ACCEPTANCE AND TRACKING OF WASTE PACKAGES FROM NUCLEAR POWER PLANTS AT THE CENTRE DE L'AUBE

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Abstract

For 30 years, the French National Agency for Radioactive Waste Management (ANDRA) is in charge of the radioactive waste management and acquired a good knowledge relating to the control of low and intermediate level waste produced by nuclear power plants (NPP), the waste characteristics and the waste conditioning. The integrated waste management system for low-level radioactive waste in France implemented by ANDRA covers all stages from waste generation to final disposal at the Centre de l'Aube near surface facility. ANDRA defined a quality assurance program for waste management that specifies the level of quality to be achieved by solidification and packaging processes, defines quality control requirements and defines waste tracking requirements, from waste generation through final disposal Verification of quality of waste packages is implemented at three levels of the waste management system. The first one consists of inspections of waste packages at the generator's premises and audits of the quality assurance organization of the waste generator. The second level of verification consists of the waste tracking system. It allows identifying and tracking each waste package from the step it is fabricated to its final disposal at the ANDRA site. The third level of verification is obtained by mean of non-destructive and destructive assays of waste packages. These assays allow to verify generator compliance with Andra's technical specifications and to investigate the accuracy of physical and radioactive characteristics reported to Andra by the generator.

1. INTRODUCTION

The nuclear power plants (57 PWR units in operation) of Electricité de France (EDF) representing an installed capacity of 61 500 MW produces nearly 368 TW·h of electricity and generates about one third of the total volume of waste packages disposed of at the Andra disposal facility, the Centre de l'Aube.

Moreover 8 units (6 Graphite Cooling Reactors, 1 PWR and 1 Fast Breeder Reactor) are stopped; the partial dismantling generates waste also disposed at the Centre de l'Aube.

ANDRA is responsible for long-term radioactive waste management. It has implemented a waste management system that covers all stages, from waste generation to waste collection, conditioning, packaging and final disposal.

ANDRA has set up a quality assurance program for waste management that specifies the level of quality to be achieved by conditioning and packaging processes, defined quality control requirements and waste tracking requirements, from waste generation through final disposal.

2. WASTE ACCEPTANCE

2.1. Waste acceptance criteria

ANDRA drew up technical specifications for waste acceptance to ensure compliance with the two principal objectives defined by the fundamental safety rules to:

— Protect the public and the environment from the radioactive materials throughout the life of the disposal facility; and
— Limit the duration of the institutional control period to a maximum of 300 years.

These performance objectives involves three primary waste acceptance criteria:

— The first waste acceptance criterion is to physically immobilize the waste;
— The second waste acceptance criterion is to prevent or delay radionuclide migration during the institutional control period; and
— The third waste acceptance criterion is to limit the specific activity of the radionuclides present in the waste.

ANDRA developed a waste acceptance process to ensure the generators' effective compliance with the waste acceptance criteria and technical specifications. In this process, the waste generator (the NPP) must perform a series of standardized tests confirming the ability of the proposed waste treatment process to comply with Andra's waste acceptance criteria and technical specifications. The results of the various tests are submitted to Andra for review and technical assessment.

2.2. Waste acceptance process

Fundamental Safety Rule requires Andra to determine the acceptance of waste packages for disposal at a near-surface site. These packages must be fabricated using Andra-approved processes «for waste sampling and analysis, processing and packaging.» To gain acceptance, waste packages must comply with applicable Andra specifications. The waste packages must be formally accepted before they are allowed in the disposal facility. The generator must submit a request for waste package acceptance to Andra, accompanied by a Waste Acceptance File containing the following documentation:

— Description of waste package fabrication process which summarizes, in particular, the used for method waste package manufacturing and quality assurance/control measures set up for the process;
— Description of activity measurement method, which provides information on the methods used to determine the activity for low, medium and long lived waste present in the waste packages and on the certification of these methods;
— Characterization file, which shows that the waste packages produced with a give process meet the requirements of the corresponding technical specifications; and
— Quality assurance plan, which identifies specific quality assurance measures taken.

The waste acceptance file is usually created in several phases, particularly during the selection of the fabrication process and of the activity measurement method, during the installation of the corresponding facilities, and during characterization testing. The generator consults with Andra at various stages of waste acceptance file development to ensure that the anticipated waste package would in fact meet the technical specifications.

3. NUCLEAR POWER PLANT WASTE

Nuclear power plants generate three types of waste:

— Low and intermediate level radioactive waste (LILW);
— Waste containing long half-life radioactive emitters;
— Fission products from reprocessing.

Only the first type of waste, coming directly from operating nuclear power plant or initial decommissioning, is described here.

Since its opening (January 1992), the near-surface disposal facility for short lived LILW waste, the Centre de l'Aube, received a total volume of 36000 m^3 (at the end of 1998) from the nuclear power plants (Table 1).

TABLE I. NPP WASTE PACKAGES DELIIVERIES AT THE CENTRE De L'AUBE (1992-1998)

Type of waste	Waste packages quantity	Waste packages volume (m^3)	Activity (TBq)
LLW solid waste	77070	18847	7
LLW concentrates and sludge	2871	5770	15
ILW solid waste and filters	4428	7159	468
ILW resins	3182	4256	460
Total	87551	36033	950

All the waste packages delivered by the NPP at the Centre de l'Aube followed the acceptance process described above and are taken into account in the quality assurance program.

3.1. Low level solid waste

Low level solid waste is waste coming from maintenance operations and represents the most part of the total NPP waste volumes consisting of papers, plastic, clothes, metal pieces, water circuit filters etc.

Waste is conditioned in 200 liters steel drums. At the Centre de l'Aube, the waste packages is treated at the compaction facility with a 1000 tons press and concreted into 485 liters drums before disposal.

The main requirements for this type of waste packages are a low level activity and the nature of primary waste.

In 1999, a great part of the waste will be treated in an incineration and melting facility. Then the ultimate waste, the ashes and ingots, will be disposed of at the Centre de l'Aube.

3.2. Low level liquid waste

Waste coming from liquid treatment effluent of NPP is treated by evaporation. The concentrates are immobilized with an hydraulic binder in a concrete container (2 m^3). For this type of waste packages no specific containment is required according to the low activity, but mechanical properties are needed. For sludge, the same process is carried out.

3.3. Intermediate level solid waste

These waste packages concern solid waste (contaminated and irradiated) and filters with a dose rate greater than 2 mGy/h. Waste is conditioned in concrete container and immobilized with an hydraulic binder. If necessary biological protections are introduced in the container.

The process must ensure the containment of the radionuclides, moreover containers used are concrete containers with high performances. These waste packages represents 50% of beta gamma activity of the NPP waste packages delivered at the Centre de l'Aube.

3.4. Ion exchange resins

Ion exchange resins, considered as intermediate level waste are the second main source of NPP beta gamma activity (50%) at the Centre de l'Aube. Spent resins are mixed with a polymer, this matrix ensures the containment of the radionuclides.

Appropriate tests (leaching tests) have been performed during the acceptance process. The containers are concrete container with steel shielding.

3.5. Decommissioning waste

Until 1998, the decommissioning waste generated was solid waste with a low activity and generally conditioned in steel drums like operating waste. But the removal of some equipment and materials needed the design of new waste packages.

It is mainly the case for waste issued from the Gas Cooled Reactors:

— Graphite waste;
— Liquid and solid waste from special operations (draining of pools).

3.6. Specific waste

During operation of NPP, maintenance operations generated specific waste, this waste need a specific treatment concerning:

— Conditioning and transportation;
— Acceptance process;
— Disposal design and handling;
— Safety assessment.

Examples of such types of waste are the vessel closure heads of PWR NPP and racks for fuel elements.

A specific study has been implemented for the direct disposal in engineered structures of PWR vessel closure heads, as illustrated in Fig.1.

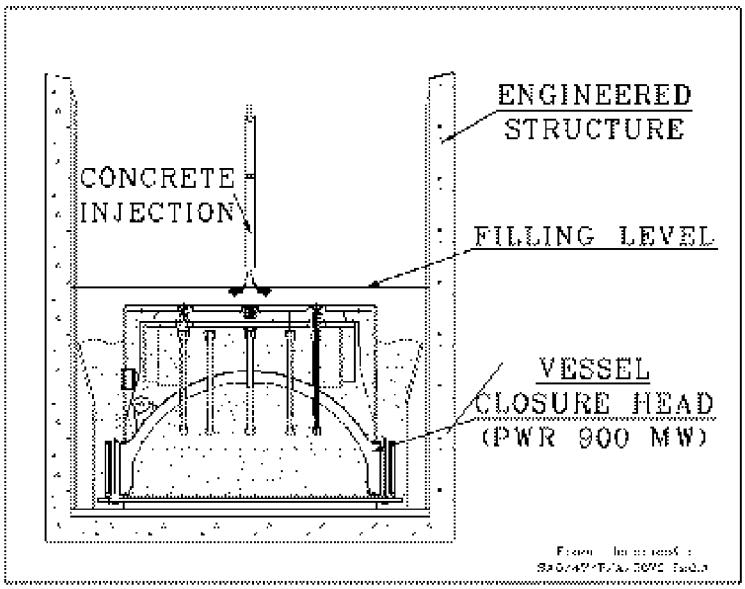

FIG.1. Disposal of vessel closure heads of PWR NPP

4. WASTE PACKAGE TRACKING

The waste management cycle covers all stages, from waste generation to waste collection, solidification, packaging and final disposal, and it includes all aspects of design, construction and disposal site management.

By Executive Order dated August 10, 1984, a special quality assurance regulation applicable to licensed nuclear facilities, the government defined quality requirements applicable to disposal sites and to any component important to site safety, particularly the first safety-related component, the waste package. Following this document, ANDRA defined a quality assurance program for waste management that specifies the level of quality to be achieved by solidification and packaging processes, defines quality control requirements, and defines waste tracking requirements, from waste generation through final disposal. The quality assurance program is based on the following:

— Definition of quality (acceptance criteria);
— Achievement of quality (acceptance process); and
— Verification of quality.

Verification of quality occurs in four stages:
inspections,

— Audits of the quality assurance organization;
— Implementation of a tracking system; and
— Destructive examinations of waste packages.

4.1. Inspections

The generators identify fabrication process parameters, sampling and analysis methods, radioactivity measurements and any other activity pertaining to their waste management process in the Waste Acceptance File. This documentation will be used for verification purposes at each stage of the waste package fabrication and control process.

ANDRA inspects the generator's site one to three times a year at regular intervals following its own inspection procedure. In 1998, 26 inspections have been carried out on NPP.
The inspections are performed by qualified ANDRA staff familiar with the waste package and with ANDRA requirements, and are intended to ensure that procedures are correctly implemented and verified. Inspection includes:

— Verification that the process matches process information reported to ANDRA during the waste acceptance process and that operating parameters identified in the related documentation are followed;
— Review of the generator's quality control of fabrication, and particularly measurement equipment calibration; and
— Inspection of fabricated waste packages.

The inspections may be broken down into two phases:

— Review of generator documentation, and
— Inspection of waste packages during and after fabrication.

4.1.1. Documentation review

Documentation reviewed during inspection relates to:

— The initial waste (general characteristics, calculated activity reported by the generator, waste collection and sorting procedure, pretreatment...)
— Waste package fabrication (fabrication procedure, fabrication ranges, solidification material formula, solidification parameters and quality control after solidification...)
— Procured materials and supplies (quality control procedures at reception, results of quality control by the generator, supplier fabrication certificates...)
— Waste package (final inspection of the waste package, report of waste package characteristics particularly activity...)
measurement equipment (measurement and calibration procedures, calibration certificates for measurement equipment...)

4.1.2. Waste package inspection

During the second phase of inspection, the quality of the waste package is verified by direct inspection of:

— The contents of some of the packages;
— The fabrication conditions;
— The waste package characteristics (dimensions, visual appearance, dose rate measurement etc.); and
— The radiological monitoring equipment.

ANDRA reviews all deviations and may make a finding of non-conformity. The waste package may be accepted after it has been reworked to comply with requirements or the deviation has been accepted, or the waste package may be rejected. The generator's appropriate implementation of requested corrective actions is reviewed during the following inspection.

4.2. Audits

The purpose of quality assurance audits performed after waste package acceptance is:

— Verification of routine, effective and satisfactory implementation of quality assurance requirements established prior to waste package acceptance;
— Review of any changes to the requirements, and
— Assessment of changes to the requirements.

ANDRA's audits are based on:

— ISO 9002; and
— The generator's quality assurance documentation, which has been provided as part of the waste acceptance file.

During the audit, all quality-related documentation is listed and reviewed for consistency. The twenty criteria of ISO 9002 are examined by the auditors, with special attention given to those criteria of direct relevance to the waste package:

— Control of purchase material, equipment and services;
— Product traceability;
— Control of processes;
— Inspections and audits;
— Control of measuring and test equipment;
— Corrective actions; and
— Internal quality assurance audits.

Audits may be performed more frequently in some cases, particularly the following:

— Internal reorganization affecting the quality assurance function;
— Detection of defects in relation to the quality assurance program for the product; or
— Deficiency detected during a prior quality assurance audit for which ANDRA requested that corrective action be taken.

In 1998, 16 audits have been carried out in NPP. The subsequent audit examines the generator's appropriate implementation of the requested corrective actions. The adequacy of the quality assurance program is assessed based on detected non-conformities and their impact on the final product. It should be noted that an unsatisfactory assessment of the generator's quality assurance program could result in a suspension of acceptance of waste packages from that generator.

4.3. Waste tracking system

The generator must report the physical and radioactive characteristics of the waste packages before shipment to enable Andra to perform its waste package tracking and compliance inspection tasks.

The tracking system is based on the principle of traceability, which consists of identifying and tracking each waste package from the moment it is fabricated to its final disposal at the ANDRA site. Each radioactive waste package has a unique identification code. ANDRA and EDF, the NPP operator, developed a computerized tracking system which assigns a «passport» to each waste package that serves to track the package through disposal. This passport consists of:

— A unique identification number; and
— An identification form.

Once waste packages have been accepted pursuant to the waste acceptance process, the computer compares the characteristics of waste packages to be shipped with Andra's accepted waste types.

Descriptive information on the packages is reported to Andra on paper or, more frequently, via computer modem transfer. Information to be provided to Andra consists of:

— The identification number;
— The identification form with the waste package characteristics (year of fabrication, generator, type of container, activity level), its waste package type, its physical characteristics, and its activity and radioactive composition.

ANDRA's computer system uses this information to:

— Calculate α and $\beta\gamma$ activity in the waste package and update it as of the date of computer processing;
— Verify specific $\beta\gamma$ activity as of this date; and
— Verify specific alpha activity after 300 years.

4.3.1. Reporting to ANDRA before waste shipment

Three preliminary steps precede each shipment of waste, each requiring individual reporting to Andra well enough in advance so that the latter may conduct the necessary verifications of conformity prior to the scheduled shipment:

— Description of the waste packages and of the radioactive composition of their contents;
— Description of the composition of a shipment; and
— Shipment confirmation.

For each report, the generator is given either confirmation of the report's conformity or a list of errors detected in the report by the computer.

Information supplied by the generators on information forms or by computer is computer-verified:

— The consistency of information is verified to ensure that the waste package is accurately identified, that reported physical characteristics conform to the *process description* for that waste package, and that enough information has been supplied to calculate its activity;
— The acceptability of the waste package and/or its activity are verified to ensure that the activity of the waste package sent to the disposal site complies with the acceptance limits set forth in the specification.

If these verifications do not reveal any non-conformities, the waste package is reported to be in conformity and may be accepted at a near-surface disposal site.

4.4. Destructive and non-destructive examinations of waste packages

Waste packages are examined destructively as part of Andra's quality assurance surveillance of waste generators. These examinations help to determine the «level of confidence» that may be assigned to a generator with respect to:

— Generator compliance with Andra's technical specifications for a given waste package type;
— Generator compliance with requirements defined in waste package documentation which served as a basis for Andra acceptance of that waste package type (documentation listed on the acceptance certificate); and
— Accuracy of physical and radioactive characteristics reported to ANDRA by the generator for that type of waste package.

Waste package examinations are performed off-site on randomly selected waste packages without prior notice to the generator. The choice of packages to be inspected is based on the activity level and the number of waste packages fabricated as well as on the fabrication process. Two types of examinations are performed:

— Non destructive examinations, referred to as activity monitoring; and
— Destructive examinations, referred to as destructive examinations.

4.4.1. Non destructive examinations

Non destructive activity monitoring is performed on waste packages with special equipment installed in either fixed or mobile units using:

— Gamma spectrometry; and/or
— Passive and active neutron counting.

Activity monitoring enables verification of:

— The conformance of activities to Andra's technical specifications, and
— The accuracy of reported activities.

4.4.2. Destructive examinations

It is usually not feasible to inspect waste packages extensively without destroying them. Andra therefore occasionally performs destructive examinations in which the waste packages are cut into pieces, cut in half or core drilled so that they can undergo a veritable «autopsy». Samples of the waste packages are sent to specialized laboratories for physical, chemical and radioactive analysis.

The following destructive examinations may be performed:

— Verification of waste package characteristics (weight, dimensions, dose rate map, surface contamination, visual and photographic inspection...)
— Verification of waste package contents (cutting into pieces or core drilling, collection of cuttings or core drilling liquids, visual examination, list of waste contents and description of their condition, etc.)
— Examination of solidified waste samples (mechanical stability or compressive strength test, analysis of chemical components, determination of the chemical composition of the waste or solidification material, analysis of radionuclides present using γ spectrometry, a assaying or a spectrometry, and analysis of long lived pure β, and $\beta\gamma$ emitters, search of complexing agents.)

In addition, access to the waste's active material means that samples may be taken of radionuclides that cannot be detected non-destructively due to their radiological characteristics so that they can be analyzed in the laboratory.

Leaching tests should also be performed. Compliance with leach rate limits is verified on a case-by-case basis, although only a few of these tests are performed due to the lengthy period of time they require.

The destructive examinations usually take from one to twelve months, depending on the availability of personnel and facilities, or one and a half years or more in the case of leaching tests.

5. CONCLUSION

After 30 years of management of NPP waste, Andra acquired a good knowledge relating to the control of low and intermediate level waste produced by NPP, the waste characteristics and the waste conditioning.

In the next years, with the decommissioning plan, new challenges are proposed for ANDRA in order to dispose of safely new types of waste packages.