high variability of radiological risks and potential situations involving the exposure of personnel to ionizing radiation.

To successfully carry out these activities at the group's facilities as well those of its customers in France and abroad, employees of Orano and of subcontractors are protected against ionizing radiation and benefit from dosimetric monitoring suitable for the type of exposure.

Results

The results presented in this report are calculated for the reference period[11] for 13,483 Group employees who underwent personal dosimetry monitoring during the period (85% in France and 15% at sites outside France), and for the 8838 employees of subcontractor companies working at these same sites.

75% of the Group's employees who underwent personal dosimetry monitoring are classified as category B. The number of workers monitored remains comparable to that of previous periods, as does the breakdown into categories A and B.

AVERAGE ANNUAL DOSES

In 2022, the average dose to supervised personnel **remained 20 times lower than the French regulatory annual limit of 20 mSv**, and is of the same order of magnitude as in previous years.

11 *The dosimetry results in this report cover the period from July 1, 2021 to June 30, 2022, for all group entities involved in this report.*

More specifically, the **average dose over 12 consecutive months for Orano employees was 0.8 mSv and 0.6 mSv for subcontractor employees.**

These values were determined using different techniques (deferred reading dosemeters[12] for Orano personnel and operational dosimeters for subcontractor personnel)

For Orano employees, the occupations with the highest average doses were glove box work (2.6 mSv), mining activities (2.3 mSv), and nuclear service activities during maintenance operations on reactors in service, as well as cleanup and dismantling activities (1.1 mSv).

There was little variation in these figures from one year to the next. The most notable change in 2022 specifically concerns underground mining activities, with a significant decrease in in-house exposure due to the closure of the COMINAK mine (Niger), whose underground mining activities generated a working environment that involved the presence of uranium dust and radon.

ANNUAL DOSE DISTRIBUTION

In 2022, **51% of Orano employees and 52% of employees of subcontracted companies received a zero dose[13]**.

The regulations set out the rules for the use of personal external dosimetry with deferred readings. In particular, it requires the use of operational quantities that correspond to the measurement of depth doses in bodily tissue (risk of exposure of the entire body).

According to regulations, the recording threshold (smallest non-zero dose recorded) cannot be higher than 0.1 mSv and the recording step can be no higher than 0.05 mSv (values applicable for whole body dosimetry since January 1, 2008). The recording threshold is to be distinguished from the detection limit of the dosimeter, which shows a value above which, taking into account the technical performance of the dosimeter, the measured value is considered valid.

Orano dosimetry laboratories (La Hague and Marcoule) apply these 0.1 mSv recording thresholds for deferred-reading dosimeters.

Excluding zero doses, the people under dosimetry monitoring for whom a dose was recorded above the recording threshold over 12 consecutive months represent:

- 76% of the group's employees and 83% of subcontractor employees with a dose below 2 mSv,
- 93% of the group's employees and 95% of subcontractor employees with a dose below 6 mSv.

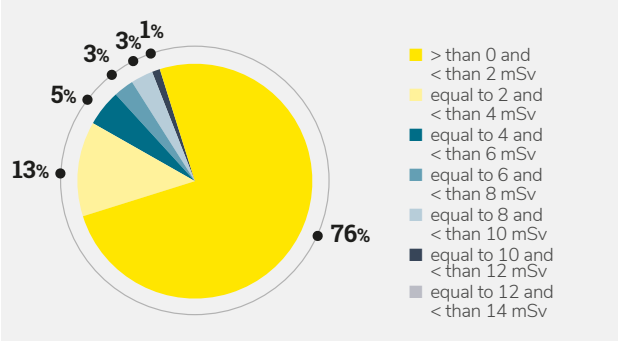


Figure 25: Breakdown of doses received over a sliding period of 12 months for Orano personnel

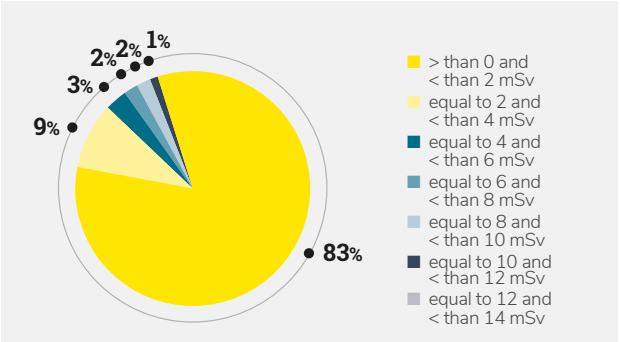


Figure 26: Breakdown of doses received over a sliding period of 12 months for subcontractor personnel

The proportion of employees with a dosimetry of less than 6 mSv per year remains of the same order of magnitude as in previous years. This percentage, above 90%, should be compared with the percentage of employees classified as category B (limit of 6 mSv), which is about 75% of the workforce. It is the employer's responsibility to classify employees with regard to the dose assessed at their working position. Employers should obtain the opinion of the occupational physician regarding the classification and update this classification when necessary, based on working conditions and the results of monitoring worker exposure.

Excluding employees who did not receive a dose above the recording threshold, **the average dose recorded over 12 consecutive months for Orano employees stands at 1.5 mSv, with a figure of 1.1 mSv for subcontractor employees.** These values are of the same order of magnitude as in previous years.

12 *For mining activities, workers are equipped with dosimeters to assess internal doses from radon and its decay products.*
13 *A dose is recorded as zero if it is lower than the dosimetry laboratory recording threshold or electronic dosimeter measurement threshold.*

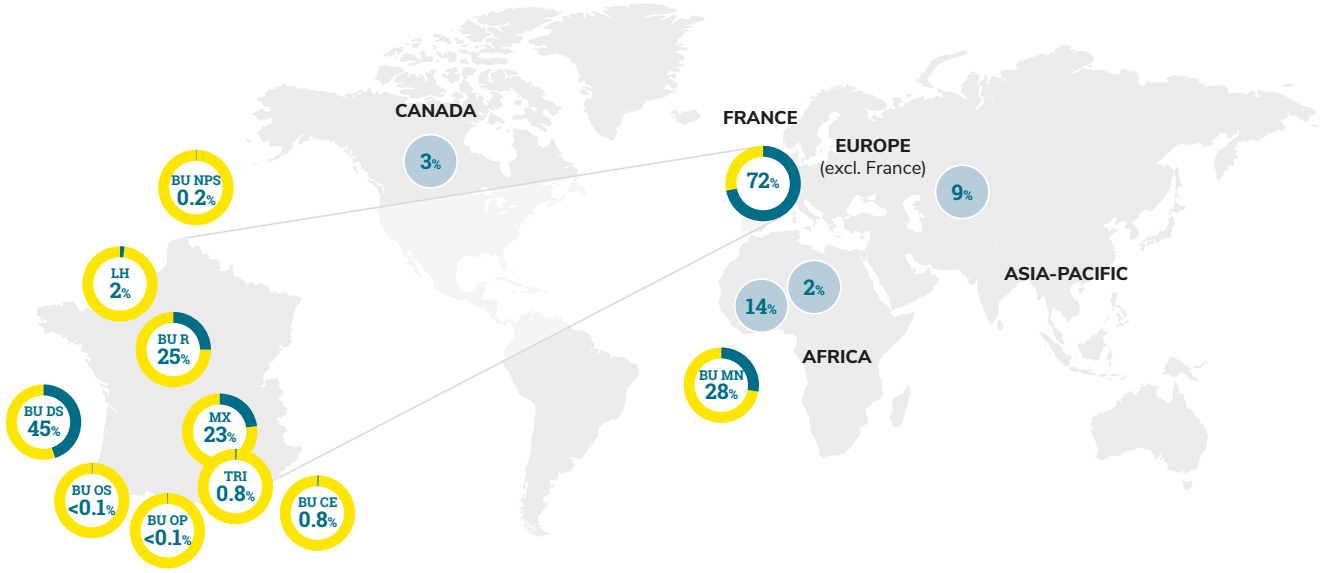


Figure 27: Distribution of doses received by geographical area and by BU

MAXIMUM DOSE

The **maximum personal dose of 20 mSv** over a sliding 12-month period, as defined by French regulations, was **not exceeded** in 2022, within the scope reported by the Group.

No employee of the group or of subcontracted companies received a dose greater than 14mSv[14] at the end of the reference period.

The maximum doses recorded for both the group's employees and subcontractor employees was lower than in 2020. **The maximum dose among the group's employees was 11.9 mSv, with the equivalent figure of 11.6 mSv** for employees of subcontracted companies.

COLLECTIVE DOSES

Collective dosimetric evaluations are crucial in preparing for a maintenance operation. The collective dosimetric evaluation is an indicator that varies depending on the operation, which comes as a consequence of the group's diverse activities.

Over the period at hand, the collective dose to Orano employees, all exposure situations combined, was 10,492 H.mSv and 5,022 H.mSv for employees of subcontracted companies. These collective doses are 84% from external exposure and 16% from internal exposure.

In 2022, the distribution of these collective doses underwent a significant change, with a 33% decrease in the contribution of internal exposure (16% in 2022, versus 24% in 2021).

Since internal doses are mainly generated by the activity of uranium decay products after the inhalation of dust and radon during mining operations at COMINAK and SOMAÏR (Niger), the closure of the COMINAK site in May 2021 can explain this change.

The geographical distribution of collective doses by Business Unit is shown in Figure 27.

Internal changes in radiation protection

More than 800 people work in radiation protection within the group. They are the ambassadors of the acceptability of nuclear power for the general public.

It is their task to address key issues:

- to manage the dosimetry at work sites and avoid dissemination throughout the working project,
- to control the radiological cleanliness of facilities while in operation, during maintenance and dismantling,
- to avoid contamination and limit exposure of personnel and other individuals operating at sites, and
- to avoid incidents and accidents.

To this end, a key project was set in motion in 2021 to identify opportunities for modernizing and transforming the radiation protection side of operations (MoTRaP) by making the most of current technology.

Its objectives are:

- to keep skills at the appropriate levels (training and upgrading) and to improve the recognition and

14 *This threshold value corresponds to a performance indicator for radiation protection.*

attractiveness of these radiation protection roles,
- to simplify and optimize tasks taking into account the reality on the ground, the appropriate regulations, and the specific requirements of the relevant activities,
- to modernize and develop tools suitable for specific needs, making the most of Industry 4.0 technologies.

This project mainly consists of deploying:
- modern, connected miniaturized tools, at low cost for easy data entry,
- interactive solutions for updating data about the equipment to be monitored and the cells,
- mobile, portable solutions that integrate existing solutions,
- innovative solutions for the protection and assistance of operators,
- new solutions to enhance the attractiveness of these roles.

▲ *Radiation protection specialist at work in a plant*

Regulatory changes in radiation protection

ORGANIZATION OF RADIATION PROTECTION

The year 2021 was a pivotal year with the definition of a new radiation protection organizational structure which brought everyone involved together within the same process.

This new system now has:
- an individual, holding the title of "radiation protection advisor (RPA)", who is an employee of the establishment or, failing that, of the company,
- a legal entity, called a “radiation protection regulatory body”, certified by an accredited organization,
- a center of expertise in radiation protection in an establishment comprising an INB.

This means that for the group, Orano Dismantling and Services, Orano Mining Bessines and an entity of the NPS BU each have a radiation protection body certified by an accredited organization

In addition, four establishments with one or more nuclear facilities under their responsibility submitted an application to the ASN (French nuclear safety authority) at the end of 2021 for approval of a radiation protection center of expertise. Within the Recycling BU, these are the La Hague and Melox sites, and within the Chemicals-Enrichment BU, this role is undertaken by the Tricastin and Malvési sites.

By January 2, 2022, each facility had implemented the provisional center, which was set up for a maximum period of one year, which is the length of time required for applications submitted to the ASN to be examined. Site organizational structures were approved in late 2022.

The experience gained in setting up this organizational structure and in the first few months of its application has been leveraged to produce internal guidelines aimed at specifying the standard constitution of a center of excellence. It also provides sites with a self-assessment tool, allowing them to verify the compliance of the organizational structure in place with regulatory requirements. These guidelines also specify the measures to be implemented in the event of any deviation that is identified.

DOSE COEFFICIENTS

Article R. 4451-12 of the Employment Code stipulates that effective dose and equivalent dose calculations should be performed using the methods defined by the order issued in application of Article R. 1333-24 of the Public Health Code.

Article R.1333-24 of the Public Health Code requires that dose coefficients should be established taking into account the values published and updated by the International Commission on Radiological Protection (e.g.: ICRP 137 for radon).

For the application of these regulatory provisions, a decree is still pending to define the methods for calculating effective doses and equivalent doses resulting from the exposure of individuals to ionizing radiation.

This text should identify the methods for calculating effective doses and equivalent doses used in France that have not been updated since the September 1, 2003 order, which will then be revoked. It will require an update to specific computer models held mainly by operators and expert organizations for calculations that take into account many parameters such as the duration of exposure, respiratory rate, age, environment, radiotoxicity of the radionuclide, and the tropism of the radionuclide for certain organs.

Its application could have significant impact, given the changes made to certain dose coefficients that have been revised upwards.

MANAGEMENT OF ENVIRONMENTAL IMPACTS

Seawater sampling for analysis, La Hague region

Making sure that our activities do not impact people, ecosystems or biodiversity requires constant monitoring - something we can provide through our proven human and technical expertise. The data acquired and the interpretation of this data are systematically shared with all parties involved through public reports, joint expert assessments and publications.

Results in terms of radiological impact

The annual radiological impact (or dosimetric impact) of the Orano Cycle's major nuclear sites remains at very low levels[15]: 0.06 µSv for the Tricastin site, 11.2 µSv for the La Hague site, and less than 0.001 µSv for the Melox site. These values should be compared with exposure associated with other sources of natural or artificial radiation and the regulatory limit value for the public of 1000 µSv per year of dose added by nuclear activities.

This very low impact is the result of constant progress over time in terms of treatment and control at source of discharge into the environment.

These overall results are published in the reports prepared by nuclear sites under Article L. 125-15 of the French Environmental Code[16].

15 Evaluated based on real releases authorized for 2021
16 These reports are available on the Orano website: https://www.orano.group/en/group/reference-publications

Results in terms of chemical impact

With regard to the discharge of chemical substances, the health impacts around sites, as assessed using the methods recommended by the French ministry for ecological transition and territorial cohesion, the National Institute for Industrial Environment and Risks (INERIS) and the Institute for Public Heath Monitoring (INVS), are **below reference values**.

The risk indicators for threshold effects are less than 1 and the excessive personal risk for non-threshold effects are **below 1/100,000**, whatever the exposure scenarios of local residents and the age categories considered.

Reliability continuously monitored

To guarantee the reliability of the different checks performed, regular cross-checking between the various laboratories involved is required by the regulations.

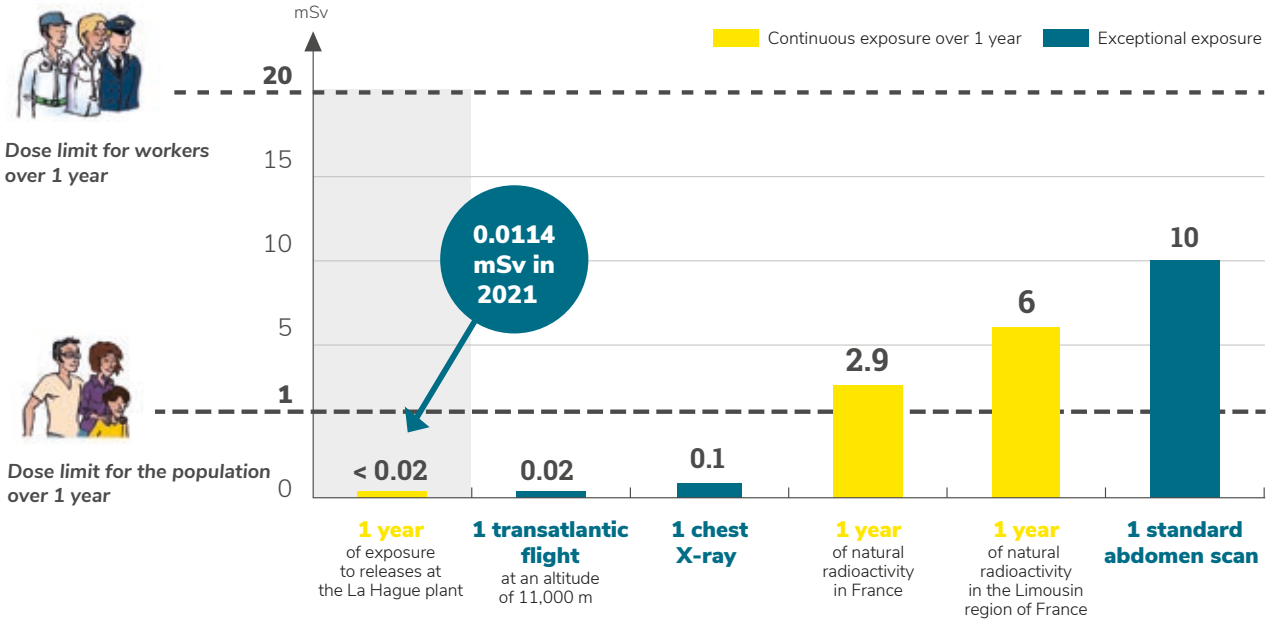
These checks relate to some of the measurements conducted by the operator and are performed by the La Hague and Tricastin sites with the IRSN Le Vésinet. The summary reports on these cross-checks verify the consistency between the various results obtained and are submitted annually to the ASN.

Conducting cross-checks properly is one of the key points for internal laboratories (which carry out supervision of discharges and environmental monitoring) being able to obtain ISO 17025 certification, thereby complying with the requirements of the ASN Ruling No. 2013-DC- 0360 of July 16, 2013, as amended.

Other measures are used to verify the suitability of the monitoring plans implemented by operators. Such is the case with the European Commission, which carried out an inspection of the Malvési facility in 2021, in accordance with the provisions of Article 35 of the EURATOM Treaty. The various French authorities and their technical support staff were present, namely ASN, DREAL, IRSN and the Euratom Technical Committee (ETC), in order to verify the radiological monitoring conditions in the environment of this site.

At the end of this inspection, the European Commission found that the checks carried out showed that the measures necessary to monitor the levels of radioactivity in discharges (and in the air, water and soil on and around the Malvési nuclear site) are adequate.

Comparison of the dosimetric impact for different exposures



A strategy for biodiversity

Following on from an analysis phase covering the contribution of the group's various activities to the mechanisms of biodiversity erosion, Orano decided to formalize its strategy for the protection of biodiversity in 2022 and to transform it into concrete actions.

In this respect, three major areas were defined:
- the preservation of existing biodiversity,
- coexistence with the biodiversity present on and around our sites,
- promoting local biodiversity and reporting on our work on this area.

This strategy is broken down into commitments and action plans, both at Group level and at the level of the various operational entities concerned. More specifically, the actions taken address all the issues identified, for all the BUs based on their individual activities and their sources of difficulty.

For example, the following actions are being undertaken to:

PRESERVATION:

- systematically implementing the Prevent, Minimize and Offset sequence (with priority given to prevention) for our various projects, wherever they may be (in France or abroad, on or off site),
- reducing our greenhouse gas emissions by 40% by 2025 (scopes 1 and 2, based on 2015).

COEXISTENCE:

- developing plans for the differentiated management of green spaces (on our relevant sites), and fighting against invasive species,
- understanding and evaluating our impact on biodiversity, using impact studies, regular local inventories and a global footprint study (GBS tool).

PROMOTION:

- promoting actions to enhance local biodiversity (with other parties involved), reporting on and raising awareness about its protection.

DISMANTLING OPERATIONS

Georges Besse plant undergoing dismantling, Tricastin

Dismantling activities are continuing at various Group sites and locations.

Dismantling and cleanup activities continue at Orano's La Hague, Tricastin, Malvési and Miramas sites. These large-scale, complex programs require the involvement of many different people whose tasks are organized around safety requirements, scheduling commitments and technical constraints.

The administrative processes specific to dismantling operations, as well as the associated dismantling and waste conditioning operations, continued in fiscal year 2022 at the relevant facilities, in some cases in conjunction with safety reviews and compliance and aging studies.

Facilities undergoing dismantling

LA HAGUE SITE

INBs no. 33, no. 38, no. 47 and no. 80

Studies and work performed in waste recovery and conditioning and dismantling have been underway for several years. They continued during 2022 at 4 INBs in the dismantling phase.

Dismantling workshops - Acronyms

- **FPW:** Fine particle waste
- **HADE:** High Activity Dissolution Extraction
- **HAO:** High Activity Oxide
- **HAPF:** High Activity Fission Products
- **MAPu:** Medium activity Plutonium
- **OWS:** Organized Waste Storage
- **WTP 2:** Wastewater Treatment Plant #2

Significant events that occurred over the year are as follows:

HADE Workshop

- removal of tanks within two cells, their reduction in volume and their disposal,
- continuation of the manufacture of equipment for the recovery of sludge located at the bottom of two cells,
- clean-up of equipment in two units,
- dismantling of a 233 mixer-settler battery,
- removal of battery tray no. 4.

▲ *Removal of the battery tray from the HADE workshop, La Hague*

MAPu Workshop

- continuation of the dismantling work for various cells and their component parts (rooms, areas and glove boxes),
- start of bitumen removal from the annular tanks after obtaining authorization from the ASN and the completion of a tank,
- continuation of preparatory work for deconstruction of the last floors of the workshop, by completing studies covering the dismantling, cleanup, and decommissioning scenario for the premises to be deconstructed, by defining the methodology for cleaning up the infrastructure, submitted to the ASN, and by continuing work on depurposing the facility.

HAO South Workshop

- continuation of optimization studies for dismantling cells 904/906 before launching detailed studies,
- carrying out research and development studies (hydrogen traps) for the conditioning of materials to be recovered with a view to storage in a card cage under water,
- continued removal of waste from the pool and cells,

WTP2 workshop

Investigations into this workshop and the qualification tests for the specific procedures are ongoing. The dismantling of the flue has started.

HAPF Workshop

The flushing of the line A equipment is continuing, enabling a significant reduction of dose rates and visual confirmation of the good cleaning of the equipment bulkheads.
A safety options file has been sent to ASN to allow operation of the NCP1 evaporator beyond 2024.

ELAN 2B Workshop

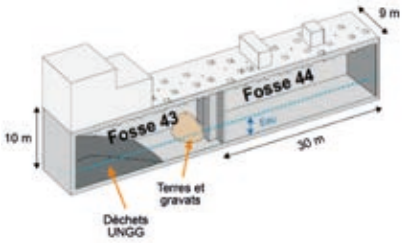
The completion of the transfer of all elution columns and capsules was an important milestone in the past year.
The dismantling of the various cells is also ongoing. The treatment of the historical asbestos drums was completed. R&D studies on the characterization of certain components are continuing.

▲ *Storage of elution columns, ELAN 2B workshop, La Hague*

Silo 130

The operation of the facilities allowed the recovery and conditioning of 36 drums of waste. However, the breakage of a cable used to operate the gripper during the year led to the shutdown of operations while waiting for its replacement.

Studies are ongoing to investigate the recovery of wastewater from the silo and the treatment of larger waste.



▲ *Section view of silo 130, La Hague*

Silo 115

The safety options file, including the recovery of waste from Building 128, its transportation and the construction of the final sorting and conditioning building, was sent to ASN.

OWS

The application for authorization to rework the sliders, which is currently under preparation, has taken into account the comments made by the ASN during analysis of the safety options file.

FPW

Work on depurposing to take into account the location of the new building is ongoing.
The decision referenced CODEP-DRC-2023-001852 of the Chairman of the Nuclear Safety Authority, dated January 10, 2023, authorizes significant modifications to INB no. 33 through the construction of a building called FPG and the installation in this building of a process for the recovery and conditioning of old waste.

HAO Silo

Work on the installation of equipment for the recovery and test cell is continuing. At the same time, the files allowing the transport of waste in drums to the planned storage sites were still under examination.

Recovery and conditioning of sludge (RCB) from WTP2
Following the abandonment of an alternative solution, the decision was made to store the sludge in new silos while completing the demonstration elements on bitumenization in order to allow the safe disposal of the sludge, but also to produce an acceptable final package.

TRICASTIN SITE

INB No. 93 - GEORGE BESSE PLANT

The administrative process for authorization to dismantle INB No. 93, initiated in 2015, was completed with the publication of the dismantling decree on February 5, 2020, and the approval of the dismantling rules on February 4, 2021.

During 2022, the dismantling program continued the optimization activities of the various scenarios under consideration. The main optimization under consideration is the construction of a multi-purpose densification and packaging unit in the vicinity of Plant 140, for which detailed design studies are expected to be completed by late 2023 or early 2024.

▲ *Mockup of the dismantling project for the Georges Besse plant, Tricastin*

The preparation work for the deconstruction of the cooling towers continues with the submission of the report supporting the application. This operation is currently scheduled for the period 2024-2028.

INB No. 105 - CONVERSION WORKSHOP

The administration process to authorize the dismantling of INB No. 105 was completed on December 18, 2019 with the publication of Decree 2019-1368 on December 16, 2019, and the approval of the rules governing the dismantling operations of December 15, 2015.

Work to remove the process from structure 2450 of this INB was carried out during 2022 and will continue in 2023.

INB PIERRELATTE

The process and operations for dismantling the Pierrelatte INB continued in 2022, most notably with the continuation of the investigations necessary for cleaning up the individual “Main Laboratory” and “Waste Processing Station” installations and the continuation of the cleanup project for the individual “TU2-TU3” and "P60" facilities.

MALVÉSI SITE

In 2022, operations for the removal of equipment and the deconstruction of structures involved:

- removal of part of the process equipment in the magnesiothermal workshop,
- continuation of the removal of the process equipment from the READ workshop,
- removal of part of the process equipment in the precipitation workshop.

Facilities nearing the end of dismantling or in reindustrialization

MIRAMAS SITE

Following the sale of the central area of the site in 2020, a small parcel of land in which residual pollution remained remains the property of Orano. The latter has been rehabilitated by the installation of a containment plan in 2021, in accordance with the management plan.

Environmental monitoring has been put in place.

VEUREY SITE

Under the terms of the agreement reached with the current tenant of the site, the land at Veurey-Voroize (Isère), which formerly housed nuclear fuel manufacturing facilities operated by SICN, an Orano subsidiary, was sold.

EXTERNAL TRANSPORTATION ACTIVITIES

▼ *Transport of a TN®17Max COVRA package*

Industrial performance requires full control of transportation flows for radioactive materials, whether their destination is our customers or our sites, and regardless of who produces them. The transportation operations are therefore carried out with safety objectives that are identical to those set out for the facilities themselves.

Supervision of transportation

Controlling the safety of transportation of radioactive materials requires a defense-in-depth approach based on the principle of three barriers: safety of design, manufacture and maintenance of the packaging, reliability of the transportation operations themselves, and the preparation of a response in the event of an incident or accident.

RISK MANAGEMENT PROCESS

The management of activities involved in the constitution and shipment of packages, through to delivery to the recipient, is based on an internal process known as the "Manage transportation risks", coordinated and implemented by the Nuclear Packaging & Services BU – NPS.

This process rounds off the application of national and international regulations on the safety of radioactive materials transportation. It takes into account the management of all risks, within a broader scope than that of safety and radiation protection.

The process of supervision therefore extends across several aspects:

- prior to transportation, by the definition and implementation of shared guidelines and constant reference to risk analysis,
- in an operational framework, by the monitoring of transportation activities on our sites, as well as anywhere that activities are carried out that impact safety,
- in the event of an incident or accident, by situation management.

Common documentary guidelines

The definition and implementation of common documentary guidelines provides a shared framework within the Group. This mostly comprises texts applicable to the transportation of radioactive and nuclear materials,

along with two major directives that cover the safety of transportation of radioactive materials and the compliance of packages.

In 2022, as part of the regulatory oversight applicable to the transportation of radioactive and nuclear materials, the following texts were analyzed and updated to take into account changes in regulations, in particular for:

- implementing the regulatory changes relating to international regulations and guidelines:
  - the International Air Transport Association (IATA) Dangerous Goods Regulation,
  - the 2022 edition of SSG-65, "Preparing for and Responding to Nuclear and Radiological Emergencies Involving the Transportation of Radioactive Materials",
  - revision 1 of IAEA Guide SSG-33 on transport regulations,
  - revision 1 of IAEA Guide SSG-26 on the application of SSR-6,
- defining the regulatory changes for the end of 2021 and 2022 in France:
  - the order of February 28, 2022 amending the order of July 9, 2008 on the organizational structure of the central administration of the Ministry of Ecology, Energy, Sustainable Development and Land Use Planning, which resulted in a minor amendment to the order of May 29, 2009 on the transportation of dangerous goods by land (known as the "TDG order"),
  - the order of November 12, 2021 making amendments to the following orders:
    - the order of December 18, 2019, on the terms and conditions of training for the competent individual in radiation protection and the certification of training organizations and competent organizations in radiation protection,
    - the decree of October 23, 2020, concerning measurements carried out as part of the risk assessment and checks over the effectiveness of the preventive measures put in place to protect workers against the risks of ionizing radiation.

Each update to regulatory texts has been notified to transportation advisors in the Group entities upon each amendment to a regulatory text, in order to ensure that these changes are reflected in operational practice.

In addition to this, an internal guide has been issued to specify the application of the regulations for taking into account the subsidiary hazards of radioactive materials in transportation, based on the different modes of transport used.

In 2022, the IAEA process of reviewing the SSR-6 (Rev. 1) was initiated by the TRANsport Safety Standards Committee (TRANSSC) through the technical working groups in charge of studying the proposed changes. TRANSSC meeting 45, which took place from November 28 to December 2, 2022, approved the need to review SSR-6 and took into account a large number of proposals for changes put forward by the Wold Nuclear Transport Institute (WNTI) with the support of the French nuclear safety authority (ASN).

RISK ANALYSIS

The risk analysis process primarily involves identifying and analyzing all transportation flows.

All transportation flows conducted or supervised by the NPS Business Unit undergo exhaustive data collection to then assess the level of risk. This risk analysis may include terrain or route assessments.

The studies require various types of expertise: organization of transportation, keeping track of regulatory requirements, safety, security, loading and stowage, or informing the public.

They also relate to the approval of ships that the group's entities may need to load with radioactive waste.

In 2022, out of 57 vessels analyzed, 2 were rejected as a result of this analysis.

Building on these analysis and approval processes, the year 2022 brought with it new transportation flows. It is worth highlighting the loading operations of Uranium concentrates at the port of Adelaide (Australia), which were inspected with the customer, using a drone to check the correct positioning of the containers.

▲ *Loading containers of Uranium concentrates, Adelaide (Australia)*

▲ *Handling of uranium containers, France*

Monitoring of activities

At shipping and destination sites, as well as at transshipment areas (such as ports and airports), qualified inspectors are deployed to monitor the preparation and shipment of packages, as well as the activities of service providers in all of the countries involved.

The change in the number of inspections declared "unsatisfactory" can be a good measure of the level control over transportation issues.

In 2022, the "unsatisfactory" rate was 7.3% of 287 inspections performed. This figure, up from 5.3% in 2021 (281 inspections performed), exceeds the acceptability threshold of 5%. This increase is explained by the results of inspections on new transport flows or activities taken over by new service providers. In addition to this, the level of soft signals identified, as measured by the rate of inspections declared "not totally satisfactory or NTS", was down in 2022 with 32.8% (39.9% in 2021).

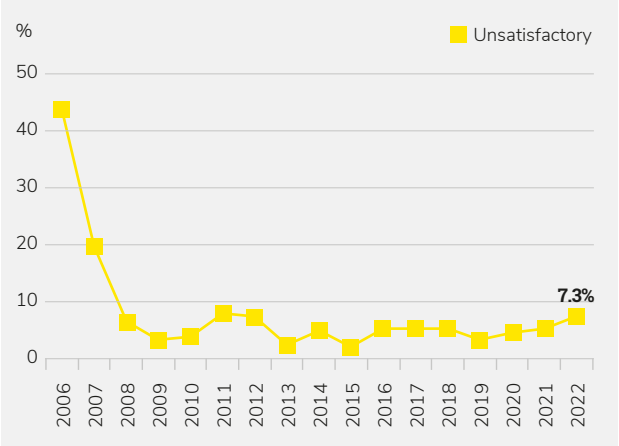


Figure 28: Changes in the level of "Unsatisfactory" inspections

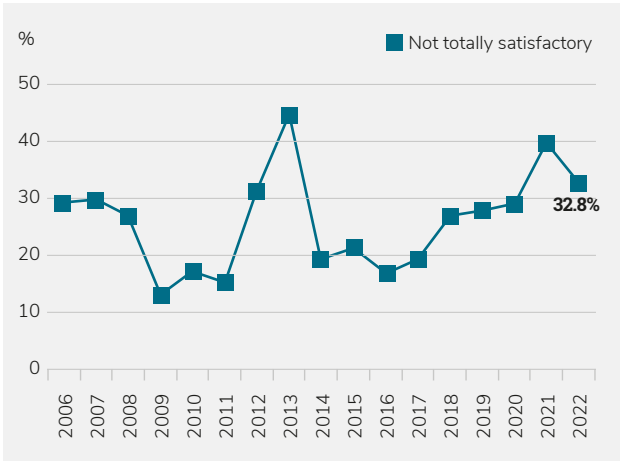


Figure 29: Changes in the level of "Not totally satisfactory" inspections

Inspections conducted in 2022 resulted in **63 findings for shipper sites and 135 for transport providers**, a figure comparable to that of 2021 for providers, but a significant decrease for shippers.

The breakdown of 80% of the findings for shippers, as shown in the following figure, shows that the area of package compliance remains the overriding factor and is decreasing slightly. The areas of labeling/marking, transport/operations documentation and training are increasing, while the other areas are decreasing. The number of findings in terms of package compliance mainly concerns the conformity of documentation and the performance/traceability of controls (81% for 19% concerning package non-conformities).

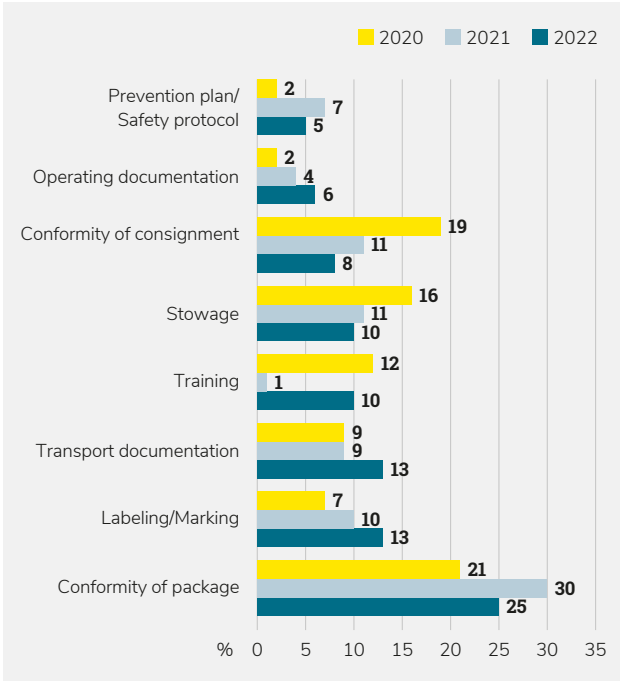


Figure 30: Change in "Shippers" inspection findings by area

Their distribution concerning transport providers, detailed in the following figure over 80% of the findings, shows that physical protection remains the predominant issue (mainly due to security) and slightly decreasing, while the shipment stowage and compliance aspects are clearly increasing, with other aspects remaining almost constant or decreasing.

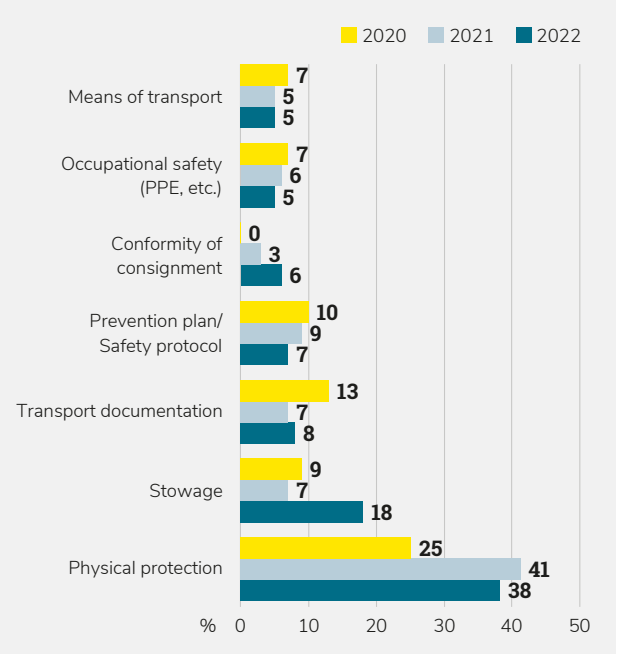


Figure 31: Distribution of "Supplier" inspection findings by area

In addition to inspections on the ground, audits of Orano and supplier sites are carried out to assess the performance of existing organizational structures and processes. In 2022, 30 audits were carried out (4 at Orano sites and 26 among suppliers).

Management of deviations

Control over transportation is also measured by the number of significant events reported and their classification level.

In 2022, 13 significant events received an INES scale classification, 12 of them at Level 0 and 1 at Level 1. They related to transports relating to a Group entity using the public highway (14 in 2021).

Of these events, four were at least partially caused by a Group entity or one of its subcontractors (compared with 7 in 2021).

A more detailed analysis of the events concerning transport safety, given by area of responsibility and by type, can be broken down as follows:

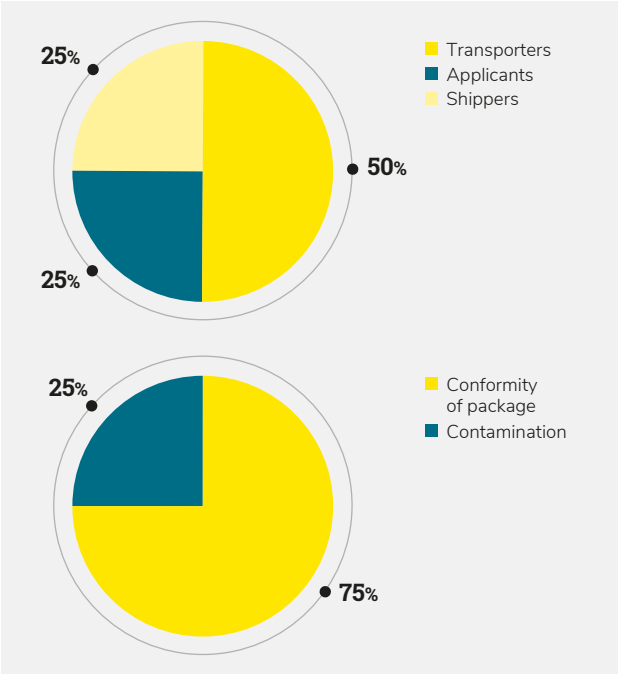


Figure 32: Breakdown of significant events concerning transports by responsibility and function

The breakdown of these events by responsibility is as follows:

- 1 event involved Orano as a shipper,
- 1 event involved an applicant for Orano approval, and
- 2 events involved a subcontracted carrier.

The breakdown of these events by type of shipment is as follows:

- 1 event related to the compliance of shipped packages (error regarding acceptable damage criteria),
- 1 event related to a package classification error, and
- 2 events related to a failure to comply with the limits for grouping together packages in groups of 50 CSIs[17].

Changes in the distribution of events by function over a period of three years is shown in figure 33.

▲ *Transshipment of a package, Valognes*

17 *CSI: Criticality safety Index, used to evaluate the criticality risk of a load of radioactive materials*

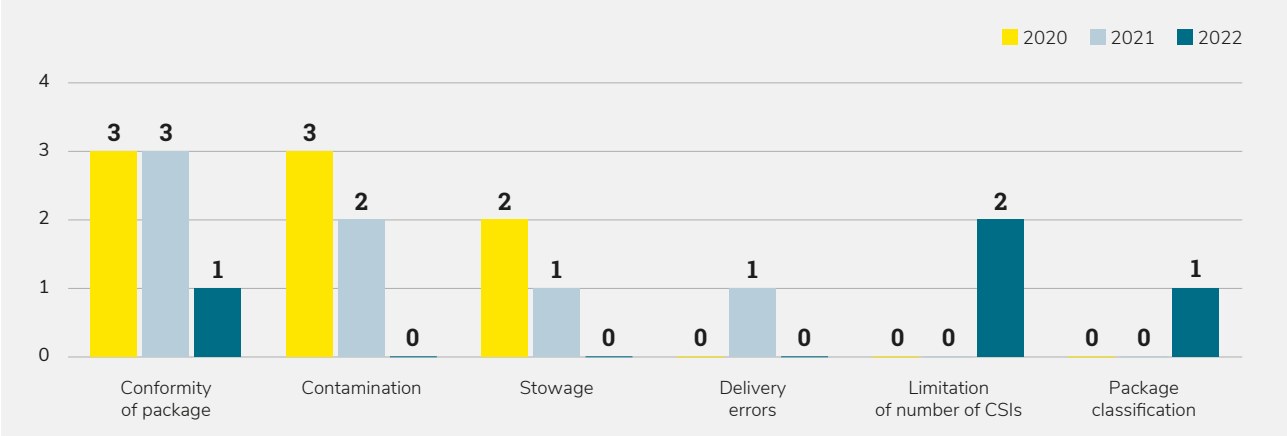


Figure 33: 2020-2022 comparison of the distribution of significant transportation safety events

Management of degraded situations

In the event of a degraded situation requiring the introduction of a transportation emergency and response plan (PUI-T), the NPS BU will set up and coordinate such a plan.

This involves:

- the creation of a Local Command and Decision Unit (PCD-L) that interacts with the Group's National Command and Decision Unit (PCD-N) and the PCD-L of the sending or receiving site. Depending on the situation, this may come in addition to a technical unit and a communications unit.
- sending out specialists to the site of the accident, to the customer's premises and, if the event occurs in France, to the relevant prefecture.

The plan is tested during internal crisis-response exercises, some of which simulate accidents taking place outside France.

In terms of organization, 2022 saw the relocation of the PCD-L from the NPS BU to Châtillon, which required an internal reorganization of the PCD-N. Although the operation of the PCD-L has been tested on several occasions, confirming that it works as it should, the interaction between the PCD-N and the PCD-L, which are located together, has yet to be validated on a large-scale exercise.

In 2022, the NPS BU ran or participated in 7 large- and small-scale transportation-crisis exercises, within the Group and externally, centered both on nuclear safety and physical protection.

To this end, a theoretical safety exercise was undertaken on June 23, 2022,, involving the three crisis organizations of EDF, Framatome and Orano. This consisted of simulating an accident involving the transport of fresh fuel from the manufacturing plant to a nuclear power plant over the course of an unusual journey involving a bridge. The simulated accident would have resulted in two new crates of fuel (FCC3) falling off the transport, one them into a river. This exercise was unusual in the comparatively large number of parties involved, with all the three operators acting at both central and local levels.

Training in the area of transportation

In line with the direction taken over previous years, training activities both inside and outside the group have continued to take place.

The group participated in one initial training session and two refresher courses, known as RAD4, at the École Nationale Supérieure des Officiers de Sapeurs-Pompiers (ENSOSP - a firefighter training center), involving technical advisors from the Directions Départementales des Services d'Incendie et de Secours (DDSIS - regional fire and emergency service management center) and the local authorities. This simulation enabled crisis team members from the NPS BU to be included as facilitators and observers of radioactive material transportation crisis exercises, designed to help them better understand the constraints of responders, and above all to help them understand the integration of the operators in the ORSEC (civil security response organization) plan, and the support they can provide to them.

In 2022, two training courses took place, specially designed for shipments of uranium mine concentrates, one at Badrakh Energy in Mongolia and the other at SOMAÏR in Niger. These training courses included regulatory and practical exercises, based on feedback from several years of inspections of various mines across the world and the follow-up of all the deviations noted at the converter sites. The various entities receiving this training appreciated the content of the courses.

PREPARATION FOR EMERGENCY SITUATIONS

▼ *FINA simulating operational situation - Tricastin*

A year with a wealth of lessons learned on an operational level. Work continues to build on capacity and expertise in crisis management.

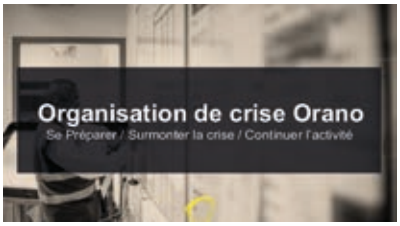
The momentum around building up emergency preparedness continues. Following on from the first large-scale exercise in 2021, FINA continues to implement its various missions in the field. Work to strengthen the pipeline of technical data to institutional experts are continuing.

Review of the past year

Feedback from simulations and large-scale exercises highlights a number of learnings which merit attention.

The update of the internal document repository at the end of 2022 was an opportunity to specify key organizational principles based on the experience acquired over several years. There are three of these:

- **prudent overreaction**, for any event leading to or possibly leading to a break with normality, whenever the question arises of whether it is appropriate to inform,
- **modularity and scalability of the mobilization** of crisis teams according to right need, supported by a tested ability to connect remotely,
- **subsidiarity in action**, the operational response to an event being the responsibility of the site or department concerned.



▲ *Intervention of a robot in hostile environment, La Hague*

The structure composed of the national and local emergency response command centers (PCD-N and PCD-L) and the forward command center remains the core structure for the management of events related to nuclear safety and the environment. With experience, this organization appears to be adapted to all types of situations - for prevention or reaction - according to the principles mentioned above. In this regard, this organization has been deployed several times in 2022 as a means of mitigating risks identified.

By way of extension to what was validated in 2020, **the operation of emergency response command centers (PCD) with a mixed organization**, combining members working in person and members working remotely, confirms the added value of such an organization during ramp-up after being triggered or in situations which would not immediately allow crisis team members to be assembled. The management of information made available to PCDs and their managers remain the main challenge of such a mode of operation.

The short "sandbox"-type exercises aimed at testing the mobilization of command centers, remain key to the capacity to rapidly manage a crisis at national level and to be in a position to respond to the demands of the Public Authorities. The effort being made to provide this type of training should be maintained so that it become a matter of routine in its implementation.

The tool for managing information to be tracked in a logbook, deployed since 2020, is providing the expected services. As with all tools, it requires sufficient practice to master its different functionalities. The ramp-up exercises and call-outs make a notable contribution in this respect. Some improvements to the tool identified during its implementation are still to be deployed.

Deployment of FINA

Following on from the major exercise for the deployment of FINA resources supplemented by those of GIE-INTRA at the Melox site in 2021, several simulations were carried out in 2022 at the group's main sites, the most significant of which took place at La Hague from May 30 to June 2, with the participation of the group INTRA[18].

These simulation exercises in the field involve:

- providing personnel, within the framework of the procedures necessary to ensure their safety and obtain the necessary administrative authorizations,
- deployiong all or part of the 28 missions, and
- testing the interfaces with the sites and the INTRA group.

Detailed experience feedback was provided for each of the missions carried out, identifying best practices to be made permanent and allowing areas for improvement to be addressed.

The momentum behind FINA deserves to be highlighted. It enables us to demonstrate the operational capacity of the FINA, while consolidating the interest and motivation of volunteers in this additional function, and reinforce its appeal.

The provision of premises at the Tricastin site, effective since 2022, should make it possible to strengthen the capacity for training and coaching of volunteers.

▲ *FINA exercise, decontamination after the intervention, La Hague*

18 *This exercise was observed by the General Inspectorate, the main conclusions of which are featured on page 23 of this report.*

Because FINA is made up of volunteers, 2023 will be used to boost this mode of recruitment in several ways: through the coordination of the volunteer pool, more targeted identification of volunteers according to priority needs, integration and training, and through greater recognition of volunteering.

Prospects for 2023 and follow-up on areas previously identified as requiring special attention

Building on feedback from experience, the level of internal momentum with a view to ensuring control over degraded situations remains high. The organization set up, which is consolidated with the experience acquired, allows us to respond to a wide range of missions. The experience of 2022 has shown that.

On the operational level, in 2023, the level of training of the teams must be maintained, just as FINA's operational readiness must be sustained. All of these developments should lead to the emergency teams' improved mastery of the information management tool.

Subsequent to the requests expressed by the Public Authorities to have continuous access to raw data on the operation of facilities in the event of a crisis, the works commenced in 2021 to put the "Diagnostic-Prognostic" method into practice in the fuel cycle facilities and to allow the transmission or raw data have gathered speed. This issue remains a challenging one due to the diversity of facilities, which are often unique.

Certain areas for attention identified in previous reports continue to be relevant. This mainly concerns:

- **expertise in conducting the post-accident phase of events**. Efforts must continue to be made to improve the grasp by a larger number of team members of tools used to assess the impact on the public and the environment,
- **capacity to simulate all the stakeholders**. This year, like last year, was not conducive to participation of external entities involved in crisis management for low-intensity exercises. This is an area in which there is still progress to be made.

GLOSSARY

ACRONYMS

AIP: Activities Important for the Protection of interests

ANDRA: French National Agency for Radioactive Waste Management (Agence Nationale pour la gestion des Déchets Radioactifs)

ASN: French Nuclear Safety Authority (Autorité de Sûreté Nucléaire)

BU: Business Unit (in the Orano organization)

CEA: French Atomic Energy and Alternative Energies Commission (Commissariat à l'Énergie atomique et aux énergies Alternatives)

COFRAC: French Accreditation Committee (Comité FRançais d'ACcréditation)

DSND: Delegate for Nuclear Safety and Radiological Protection for Defencerelated Activities (Délégué à la Sûreté Nucléaire et à la radioprotection pour les activités et les installations intéressant la Défense)

ECS: Complementary Safety Assessment (Evaluation Complémentaire de Sûreté)

EIP: Equipment Important for the Protection of interests

EURATOM: European Atomic Energy Community

FINA: Orano's National Response Force

HCTISN: High Committee For Transparency and Information on Nuclear Security (Haut Comité pour la Transparence et l'Information sur la Sécurité Nucléaire)

HOF: Human and Organizational Factors

HSE: Health, Safety and Environment

IAEA: International Atomic Energy Agency

ICPE: Environmentally Regulated Facility (Installation Classé pour la Protection de l'Environnement)

IG: General Inspectorate (Orano)

INB: French Regulated Nuclear Facility (Installation Nucléaire de Base)

INBS: French Defense Nuclear Facility (Installation Nucléaire de Base Secrète)

IPR: Incident Prevention Rate

IRSN: Institute for Radiation Protection and Nuclear Safety (Institut de Radioprotection et de Sûreté Nucléaire)

OEF: Operating Experience Feedback – process designed to organize Operating Experience or Lessons Learned (REX in French)

TSN Act: French law no. 2006-686 of June 13, 2006 on transparency and security in the nuclear field, now codified

WANO: World Association of Nuclear Operators

A

ASSESS scale (Advanced Severity Scale for Events and Soft Signals): Internal scale put in place for the management of industrial safety events. It provides comparative elements that can be used to assess the severity of events. Based on similar principles to the ARIA scale and the INES scale, it is graduated from 0 to 7.

B

Becquerel (Bq): International unit of measurement of nuclear activity (1Bq = decay of 1 atomic nucleus per second). The becquerel is a very small unit. Formerly, activity was measured in curies (1 curie = 37,000,000,000 Bq).

C

Cask: Assembly of components needed to safely contain the radioactive material transported. It may include a variety of special materials, such as radiation-absorbing materials or thermal insulation materials, as well as service equipment, impact limiters, and devices for handling and stowage.

Category A or B: Classification categories for workers likely to receive, in normal work conditions, an effective dose of more than 6 mSv per year in the case of a category A worker and of more than one of the dose limits set for the public in the case of a category B worker.

Cleanup: All technical operations to eliminate radioactivity-related risks in a nuclear facility, consisting of decontaminating the structures, equipment, floors and walls of the buildings.

Containment: System of protection which consists of containing radioactive products inside a defined area.

Contamination: Presence of radioactive substances (dust or liquid) on the surface or inside a medium. Contamination in humans may be external (on the skin) or internal (via the skin or by inhalation or ingestion).

Controlled area: Area where access and residence time are regulated for reasons of radiation protection.

Conversion: Combination of chemical transformations to convert solid uranium concentrates into uranium hexafluoride so that they may be enriched in fissile uranium (U^{235}) by centrifugation.

Criticality (criticality safety): The study and control of conditions to protect against the occurrence of a criticality accident due to an uncontrolled nuclear fission reaction in normal, incidental and accidental situations.

D

Decommissioning: Administrative procedure consisting of removing a facility from the list of regulated nuclear facilities (INBs). At that point, the facility is no longer subject to the legal and administrative requirements pertaining to INBs.

Decontamination: Physical, chemical or mechanical operation designed to eliminate or reduce the presence of radioactive or chemical materials deposited on a person or equipment, or in a facility or open area.

Defense in depth: A series of lines of defense designed to prevent the appearance, or limit the consequences as necessary, of human or technical failures that could lead to accidental situations.

Dismantling: Combination of technical and administrative procedures carried out following the final shutdown of a facility to achieve defined final conditions enabling it to be decommissioned. Dismantling includes the physical dismantling and decontamination of all machinery and equipment, and the management of the associated radioactive waste.

Dosimeter: Instrument for measuring radioactive doses received by an individual, or by certain of that individual's organs (passive or operational dosimetry), or by the environment (site dosimetry).

E

Effective dose: The sum of an individual's internal and external exposure to ionizing radiation (energy received and effects related to the type of radiation). It generalizes the effects to the whole body of an individual, taking into account differences in the sensitivity of different organs. It is expressed in millisieverts (mSv), a sub-unit of the sievert (1 Sv = 1,000 mSv).

Enrichment: Process in which the abundance of fissile isotopes is increased in a chemical element. Naturally occurring uranium essentially consists of 0.7% U^{235} (fissile isotope) and 99.3% U^{238} (non-fissile isotope), and must be enriched in U235 for it to be usable in a pressurized water reactor. The proportion of U^{235} is brought to approximately 3 to 5%.

F

Fissile: Describes a nuclide capable of fission; the fission of atoms generates several neutrons.

Fission products: Fragments of heavy nuclei produced during nuclear fission or the subsequent radioactive decay of the nuclides formed. These fission fragments and their decay products are collectively referred to as "fission products".

Fission: Spontaneous or forced splitting of a heavy nucleus, generally after absorption of a neutron, into two or three smaller nuclei (fission products), accompanied by the release of neutrons, radiation and a considerable amount of heat. The

substantial energy released is the principle underlying nuclear power generation.

Fuel cycle: The combination of industrial operations involving nuclear fuel. These operations include uranium ore mining and processing, uranium conversion and enrichment, fuel fabrication, used fuel treatment, recycling of recovered fissile materials to fabricate new fuel, and radioactive waste management.

G

Glass: High-level radioactive waste is vitrified and poured into stainless steel canisters.

Glove box: A transparent enclosure in which equipment and radioactive substances can be handled in isolation from the operator. Handling is done with gloves which are sealed to openings in the wall of the enclosure or with mechanical manipulators.

H

Hot work: Any operation or maintenance work requiring the use of an open-flame device, a spark generator or a hot surface.

Hulls: Pieces about 3 centimeters long produced by the shearing of the metal cladding (fuel rods) that had contained nuclear reactor fuel.

I

Incident Prevention Rate (IPR): Internal Group indicator based on the ratio of the number of INES level 1 events to the number of INES level 0 events.

International Nuclear and Radiological Event Scale (INES): International scale designed by the IAEA to facilitate communication about nuclear events. It provides comparative elements that can be used to assess the seriousness of an event. The scale ranges from level 0 (deviation with no safety significance) to level 7 (major accident with considerable health and environmental consequences).

Ionizing radiation: Electromagnetic or corpuscular radiation capable of producing ions directly or indirectly as it passes through matter. This ionizing radiation can be produced by the radioactivity of atoms such as uranium or plutonium.

Irradiation: Exposure of an organism or an organ to ionizing radiation when the radiation source is outside the organism.

M

MOX (Mixed OXide): A mixture of uranium and plutonium oxides used to fabricate certain types of nuclear fuel.

N

Nozzle: Metal component located at the top (top nozzle) or bottom (bottom nozzle) of a fuel assembly. The top nozzle is used to handle the assembly.

Nuclear materials safeguards: Safeguards aimed at preventing any loss or diversion of material, in particular for malicious purposes.

Nuclear safety: Combination of technical and organizational measures related to the design, construction, operation, shutdown and dismantling of regulated nuclear facilities, and to the transport of radioactive substances, which are taken to prevent accidents or limit their effects.

P

Periodic review: The periodic review of a facility assesses the facility's status in terms of the rules applicable to it and updates

the assessment of the risks or drawbacks that the facility may present, taking into account in particular the condition of the facility, the operating experience, developments in knowledge and changes to the rules applicable to similar facilities.

Plan National de Gestion des Matières et des Déchets Radioactifs (PNGMDR): The National Radioactive Waste and Materials Management Plan is a document which assesses existing methods of managing radioactive waste and materials, identifies foreseeable storage and disposal facility requirements, indicates the capacities needed for those facilities and the duration of storage, and sets objectives for radioactive waste for which no final management method exists.

Pressurized nuclear equipment: Equipment that is specially designed for nuclear applications and whose failure could give rise to radioactive releases.

R

Radiation protection: Combination of rules, procedures and means for prevention and monitoring aimed at preventing or reducing the exposure of employees and the environment to the harmful effects of ionizing radiation.

Radioactive waste disposal: In France, operation consisting of placing radioactive waste in a specially designed facility for potentially permanent keeping in compliance with the principles laid down in article L. 542-1 of the Environmental Code, with no intention of withdrawing them later.

Radioactive waste packaging: Operation consisting of packaging waste in a form suited to the containment of radioactive materials, enabling its shipment, storage and final disposal.

Radioactive waste: Radioactive substances for which no further use is foreseen or planned, or which have been requalified as such by the administrative authority pursuant to article L. 542-13-2 of the French environmental code.

Radioactive material: Substance containing natural or artificial radionuclides whose activity level or concentration warrants radiation protection monitoring.

Radioactivity: Phenomenon involving transformation of a nuclide with release of ionizing radiation. Radioactivity may be natural or artificial. The radioactivity of an element decreases over time as the unstable nuclei disappear.

S

Safety analysis report: Report describing the design of regulated nuclear facilities and the measures taken to ensure safety. It inventories the risks presented by the facility and specifies the measures taken to prevent them as well as measures conducive to reducing the probability of accidents and their effects.

Safety standards: Combination of documents called for by the regulations of each country which present measures taken to ensure the safety of a facility. The safety analysis report is one such document.

Sievert (Sv): Unit of measurement of radioactive dose, i.e. the fraction of energy from ionizing radiation received by 1 kilogram of living matter, taking into account the effects on the organ in question, which are a function of the type of radiation. The millisievert (mSv) is used more frequently, which corresponds to one one-thousandth of a sievert, and sometimes the microsievert (µSv), which corresponds to one one-millionth of a sievert.

Storage: Temporary surface or geologic storage of radioactive materials and waste in a facility that is specifically designed for that purpose, pending their removal.

Subcontractor: Natural or legal entity other than the owner-operator, performing operations or supplying goods and services for the latter. These activities may be related to an AIP or EIP.

U

UF_4: Uranium tetrafluoride. Chemical form of Uranium used for conversion.

UF_6: Uranium hexafluoride. Chemical form of Uranium used for enrichment.

UO_2: Uranium dioxide. May be in powder or pellet form. It is the constituent component of nuclear fuel.

Uranium concentrate: Magnesium uranate, sodium, ammonium or uranium peroxide in solid form resulting from the mechanical and chemical treatment of uranium ore. This marketable concentrate contains about 80% uranium.

Used nuclear fuel recycling: After a use cycle in the reactor, the used nuclear fuel must be unloaded. At that time, 96% of the fuel materials are reusable (95% uranium and 1% plutonium), while 4% are fission products and minor actinides (final waste). A first step is to separate recoverable radioactive materials from the final radioactive waste contained in the used fuel. The former can be recycled to produce electricity, economizing on natural resources. The waste is packaged safely and sustainably for storage.

Used nuclear fuel: Fuel permanently removed from a reactor core after having been irradiated there.

V

Vitrification: Process used to incorporate concentrated solutions of final radioactive waste (fission products and minor actinides), which have been chemically separated from the used fuel, into a glass structure by mixing it with a glass matrix at high temperature.

W

Waste rock: Earth, sand or rock that contains little or no uranium, but that must be extracted to gain access to the ore itself. Their naturally occurring radioactivity is comparable to that of the surrounding rock.

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orano

125, Avenue de Paris
92320 Châtillon - France