COMPUTERIZED ANALYTICAL DATA MANAGEMENT SYSTEM AND AUTOMATED ANALYTICAL SAMPLE TRANSFER SYSTEM AT THE COGEMA REPROCESSING PLANTS IN LA HAGUE

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ABSTRACT

Managing the operation of large commercial spent nuclear fuel reprocessing plants, such as UP3 and UP2-800 in La Hague, France, requires an extensive analytical program and the shortest possible analysis response times.

COGEMA, together with its engineering subsidiary SGN, decided to build high-performance laboratories to support operations in its plants. These laboratories feature automated equipment, safe environments for operators, and short response times, all in centralized installations.

Implementation of a computerized analytical data management system and a fully automated pneumatic system for the transfer of radioactive samples was a key factor contributing to the successful operation of the laboratories and plants.

INTRODUCTION

COGEMA began commercial operation of a reprocessing facility at La Hague in the mid-sixties. In order to operate a reprocessing plant, monitor nuclear materials and control the quality of the end-products (e.g. uranium, plutonium), a significant analytical program was needed. For this first commercial reprocessing plant at La Hague, the analytical program was managed manually by the process facility operators and the laboratory operators.

In the late seventies, COGEMA decided to build two new large reprocessing plants: UP3 dedicated to reprocessing foreign spent fuel and UP2-800 for domestic fuel. The total capacity of this reprocessing complex is 1600 metric tons of uranium per year. The design criteria for the plants design drew on experience from operating early French reprocessing plants. Based on this experience, three important design goals were set for both plants to:

- reduce individual operator doses to less than 5 mSv/year;
- limit environmental impact;
- guarantee production availability throughout the life of the plant.

These principles were applied to design of the plants, including the facilities and equipment needed to perform the analytical program associated with the operation of the La Hague reprocessing complex. Since the capacity of the new plants was four times greater than that of the first plant, the analytical program has expanded significantly.

The UP3/UP2-800 laboratory has been designed for automatic operation, which required:
- the design of a sampling system that can be remotely operated;
- the installation of a fully automated pneumatic system to transfer samples from the sampling unit to the analytical facilities;
- the design and the deployment of a computerized system to manage the huge amount of analytical data on centralized work stations;
- the design and construction of analytical laboratories, in which most of the analytical determinations are still performed manually.

The UP3 plant entered service in 1990 and the UP2-800 plant was commissioned in 1994. Innovative technologies, simplification, improvement of reliability and anticipation of the regulations are the most salient features of these new plants. Within four years, UP3 reached its nominal capacity of 800 metric tons per year. The high-activity facilities of the UP2-800 plant started active operation in 1994. Immediately after start-up, UP2-800 reached its nominal capacity of 800 metric tons per year. The analytical laboratories made a key contribution to the successful start-up of the La Hague complex and its continued smooth operation.

This paper describes the main features of the analytical facilities operated at La Hague, with the capability to support the analytical program associated with the reprocessing of 1600 metric tons of spent fuel per year.

ANALYTICAL PROGRAM

The analytical program comprises several analyses designed to determine the radiological and chemical characteristics of the radioactive materials contained at various locations in the plants. The objective is to support control of the process facilities which are part of the reprocessing plants, waste control, and quality control of the inlet and outlet products.

The computerized analytical data management system, the automatic sampling units, and the pneumatic transfer systems have been designed to fulfil the new plant analytical needs:
- 150,000 analysis per year;
- 200 analysis methods;
- 700 sampling locations in seven buildings;
- radioactive solutions of up to 5×10^{16} Bq/m^3.

COMPUTERIZED ANALYTICAL DATA MANAGEMENT SYSTEM

The computerized laboratory data management system supervises and manages the analytical requirements, from the requests prepared in the process facility control rooms to their transmission to the laboratories, to the validation of the analytical results, up to their delivery to the requesting facility operators. The system handles any analytical results, whether the analyses are performed manually or fully automated.

The analytical request cycle includes the following steps:
- analytical request, initiated by a process facility and submitted to the laboratory;
- validation of the request by the laboratory;
- sampling in the facility;
- transfer of the sample from the sampling location in the facility to the analytical enclosure (hot cell or glove box) in the laboratory;
- analytical determination, performed in the laboratory;
- validation of the results by the laboratory;
- transmission of the analytical results from the laboratory to the facility;
- computerized recording of the analytical results.

Thanks to the computerized analytical data management system, the automatic sampling units, and the automated pneumatic transfer system, all these steps are automated and controlled from the laboratory control room.

Throughout an analytical determination, the computerized system:
- proposes analytical programs;
- manages the analytical method list;
- calculates the number of sampling vials needed for each sampling;
- checks the reference number of each vial;
- manages the analytical requests and interfaces the various La Hague site organizations involved in the analytical cycle (facility control rooms, laboratory centralized control rooms, pneumatic transfer control room and laboratory rooms);
- manages the sampling;
- controls the transfers;
- displays analytical data sheets on the laboratory room consoles;
- displays the analytical request cycle status, the analytical results, and the analytical program status on the consoles of the facility control rooms and laboratory control room;
- stores the analytical results.

Traceability of the sample is ensured throughout the analytical cycle.

AUTOMATIC SAMPLING CYCLE DESCRIPTION

The cycle starts after validation by the laboratory operator of the analysis request from the process facility. At the appropriate time, the liquid recirculation loop starts on the concerned tank. A new empty vial is prepared by an automatic feeding machine. The pneumatic transfer line is configured from the vial feeding machine to the selected automatic sampling unit. The transfer starts, the vial arrives in the sampling unit and is filled. The pneumatic transfer line is configured from the sampling unit to the selected analytical enclosure. The vial is transferred from the sampling unit to the analytical enclosure. When it arrives, the transfer stops and the laboratory operator is informed.

In the course of a year, 210,000 single-use disposable vials (Figure 1) are sampled and transferred to the laboratories on the La Hague site.

AUTOMATIC SAMPLING UNIT

The sampling unit (Figure 2) is designed for sampling highly radioactive liquids. It has two main components:

- a fixed tank sunken into the floor of the cell supports the sampling heads, which are connected to the liquid transfer circuits to be sampled;
- a mobile rotating tool with mechanisms that remotely connect to sample vials.

Components are designed to provide total continuous shielding. The sampling unit can be equipped to connect up to 24 sampling heads.

Liquid samples are taken by piercing a vial placed under vacuum with a hollow needle and drawing the solution from the vial. The needle remains attached to the sampling head, but the vial is movable.

The mechanical components of the sampling unit serve to move the vial for the various operations:

- reception of the empty vial;
- placement of the vial on the designated sampling head;
- injection of the sample into the vial with the needle;
- washing the vial with water;
- drying the vial with air;
- removal of the filled vial;
- removal of an used needle and installation of a new needle.

The automatic sampling unit features the advantages of small-size equipment, fast and fully automatic sampling—less than 10 minutes are needed for one vial— and easy maintenance. All mechanical parts are installed outside active areas and designed to be removed under containment. The replacement of a sampling needle is automatic and controlled from the laboratory control room.

The volume of the vial is about 10 ml. In the La Hague laboratories, this volume is sufficient for most of the analyses. If more solution is needed, additional vials are filled and sent to the laboratory. The right number of vials is calculated by the data management system, but the laboratory operator may request more, if necessary.

A total of 35 automatic sampling units are operating at the La Hague site.

PNEUMATIC TRANSFER SYSTEM

The main functions of the system are to:
- transfer the new empty sampling vials from the vial feeding machines to the sampling units;
- transfer radioactive samples from a sampling unit to a receiving analytical enclosure;
- check that the gamma activity of the sample to be transferred is consistent with the biological shielding of the receiving analytical line and, if not, prevent the transfer; the receiving analytical enclosures may be either shielded analytical enclosures (hot cells) or glove boxes;
- ensure the containment of radioactive sample during the transfer.

The main characteristics of the system are:
- a sampling unit can send samples to several analytical enclosures;
- an analytical enclosure can receive samples from several sampling units;
- the pneumatic lines can operate in reciprocating motion to dislodge a sample blocked in the transfer pipe;
- the sample circulates inside the pipes at a speed 10 to 20 m/s;
- the samples are transferred individually, i.e. only one sample in the transfer pipe at a time;
- the transfers are monitored by vial passage detectors installed all along the lines;
- the transfers are fully automated, with the status of the transfers and all components displayed on mimic diagrams on the control room consoles;
- the system is designed to ensure redundancy of the main analytical enclosures and analytical apparatus.

The La Hague transfer pneumatic system (Figure 3) connects the 35 automatic sampling units to 10 analytical enclosures. The total length of its transfer pipes is about 50 km. A total of 127 diverters are used to configure the transfer lines. The vials are placed under vacuum and marked by eight automatic vial feeding machines.

CONCLUSION

Compared to the previous manual system, the fully computerized system has proven to be very efficient.

The computerized exchanges of analytical data avoid the constraints of paper flow between controlled and non-controlled areas and limit the risk of errors which can occur through data exchanges. All analytical data are stored in the computerized system data base or on magnetic tape without risk of loss. The capacity of analytical results storage is increased and use of the stored analytical results is easier.

Sample traceability is ensured from the sampling through to the analysis data return. The system has enabled the development of fully automated analysis. It is easily adaptable in case of facility modification (addition of units, facilities) or modification of the laboratories (new lines, new methods, or elimination of methods), and has demonstrated its adaptability when integrated into the UP2-800 plant analytical program. Lastly, it can easily be adapted to other computerized system interfaces, such as the automated analytical lines system.

Laboratory productivity, quality assurance, flexibility, redundancy, user friendliness and scaleability have been improved by implementation of the fully computerized system.

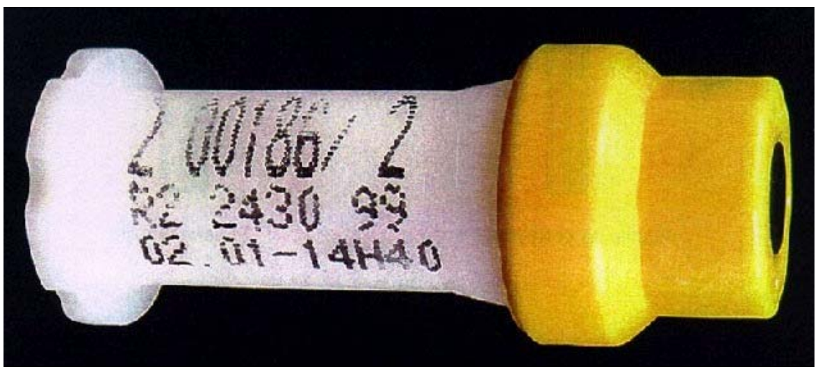

Fig. 1. Sampling Vial

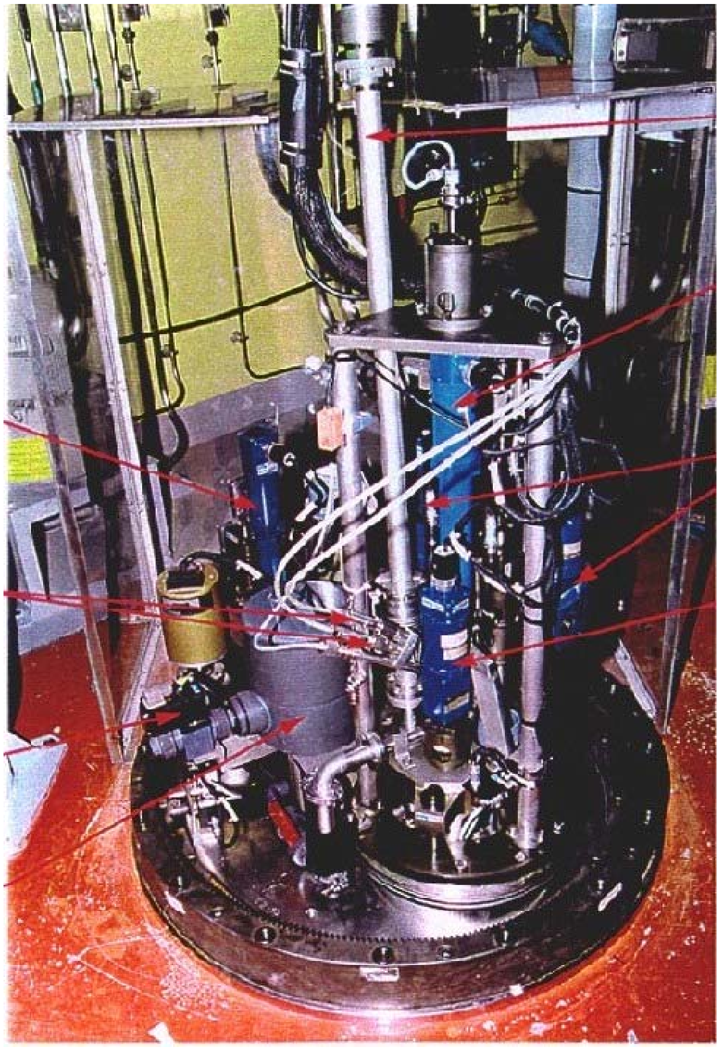

Fig. 2. Automatic Sampling Unit

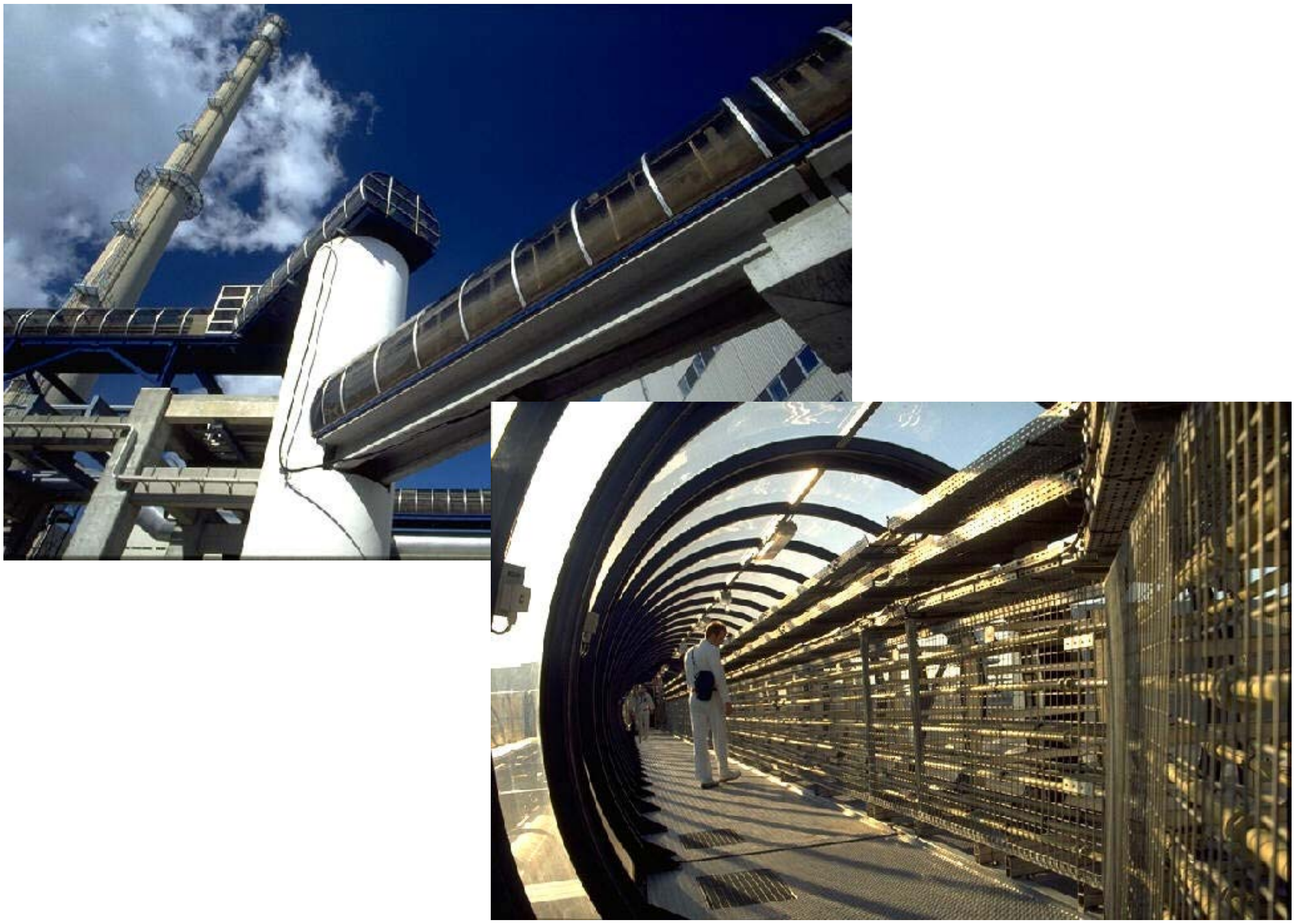

Fig. 3. Pneumatic Transfer System