FROM AMI CHINON TO LIDEC NUCLEAR FACILITIES (EDF INTEGRATED LABORATORIES FACILITIES FOR EXAMINATIONS)

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AMI[1] Chinon nuclear facilities is a structure without any equivalent in France, equipped with mechanical, metallurgical, chemical and radio-chemical facilities to answer to EDF nuclear and fossil power plants needs in the field of examinations.
AMI design, commissioned in September 1963, is not based on nuclear industry regulatory texts, which has been published later.
Several projects concerning the future of AMI Chinon have been encountered difficulties since 1994. In june 2006, EDF has decided, in front of French Safety Authorities, to take new orientations :

- confirm the renunciation on fuel examinations,
- AMI Chinon decommissioning before 2015,
- building new nuclear facilities called LIDEC, located on NPP of Chinon close to chemical and radiochemical facilities in the field of effluents and environment, commissioned before end of 2011.

The present paper is structured according three different parts :

- a presentation of history and activities performed on AMI chinon and a description of laboratories equipments which will be reconducted in the new nuclear facilities,
- needs for the next fifty years in the scope to answer to EDF nuclear and fossil power plants, with the best efficiency, the best radiological cleanliness inside facilities and with the lowest collective dosimetry for the staff,
- main design options retained in the fields of :
  - o transport of nuclear materials, reception, cutting, machining and transfer of nuclear specimens inside facilities,
  - o reduction of dosimetry at the working posts,
  - o reduction of contamination (in terms of containment and nuclear wastes).

1. Introduction

AMI Chinon nuclear facilities is a structure without any equivalent in France, equipped with mechanical, metallurgical, chemical and radio-chemical facilities to answer to EDF nuclear and fossil power plants needs in the field of examinations.

Several projects concerning the future of AMI Chinon have been encountered difficulties since 1994. In June 2006, EDF has decided, in front of French Safety Authorities, to take new orientations.

[1] AMI : Irradiated Materials Workshop

This paper describes briefly the history of AMI from 1963 up to now. Then, a presentation of activities performed on AMI Chinon hot labs and a description of laboratories equipments will be proposed. These activities and equipments will be transferred in the new nuclear facilities. After that, main design, operating and maintenance options for LIDEC nuclear facilities, will be presented.

2. History of AMI and description of activities

2.1 History of AMI

Decision to build nuclear facilities on NPP of Chinon for metallurgical examinations has been taken in 1954. Building started in 1960 and finished in 1963. Official start up is obtained the 12th September of 1963. AMI Decree is published the 31st January of 1964. From the beginning, these nuclear facilities are designed to receive fuel elements coming from graphite-gas nuclear power plants. Principle of the design is based on a line of six independent hot cells where metallurgical and physics examinations can be performed (Figure 1).

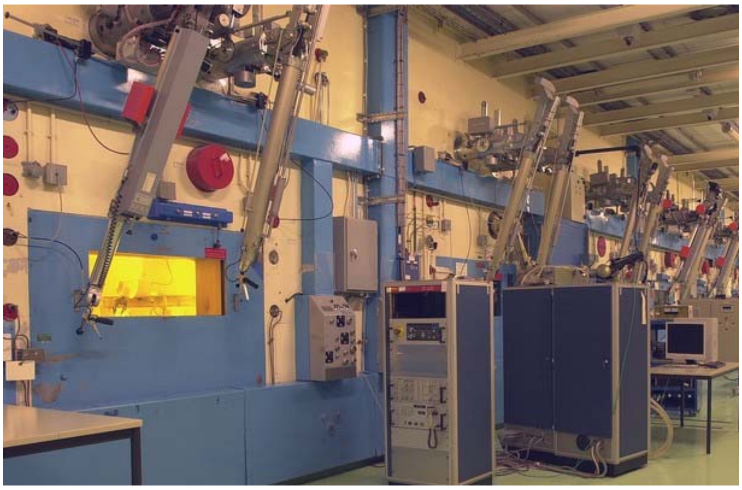


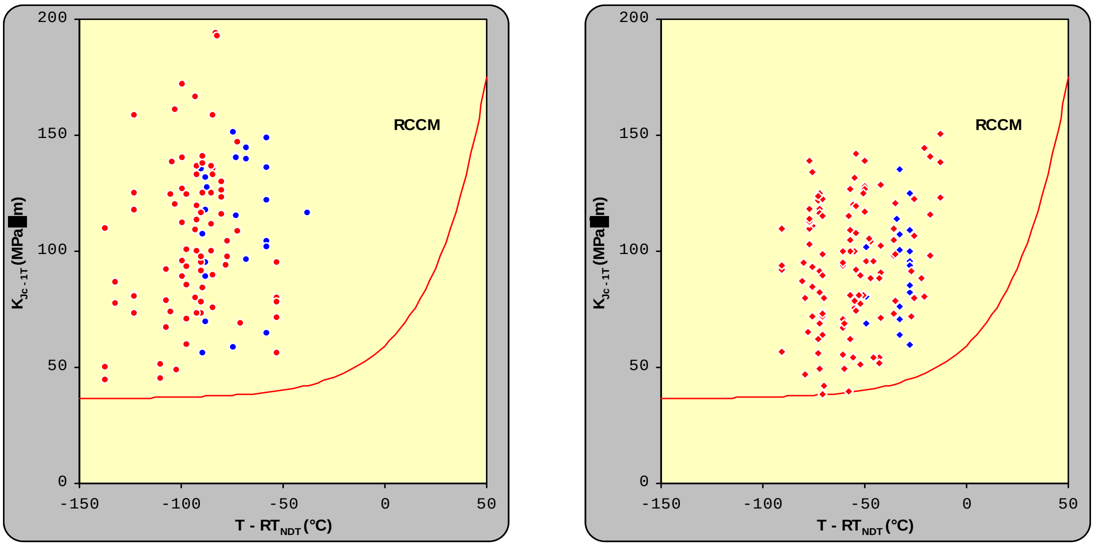
Figure 1 : general view of AMI hot cells line

Medium and low activity nuclear facilities are also built for metallurgical examinations on internal structures coming from graphite gas NPP. In 1967, first metallurgical examinations on PWR nuclear plants and the Pressure Vessel Surveillance Program begin with CHOOZ A start up.
In the eighties, hot cells are modified to receive fuel elements coming from PWR power plants. 2 years of works are necessary to modify hot cells and to obtain the modified decree. Metallurgical examinations on fuel elements will be performed in these hot cells up to 2000, where it has been decided to completely transfer this activity to CEA.
From the beginning AMI nuclear facilities are in support for NPP in the field of materials and more recently, in the field of fluids and effluents characterization. Follow up surveillance program on different components are performed in the objective of life assessment. Examinations on equipments or fluids coming from nuclear and conventional islands are proposed in the objectives of availability, safety and maintenance optimisation. More recently (2004), prescription for chemical and radio-chemical analysis methods are proposed in the field of process, effluents, wastes and environment in the objective to harmonize methods for all NPP.

Three next paragraphs describe more in details surveillance program on 2 components and metallurgical examinations for NPP performed in AMI nuclear facilities.

2.2 The pressure Vessel Surveillance Program (PVSP)

The demonstration of the in-service resistance of the PWR vessels is based on the toughness evaluation of the materials constituting the vessels. The toughness of the materials is determined according to an indirect method. It is based on a codified lower bound curve associating the minimum K_{1c} to a reference temperature, the RT_{NDT}. RT_{NTD} is characteristic for a material and integrates the evolutions due to neutron bombardment through specific irradiation formulae.



(a) (b)

Figure 2 : RCCM codified curve for the toughness evaluation of pressure vessel material (a) parent material (b) weld material

The PVSP allows to verify that the formulae are conservative and is a key element in the validation of the assessment methodology. Its main objective is to confirm the conservatism of the ageing formulae. The PVSP is applied to each reactor vessel in operation in France (plus 2 in South Africa) and allows to monitor periodically the irradiation induced material embrittlement. The results obtained represent the shell state after approximatively 10, 20, 30 and 40 years of operation.

Thanks to representative materials irradiated into capsules (Figure 3), it provides an anticipated evaluation of the shell material embrittlement. The capsules are positioned closer to the fuel assemblies than the shell internal surface, at locations well characterized where the neutron flux is higher than the one undergone on the vessel. The embrittlement measurement is given by impact strength testing (on Charpy V samples) performed on both irradiated and unirratiated samples tested on AMI hot cells.

The French legislation (decree and application circular of 10 November 1999 – article 12) stipulates that the surveillance program must be representative of the shell irradiation conditions and materials. The materials are thus selected as follows :

- the base metal is taken from over lengths of one of the two core shells (the shell is chosen on the basis of the fracture characteristics, considering the initial property of the base metals and their embrittlement behaviour),
- the weld and associated heat affected zone are elaborated under identical welding conditions as the core zone components.

All the samples come from ¼ thickness of the product. Moreover, in the capsule of each reactor, some specimens coming from a unique plate of grade very close from the vessel base metals are also irradiated. The embrittlement results of this reference material are very useful for comparisons between different reactors.

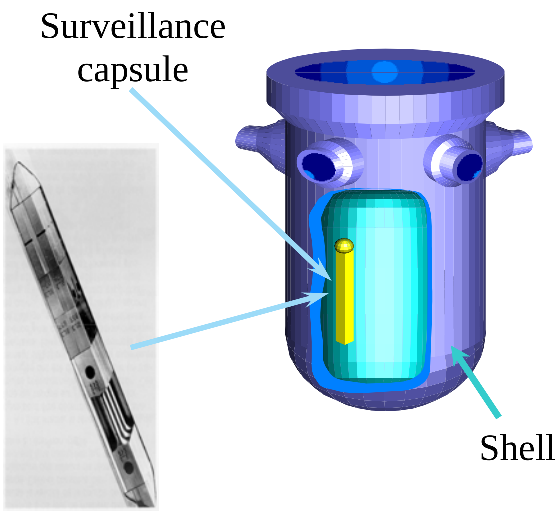


Figure 3 : schematic representation of capsule localization into pressure vessel

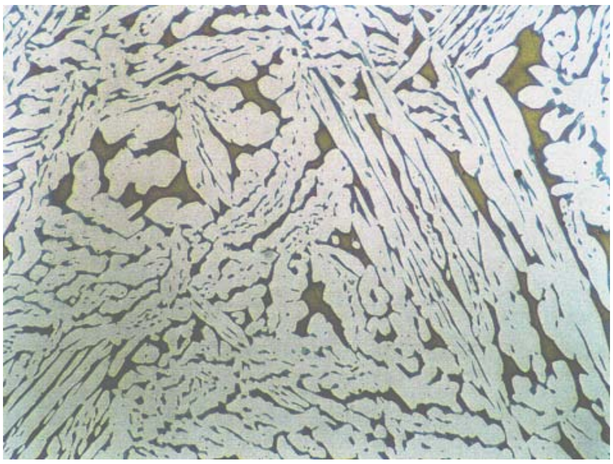
In complement of the Charpy V samples, some tensile, bending and CT specimens are also irradiated in the capsules. The capsules contains some thermal instrumentation, based on low melting point alloys, and nuclear instrumentation, based on fissile and activation dosimeters.

2.3 Thermal ageing of cast duplex stainless steel of PWR : material assessment on removed cast elbows

Some parts of reactor coolant circuit of nuclear PWR power plants – elbows on primary circuit – are made of cast duplex stainless steels. It is now identified that the mechanical characteristics of these steels can decrease upon thermal ageing after long term operation at reactor coolant circuit temperature conditions, close to 300°C. The sensitivity to thermal ageing of these components is related to the chemical composition and the ferrite content, especially the Chromium equivalent content.

In order to assess the ageing behaviour of in-service components, a laboratory ageing program has been initiated. This program, perfomed in AMI hot labs, consists in measuring the evolution vs ageing of the mechanical properties (hardness, toughness) of blocks cast at the same time as components (Figure 4). These materials have been chosen in order to cover the entire range of cast duplex components on PWR plants.

(a)



(b)

Figure 4 : (a) removed elbow (b) cast duplex stainless steel microstructure

Ageing thermal treatment have been carried out between 285 and 400°C for times up to 100000 hours in order to cover the real service temperature range (285 – 325°C) and to provide “accelerated” ageing data which may be used for extrapolating to low temperatures. The results obtained in the frame of the surveillance program have been used as a data base to develop formulae for predicting the ageing.

Moreover, a large program of material assessment was carried out on cast elbows removed during Steam Generators Replacement (SGR). The material assessment was based on metallurgical, mechanical and chemical characterization of in-service aged components. This contributes to validate the prediction formulae established from the laboratory ageing program results (Figure 5).

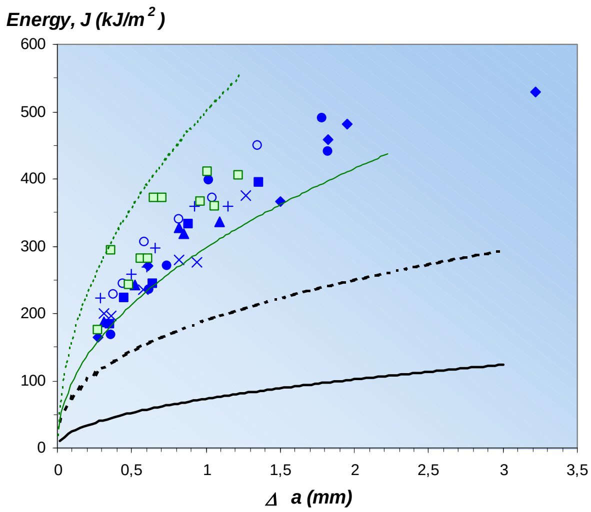


Figure 5 : comparison between predictive formulae and experimental results

2.4 Metallurgical examinations performed in support to PWR and fossil power plants

Besides surveillance programs, metallurgical, chemical and radio-chemical examinations are performed in AMI nuclear facilities for all EDF PWR and fossil power plants. Majority of these examinations are not foreseen at the beginning of the year and it is necessary to adapt request analysis to improve efficiency of treatment. More than 150 examination requests are treated by year, coming from 58 PWR power plants or fossil power plants. Safety, availability and maintenance optimisation are concerned by these examination requests.

An important feedback analysis has been developed in AMI hot labs to better adjust the answer to our internal customers. Expert advices or subcontracting can be proposed to adjust the priority of instruction.

The two following figures illustrate equipments and materials concerned by these examinations :

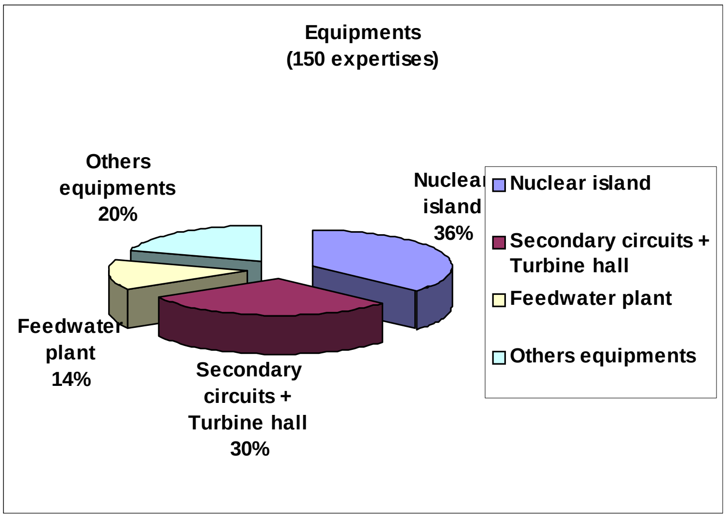


Figure 6 : equipments concerned by examinations performed in AMI nuclear facilities

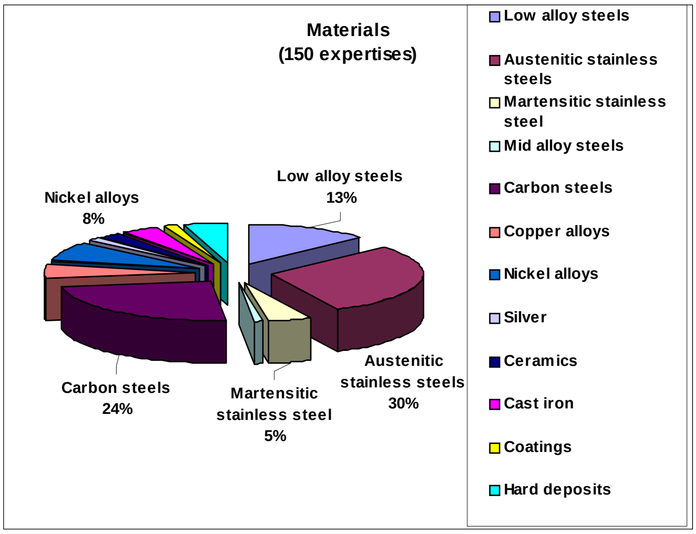


Figure 7 : materials concerned by examinations performed in AMI nuclear facilities

For the beginning of seventies, AMI nuclear facilities have developed an important feedback analysis in the field of damage mechanisms on different materials and equipments. These competencies are considered absolutely necessary for EDF in the future, in a context where PWR and fossil power plants are more and more aged.

3. Future of AMI hot labs

Since 1994, several projects have been proposed to define AMI nuclear facilities future. Decision has been taken at the end of 2001 to definitively stop examinations on fuel and to significantly reduce radiological inventory. This reduction is obtained by complete fuel evacuation and cleansing of storage holes.
New safety evaluation studied by NPP of Chinon and CIDEN, combined with the French safety authorities position who consider AMI nuclear facilities too old and the necessity to inject a lot of money to renovate buildings have led to take the decision in the 1st of june 2006 :

- confirm the renunciation on fuel examinations,
- AMI Chinon decommissioning before 2015,
- building new nuclear facilities called LIDEC, located on NPP of Chinon close to chemical and radiochemical facilities in the field of effluents and environment, commissioned before end of 201

Fuel examinations renunciation combined with a strict following of radiological inventory for metallurgical examinations will enable to define a new status for new nuclear facilities. This new status is called " facilities identified to protect environment'" (in French ICPE).

4. From AMI to LIDEC hot labs

The LIDEC will be made up to replace AMI facilities from beginning of 2012. The missions of LIDEC nuclear facilities will be the same as AMI ones.

4.1 Needs expression - Prescriptive field

Localization

LIDEC will be located on Chinon power plant site near Avoine City in Indre et Loire (France). The place chosen by EDF is near the entrance of the plant, on a 5750 m^2 field. Due to this localization, LIDEC construction have to be an exemplary yard (Figures 8 and 9).

Figure 8 : view of NPP site of Chinon

Figure 9 : schematic view of LIDEC in front of "the bowl"

Lifespan

The duration is 50 years for civil works (shielded hot cells included)

Radiological conditions

Inventory
The building design will enable to contain an activity of 35TBq in equivalent ^{60}Co activity. This level covers our needs (no more fuel examinations in LIDEC) and will enable to simplify administrative steps with French regulations.

Radiological cleanliness
Design is thought to protect staff against contamination in each situation (normal or accidental). Depending on the risk of dissemination, the containment of equipments are studied to definite the best solution (dynamic and/or static, in glove boxes or not).

These dispositions will enable staff to work with usual clothes (over clothes), in normal situation.

Particular protections will be wear in exceptional areas (Mururoa over clothes).

Dosimetry
The building is designed to class outsides of the building and maximum of maintenance premises as « public areas ». To maximize workers protection against external exposure, a maximum of permanent stay areas are designed to have a dose rate lower than 25 μSv/h.

Evolutions and modularity of laboratories

The surfaces chosen enable to :

- contain all needs of expert examinations,
- add activities without enlarge building (for example : 2 reserved locations for possible future hot cells in shielded cells),
- enlarge the building if necessary in the same area (a 300 m^2 area is available in the north and west part of the building).

4.2 Needs expression - Functional field

Examinations on materials or fluids

Directly connected to EDF Ceidre Laboratories missions, activities performed in LIDEC are two types :

- foreseen and planned in EDF survey programs : Irradiation Vessel Survey, ageing of cast primary elbows,
- fortuitous, often in urgency, answering a need of one particular EDF plant in relation with safety or availability of power plant.

These objects could be contaminated or irradiated : they are treated in hot laboratory or in hot cells depending on their radiological characteristics.
They also can be without contamination coming from conventional part of EDF utilities.

Fuel is non included and no planned in LIDEC sizing, but primary fluid coming from main primary circuit in a situation of fuel casing breakdown will be allowed.

Principal functions of new facilities are as follows :

- reception and radiological characterization of objects, parts, fluid, specimens…
- prepare samples for examinations
- perform the examinations (solid or fluid)
- archive samples and material

- evacuate wastes

Auxiliary functions are also to :

- allow in site maintenance of equipment
- anticipate future extensions
- allow a new layout of premises

Constraints functions are to :

- integrate the defined perimeter on Chinon plant
- master radiological inventory
- master radiological and cleanliness zoning
- protect workers
- interface with plant utilities
- generate his own utilities

4.3 examination equipments

LIDEC will be an integrated laboratory. It will enable to perform in the same place, metallurgical or chemical examinations and mechanical testing.

To illustrate examinations that will be performed, main equipments are listed underneath :

Equipments in hot cells :

- 250 kN hydraulic tensile tester (-180° to 600°)
- 100 kN hydraulic tensile tester (-180° to 600°)
- 100 kN electro mechanical tensile tester (-180° to 600°)
- 2 Charpy pendulum impact testing 300 joules (-180° to 450°)
- 1 profile projector
- 1 micro hardness testing machine
- metallurgical sample preparation equipments
- microscope (with ocular out of cell)
- electron probe micro analyzer
- Scanning Electron Microscope (SEM)
- Electrical Discharge Machining

Most of these equipments can also be used with the shielded hot cells opened (in case of low irradiated specimens).

Equipments out of hot cells :

- X-ray diffraction
- Burst Testing of Steam Generator tubes
- Coordinate measuring machine
- Laser profilometer
- Charpy pendulum impact testing
- metallurgical sample preparation equipments
- microscopes with numerical image system
- Transmission Electron Microscope
- X - radiography
- ICP (inductively coupled plasma)
- carbon & sulfur analyser
- oxygen & nitrogen analyser

Cold Laboratories :

- SEM
- X-ray fluorescence equipment
- metallurgical sample preparation equipments
- microscopes with numerical image system

5. Design options

5.1 Civil works

The LIDEC building is made of reinforced concrete, with an architectural external cladding and vegetal roof. The footprint is approximately 3 500 m² (106 m x 33 m), and 9,6 m height (without chimney and cooling set).

The building has 3 levels :

- basement : technical galleries for liquid effluents collecting (4 tanks: 2x15 m^3 for low activity effluents, 2x5 m^3 for high activity effluents), solid contaminated wastes sorting and storing,
- ground floor : reception, preparation and material assessment,
- first floor : utilities and sample archiving.

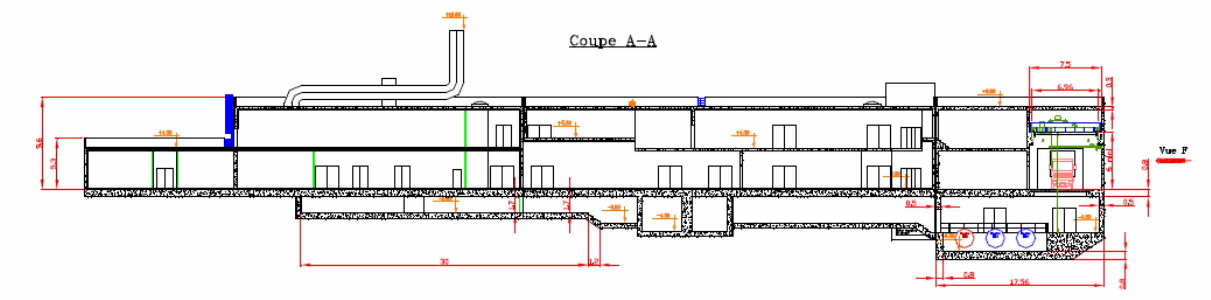


Figure 10 : tranverse cutting of the LIDEC nuclear facilities three levels

Some premises are double levels : reception hall, shielded cells hall.
There are no office in the facility : they are located in a building close to the LIDEC.

The ground floor is separated in two zones (not connected together) :

- cold laboratory for non-radioactive materials (only ground floor on this part of the building),
- hot laboratory for radioactive materials.

Considering the proximity of the substratum (8 m), the LIDEC is based on piles (approximately 200).

The building is designed to resist to extreme weather conditions, earthquake, external explosion, and external flooding.

5.2 Materials reception

The conventional materials arrive by road transport / mail, directly to the conventional laboratory.
The radioactive materials arrive by road transport, in the reception hall. For these materials, there are 3 paths inside the nuclear laboratory :

5.2.1 Reception glove boxes

5 glove boxes connected together receive the low activity materials. The main functions are :

- characterisation
- visual inspection
- decontamination
- cutting

After that, the materials are dispatched to specific assessment workplaces in airproof containers.

The maximum weight / size for the reception glove boxes are 20 kg / 550 mm x 340 mm. It corresponds to approximately 80% of the AMI materials flow.

5.2.2 Exceptional working zone

The exceptional working zone receives the low activity materials that cannot go in reception glove boxes because of their weight or size. In this zone, the materials are cut in order to be accepted in the reception glove boxes.

5.2.3 Shielded hot cells

The shielded hot cells receive high activity materials, in transport casks (R48, TN106, Padirac or specific flasks).

5.3 Shielded hot cells

The LIDEC has 15 shielded hot cells, plus 2 reserved locations for possible future hot cells.

The shielded hot cells are designed with a separation of containment and biological shielding functions :

- a stainless steel containment box assures the static containment,
- a filtered ventilation assures the dynamic containment,
- the concrete surrounding walls of the cells, inside which the containment box is inserted, assures the biological shielding.

The cells are equipped with remote manipulator systems and windows for vision.

The transport cask (R48, TN106, Padirac or specific flask) is accosted to a reception cell.

For biological shielding, the concrete thickness is 70 cm for about half of the cells (walls, floor and ceiling), 110 cm for the other half. The concrete is standard concrete.

The storage cells are designed to resist to earthquake.

All cells have an access to the rear zone (by a shielded door or trapdoor) for equipment installation, maintenance and decontamination of the cell.

Most of cells have an access to the front zone by a shielded door, for the adjustment of equipments, maintenance and introduction of low activity materials. For contaminated materials, the containment box is used as a glove box.

The transfer between cells is done :

- by pneumatic transfer for small parts (diameter max 72 mm),
- by direct transfer between 2 party wall cells, via lateral shielded doors and motorized conveyor belt between the cells,
- with a Padirac cask for equipped cells,
- with an airproof container connected directly to the containment box for low activity materials.

For radioprotection reasons, the activity send able by pneumatic transfer is limited.

5.4 Handling equipments

The main handling equipments in the LIDEC are :

- 2 travelling cranes (20 t), one in reception hall and one in the rear zone of shielded cells (for casks handling),
- 4 monorails, 3 (1 t) in the front zone of shielded cells to extract remote manipulator systems, and 1 (2 t) in the exceptional working area,
- 1 freight elevator to lead to the 3 levels of the building,
-1 forklift.

5.5 Utilities

5.5.1 Ventilation

2 ventilation systems are used in the LIDEC :

- process ventilation : filtered ventilation for shielded cells and glove boxes,
- building ventilation : air conditioning, and filtered ventilation for nuclear laboratory including fume cupboards.

5.5.2 Electrical supply

The LIDEC is powered by 2 sources of 5,5 kV, transformed by 3 voltage transformers (5,5 kV/410V) of 1250 kVA each, with 2 uninterruptible power supply (80 kVA during 1 hour for fragile equipments, and 20 kVA during 8 hours for monitoring).

5.5.3 Fluid supply and evacuation

The LIDEC is supplied with drinkable water, demineralised water and fire extinguishing water (under pressure).
A system assures the production of cold water from drinkable water, for the cooling of equipments.
Sanitary hot water is produced by solar panels on the roof of the LIDEC.

The wastewaters and rainwater are evacuated by site systems. The radioactive effluents are evacuated by tank truck to a treatment facility (outside the site).

5.5.4 Gases

Bottles stored outside the building, in a specific area, supply the gases : nitrogen, oxygen, argon, argon / methane, argon / carbon dioxide, carbon dioxide, helium, SF_6.

Compressed and breathable air are produced by the same system, with 2 secured compressors.

5.5.5 Liquid nitrogen

Liquid nitrogen is supplied from an external tank (3000 l).

6. Operating and maintenance area

6.1 Work station study

One of the objectives of LIDEC design is to improve radioprotection and radiological cleanliness.

In particular, each work station used in AMI is restudied to reach objectives of dose rate and contamination level. It supposes to integrate, since design, cleaning and decontamination tasks and to limit radiological and chemical dissemination.

<u>Analysis</u>

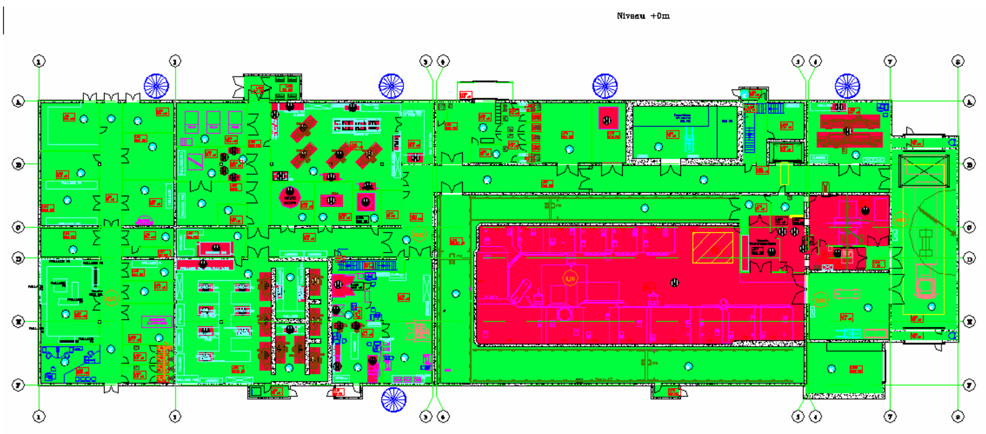
The study of work station is based on a risk analysis approach. Its goal is to identify causes and types of potential accidents and preventive measures to limit frequency and gravity.
The analysis also integrate 40 years AMI experience and some known referential as CEA "practical guide Radio nuclides et radioprotections – EDP science".

Type of work station for integration of equipments is defined depending on radiological characteristics of specimen manipulated.
Irradiated material are examined in watertight hot cells, unirradiated but contaminated material can be used on different types of work station depending on the contamination level :

- glove box and shielded glove box
- sorbonne
- pallet and pallet under air flux
- ventilated cabin

6.2 Cleanliness zoning

Cleanliness is one of major objective of LIDEC project, to minimize nuclear wastes and facilitate access to each place.
Cold laboratories, public zones, utilities premises are without risk of contamination, wastes are conventional zones.
To minimize nuclear wastes, no conventional wastes zones are limited (using confinements) to the very nearest zones around the contamination sources.



Type de Zone	Indication
K Zone à déchets conventionnels	K
N Zone à déchets Nucléaires	N

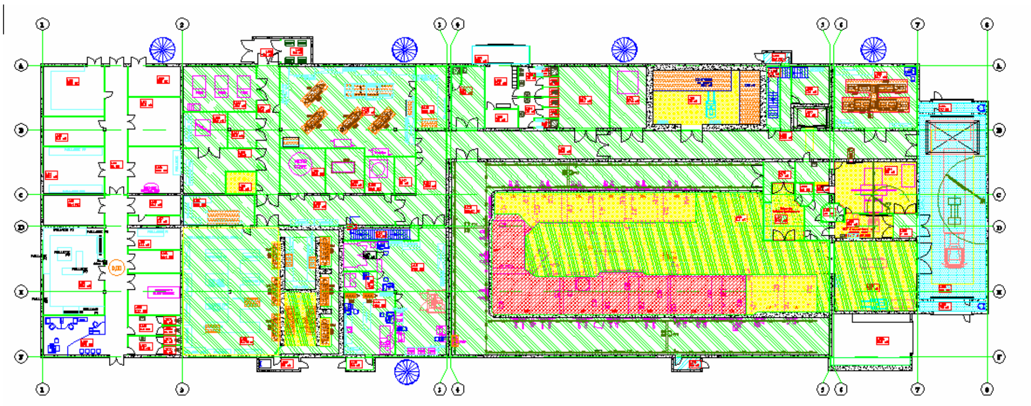
<u>Figure 11</u> : cleanliness zoning

6.3 Radioprotection zoning

Objectives of collective and individual doses bring to design a maximum of zones as "green" that is equivalent to a dose rate lower than 25 μSv/h, except for exceptional working zone.

Steps of reception, visual observation, machining, decontamination are regrouped in a dedicated room, in shielded glove box unit. It enables to protect workers effectively from main exposure operations.
In chemical laboratory, dose rates around some work stations are still high. So, to limit impact on neighbor, work stations have been separated by concrete wall.

Public area will be all accessible from outside of the building. It will simplify maintenance operations, for example.



Type de Zone	Prescriptions EDF	Indication
Limite de Zone P "Zone dite public" à l'intérieur du site	ddd<2,5 µSv/h	
Zone surveillée	2,5 µSv/h<ddd<7,5 µSv/h	
Zone contrôlée	ddd>7,5 µSv/h	
Zone verte	7,5 µSv/h<ddd<25 µSv/h	
Zone jaune	25 µSv/h<ddd<2000 µSv/h	
Zone orange	2 mSv/h<ddd<100 mSv/h	
Zone rouge	ddd>100 mSv/h	

Figure 12 : radioprotection zoning

7. Conclusion

Decision to definitely stop AMI Chinon nuclear facilities before 2015 have been taken by EDF in 2006. In substitution, EDF has decided to build new nuclear facilities, called LIDEC, also located on NPP of Chinon and commissioned before end of 2011. The status of these new facilities will be different to AMI ones, due to no fuel examinations and a strict following of radiological inventory for examinations.

For the beginning of seventies, AMI nuclear facilities have developed an important feedback analysis in the field of damage mechanisms on different materials and equipments. These competencies are considered absolutely necessary for EDF in the future, in a context where EDF ambitions are to increase as long as possible his PWR plants life assessment and to be a major actor in civil nuclear restart.

Needs expression (prescriptive and functional fields) for LIDEC nuclear facilities are presented. Design options, operating and maintenance area are also described.