Experience of management of radioactive waste issued from dismantling activities in France: waste zoning, sorting and incineration of combustible radioactive waste, melting and recycling of metallic radioactive waste

Christian DEREJEL, IRSN, France

1 Abstract

The French nuclear industry in France has gathered a lot of experience in operation and dismantling of nuclear installations (NPPs, laboratories, nuclear submarines) and managing of radioactive waste (treatment by incineration and melting and conditioning (SOCODEI activities), disposal (ANDRA activities)).

According to international standards, France has established a comprehensive set of rules concerning the operation and the dismantling of nuclear installations.

These rules contain a lot of provisions concerning radioactive and non radioactive waste management (waste zoning inside nuclear installations, acceptance criteria for radioactive waste packages in the French disposal centres for low-level and very-low-level waste, obligation for waste producers to reduce the volume of waste produced and to recycle with the aim to minimize the quantity of ultimate waste to be disposed).

As of the early 1990’s, the national French electricity producer EDF and the French Company COGEMA (reprocessing of spent nuclear fuel) clearly demonstrated their determination to acquire the industrial means necessary to face the challenges raised by the management of waste produced by operation and dismantling of nuclear installations with the creation of SOCODEI (French Society for industrial Waste treatment).

SOCODEI was assigned the missions of designing, building, financing and the operating the installations for the treatment of low-level and intermediate-level radioactive waste.

Accordingly, since 1999, SOCODEI has operated the basic nuclear installation CENTRACO (Nuclear Waste Treatment and Conditioning Plant dedicated to very low level and low level radioactive waste) located near the Marcoule site (Rhone valley). CENTRACO contains, on a single site, an incineration unit for burning liquid and solid waste, a melting facility for metallic waste and a recycling unit for scrap metal.

The institute for Radiological Protection and Nuclear Safety (IRSN), in support to French and foreign Nuclear Safety Authorities (NSA), assesses nuclear safety reports established by operators in support to licensing request for design, building, operation and dismantling of nuclear installations.

For example, IRSN assessed nuclear safety reports concerning decommissioning operations of following installations:
- French NPP’s (graphite-gas reactors …),
- French nuclear submarines,
- Foreign NPP’s (feasibility studies for the decommissioning of KOZLODUY 1 and 2 in Bulgaria), INGALINA in Lithuania), as well as the nuclear safety reports for the licensing of the CENTRACO facility.

2 Specificity of decommissioning and dismantling (D&D) activities

2.1 General remarks

D&D operations are characterised by intensive work inside a nuclear installation with many workers involved, some of them not accustomed to the work in nuclear installations and activities not covered by the standard operation procedures of the nuclear installation. It means nuclear risks (irradiation by alpha, beta, gamma and neutron emitters, contamination, criticality) and conventional risks (fire, accidents, toxicity, exposure to chemical substances, and so on).

For these reasons, the safety of D&D operations has to be presented in the D&D nuclear safety reports established by the operators in support to the licensing request sent to the nuclear safety authority (NSA) and must be assessed on following aspects:

- radiological protection (mainly risks of contamination induced by cutting operations),
- containment of radioactive substances (static or dynamic containment by existing and specific devices (if necessary temporary on place ventilated tenting)),
- environmental protection (radioactive and non-radioactive waste processing, conditioning and temporary storage or disposal, control of gaseous and liquid effluents releases and limitation according to release licenses issued by the Nuclear Safety Authority),
- fire, chemical and toxicity hazards prevention.

2.2 Specificity of dismantling of nuclear surface ships and support ships of the nuclear fleet in the Russian Federation

According to information available, one should take in consideration following remarks.

1- On board nuclear surface ships the boundaries of “nuclear compartments” are not so strictly established as on board submarines (larger compartments, no pressure hull, boundaries of the reactors compartment being part of the structure of the hull, may be excluding the possibility to cut out the reactors compartment as a whole).

2- On board support ships, the containment of radioactive material is probably not as clearly defined as on board vessels with nuclear reactors.

3- Some ships are old and poorly maintained; it means probably a loss of knowledge concerning the exact situation of the ship itself (status of security and ventilation installations, status of installations dedicated to the containment of radioactive material and clear inventory of nuclear material present on board); the existence of a skilled work craft for the operations on board support ships has to be verified.

2.3 D&D activities and waste management

The dismantling of vessels equipped with nuclear reactors or used for the support of nuclear vessels (collection and temporary storage of spent fuel, of liquid and solid radioactive waste, workshops for the maintenance and repair of reactor’s equipments) will produce large amounts of radioactive waste.
Actually, the fate of long lived and high activity waste is not clearly determined and the temporary storage in safe conditions of such waste is the to-day solution:
- temporary storage of the reactors compartments of submarines as a whole,
- wet or dry temporary storage of spent fuel if not reprocessed,
- temporary storage of conditioned (embedded or vitrified high level waste).

Researches are underway in many countries for the determination of the optimal solution with laboratories for the study of subsurface or deep geological disposals.

Concerning the management of short lived low-level waste, different solutions exist and are in use on industrial level (compacting, incinerating, conditioning of solid waste, treatment of liquid waste, melting of metallic waste).

These solutions have to be optimized in order to reduce the quantity of ultimate waste to be disposed.

3 French experience

3.1 Regulatory framework

According to the IAEA and ICRP recommendations, the EURATOM and European Community guidelines and regulations, French laws have been passed concerning radiological protection of public and workers, air and water protection, waste management and rules to be followed for pollution-prevention.

Concerning the operation and dismantling of nuclear installations, one of the most important documents is the decree of December 31st 1999 issued by the ministry of Industry and Environmental Protection which gives the technical prescriptions to be followed “in order to prevent and limit the harmful effects and external risks induced by the operation of “basic” nuclear installations (INB)”.

For example, in case of D&D operations, these prescriptions concern following items:
- the prevention of nuclear risks (irradiation, contamination, criticality) in order to protect the environment and the workers,
- the prevention of risks induced by waste; for this purpose the “operating entity” has to identify inside the installation two kinds of zones, namely zones producing conventional (non-radioactive) waste and zones producing radioactive waste,
- the establishment and the assessment of a “waste management report” which presents measures taken for waste collection, waste sorting, techniques selected for waste conditioning, interim and final storage of waste and which predicts the yearly trough-out,
- measures taken for conventional risks prevention (fire, chemical and toxic substances), for noise and vibration prevention, for air and water pollution prevention.

---

1 In France, installations containing or using radioactive material are classified as “ICPE”. If the amount of radioactive material inside the installation is significant, the ICPE is classified as an “INB”. Specific rules in the field of nuclear security and nuclear safety are to be followed for the operation of INBs. An “INB” working for the ministry of Defence is called a “secret INB” (INBS).
The corresponding reports must be assessed and approved by the NSA prior to D&D operation start-up.

According to the “principle of precaution”, the exemption limits of EURATOM directive 96/29 are not applied in France.

It means that waste produced in a zone producing nuclear waste cannot be considered as “conventional” even if the activity after measuring is under the detection limit and under the exemption limit of the EURATOM directive. It is a French specificity and it limits the possibility of recycling very low activity radioactive waste (obligation to send such waste to a disposal facility dedicated to very low level waste).

### 3.2 Implementation of the French regulation concerning waste zoning for the decommissioning of submarines

The implementation of the waste zoning by the operators on board a submarine under decommissioning is made in following manners, taking in consideration the past activities on board the submarine (including incidents which occurred) and the actual activities:

1. **Zones with conventional waste**: the operator delimits to kinds of zones:
   1. **Non-contaminating zone**: it means a zone where radioactive material and/or radioactive contamination was present in the past but which has been “cleaned” (removal of radioactive material, decontamination), for example reactor’s auxiliary rooms,
   2. **Zone without added contamination**: it means a zone where radioactive material was never present, for example operational centre, living quarters of the crew,

2. **Zones with radioactive waste**: the operator delimits on board “contaminating zones”, it means zones where the production of radioactive waste with high, low or very low activity is possible due to the actual presence of radioactive material (reactor’s compartment, temporary zones when cutting for example a pipe which contained primary coolant inside a zone classified as “non-contaminating zone”).

The following schemes summarize the organisation used for waste management and environmental protection:
This organisation aims to prevent a dissemination of contamination and a mix between conventional and radioactive waste (separate channels for control, conditioning and transport).

3.3 IRSN experience feedback

The experience of previous assessments of nuclear safety reports concerning dismantling activities in France and in foreign countries allows IRSN to learn following lessons:

1- It is necessary to underline the particularities of installations under dismantling process:
   - workers not accustomed to deal with radioactive material could be present in rooms where radioactive products are present and they could even handle some of them,
   - spread of contamination may occur not only during accidental situations but also during normal operations (cutting of contaminated material, sorting out or conditioning of radioactive waste, ...),
   - very high radiotoxic nuclides could be present, they can be dangerous even with a very low concentration in the air (alpha emitters) ; for example, 0,1 Bq of Pu per cubic meter of air would lead to an integrated dose per inhalation of 20 mSv/year,
   - for these reasons, it is necessary to focus on the releases outside the installation into the environment but also inside in rooms where workers are located.

2- On the step of the first studies concerning the dismantling of an installation, it is necessary to identify the risk of spread of contamination during normal operations and to design prevention, detection, and mitigation means.

It is also necessary to analyse incidental and accidental situations and their consequences on safety functions dedicated to the containment of radioactive material:
   - evaluation of the occurrence of such situations (eventually probabilistic assessment),
   - analysis of the completeness of the basic design situations considered,
   - analysis of the behaviour of barriers and systems taking part to the containment of radioactive material (safety functions),
   - analysis of the consequences of such situations:
     - impact on the barriers,
     - calculation of consequences inside the installation (dose for workers),
     - calculation of consequences outside the installation (dose for public).
3- During the D&D operations, the operator must send incident reports to the NSA and these reports must be assessed in order to verify if it is necessary to improve the working procedures or the technical installations used for D&D activities.

### 3.4 Management of combustible and metallic low-level radioactive waste in France

As of the early 1990’s, the national French electricity producer EDF and the French Company COGEMA (reprocessing of spent nuclear fuel) clearly demonstrated their determination to acquire the industrial means necessary to face the challenges raised by the management of waste produced by operation and dismantling of nuclear installations with the creation of SOCODEI (French Society for industrial Waste treatment).

SOCODEI was assigned the missions of designing, building, financing and the operating the installations for the treatment of low-level and intermediate-level radioactive waste.

Accordingly, since 1999, SOCODEI has operated the basic nuclear installation CENTRACO (Nuclear Waste Treatment and Conditioning Plant dedicated to very low level and low level waste) located near the Marcoule site (Rhone valley). CENTRACO contains, on a single site, an incineration unit for burning liquid and solid waste, a melting facility for metallic waste and a recycling unit for scrap metal.

#### 3.4.1 Waste forms processed by CENTRACO

The waste processed by SOCODEI at CENTRACO includes three distinct types: scrap metal, combustible solid waste and liquid waste.

**Metallic waste** is produced mainly by outage and dismantling operations, and consists largely of stainless steel, carbon steel and, to a lesser extent non-ferrous metals. They are shipped to CENTRACO in metal drums or metal boxes, in containers in compliance with applicable regulations for transporting hazardous materials.

**Combustible solid waste**, consisting primarily of technical waste, resins and wood, is compacted when possible by the waste producers and shipped in metal or incinerable drums.

**Aqueous or organic liquid waste** such as chemical scrubbing solutions, evaporator concentrates, oils and solvents, are shipped to CENTRACO in tanks or metal drums.

Physical, chemical, dimensional, metallurgical and radiological acceptance criteria are specified for each type of incoming waste:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Melting</th>
<th>Incineration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum specific activity</td>
<td>$\beta\gamma$ emitters: 20 000 Bq/g</td>
<td>$\beta\gamma$ emitters: 20 000 Bq/g</td>
</tr>
<tr>
<td></td>
<td>$\alpha$ emitters: 370 Bq/g</td>
<td>$\alpha$ emitters: 370 Bq/g for solid waste</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 Bq/g for liquid waste</td>
</tr>
<tr>
<td>Chemical</td>
<td></td>
<td>Chlorine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sulphur</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Halogens (fluorine)</td>
</tr>
<tr>
<td>Metallurgical</td>
<td>Carbon and stainless steel</td>
<td>Metal or incinerable drums in 20’ containers</td>
</tr>
<tr>
<td></td>
<td>Non ferrous 5%</td>
<td>and different types of tanks</td>
</tr>
<tr>
<td>Conditioning</td>
<td>Metal drums or boxes in 20’ ISO containers</td>
<td></td>
</tr>
</tbody>
</table>

Deregel-eng
3.4.2 Final waste package allocation

In the CENTRACO feed stream, SOCODEI mixes together the waste received from all French customers.

Final packages resulting from treatment are the following:
- 200 litres ingots, from melting,
- 400 litres drums with embedded bottom and fly ashes, from incineration,
- m3 containers and 200 litres drums for ultimate process waste that cannot be reprocessed in CENTRACO (refractory, metal bath slag, filters…).

The resulting waste is proportionally allocated among the producers who supplied solid waste for that melting or incineration. No final packages are allocated for incineration of liquid waste.

All process and maintenance waste packages produced by processing are also allocated to producers in accordance with the activity contained in the waste sent to CENTRACO (the waste producer keeps the “ownership” of the waste he produces).

According to the design license of CENTRACO (ministerial order n° 96-761 of 27 August 1996), waste received from foreign customers (actually about 5% of the waste processed in CENTRACO) will be processed in specific campaigns and returned to the producer after conditioning.

SOCODEI plays the role of transformer and processing intermediary. Its customers retain the ownership of the incoming and outgoing products, while SOCODEI produces final waste packages acceptable by ANDRA and suitable for shipment to the disposal site in compliance with applicable regulations (AUBE Centre for LLW and ILW and Morvilliers Centre for VLLW).

3.4.3 Incineration of combustible waste

3.4.3.1 Objectives and scope

The CENTRACO incineration unit is designed to process short-lived low-level radioactive combustible solid and liquid waste produced in nuclear installations, laboratories and hospitals including:
- coveralls, gloves and over boots,
- ion exchange resins and filters,
- oils, concentrates and scrubbing or decontamination solutions.

SOCODEI takes charge of processing the waste and reallocates it to customers after conditioning. This procedure is part of the comprehensive low-level waste processing mission of CENTRACO, in conjunction with its metal waste melting facility.
3.4.3.2 Description of service

The overall incineration service comprises:
- reception and interim storage of waste packages,
- reconditioning (notably grinding, compaction and baling of solid waste),
- incineration of the reconditioned waste,
- encapsulation of incineration ashes and clinker in hydraulic binder (called IAF process), and conditioning in 400 liter shielded metal drums,
- reallocation and assignment of finished products.

3.4.3.3 Throughout capacity

The throughout capacity of the incineration unit is up to 5 000 metric tons per year (including 1 500 metric tons of liquid waste), 1 000 kg/hour.

3.4.3.4 Finished products

The IAF\(^2\) packages consist of fly and earth ashes immobilized by a hydraulic matrix in a 400-liter metal shielded drum 30 mm thick (biological protection).

The volume reduction factor of incinerated and conditioned waste reaches up to 20 (average 14). Taking in account radioactive waste generated by the operation of the incineration unit (maintenance activities - periodic replacement of filters and refractory coating of the incineration unit, fumes and liquid releases treatment), the average volume reduction factor is 9 to 13 depending on the density of the waste sent by waste producers.

\(^2\) IAF: Inertage A Froid (immobilization in an hydraulic binder)
3.4.3.5 SOCODEI commitment and main references
SOCODEI holds contracts for processing waste by EDF (French Electricity producer), COGEMA facilities (reprocessing of spent nuclear fuel), ANDRA small waste producers department, CEA and GNS for waste coming from research and medicine activities.

3.4.4 Melting of metallic waste

3.4.4.1 Objectives and scope
The CENTRACO melting unit is designed to process short-lived low-level radioactive metal waste produced in nuclear installations during routine operation, during process maintenance and refurbishing activities, or by dismantling of nuclear facilities.

SOCODEI takes charge of processing waste and reallocates it to customers after conditioning; this procedure is part of the comprehensive waste processing mission of CENTRACO, in conjunction with its combustible solid and liquid waste incineration facility.

3.4.4.2 Description of service
The overall melting service for metal waste comprises:
- reception of waste packages,
- waste sorting according to metallurgical criteria,
- preparation (cutting, shot blasting, oven drying),
- resizing of large items,
- melting down into ingots or recycled products,
- reallocation and assignment of finished products.

3.4.4.3 Throughout capacity
The throughout capacity of the melting facility is of 4 500 metric tons per year (3 shifts per day) and 8 metric tons per shift (4 metric tons at once).
3.4.4.4 Melting products

3.4.4.4.1 Standard products

The standard products produced by the melting facility are ingots ready for disposal, clinker and ashes encapsulated in hydraulic binder and conditioned in shielded metal drums and tubes produced by centrifugation.

The waste volume can be reduced by a factor up to 10 for ingots and up to 20 for tubes (average 6 to 10) and is reduced to 5 to 6 by taking in consideration the radioactive waste produced by the operation of the melting and centrifugation units (shotblasting, cleaning residues, periodic replacement of filters and refractory coating of melting and centrifugation equipments, maintenance).

3.4.4.4.2 Reusable products

Reusable products are fabricated from centrifuged tubes.

3.4.4.4.2.1 Objectives and scope

SOCODEI has the assigned objective of recycling a maximum of the steel processed at CENTRACO.

This objective is warranted by economic considerations – scrap steel constitutes a reusable raw material - and covered by a legal framework–legislation passed by the French parliament in July 1992 requires industrial firms to recycle their waste and restricts the disposal of all but ultimate waste forms-subject to mandatory compliance with stringent safety and radiological protection standards.

3.4.4.4.2.2 Manufactured products

SOCODEI fabricates a line of manufactured products for the nuclear industry to meet the needs of nuclear operators:

- integral radiological shields consisting of a cylinder 100 cm diameter, 100 cm height, 4 to 7 cm thickness with upper and lower covers made from non radioactive steel; these shields are designed for incorporation in concrete containers to form shielded containers (storage of medium-level waste);
- shielded metal drums have a diameter of 70 cm and an height of 110 cm, a thickness of 3 cm with upper and lower covers made from non radioactive covers.

These products correspond to currently identified needs for which a market exists.

CENTRACO includes all the facilities necessary to assemble these manufactured products. SOCODEI is thus able to study the manufacturing of any other type of recycled product to meet customer-specific needs.
Actually, at CENTRACO, SOCODEI fabricates:
- shielded containers used in conjunction with the Mercure mobile conditioning unit to condition ion exchange resins from the primary cooling systems of EDF power reactors,
- drums used for encapsulating and conditioning of fly and earth ashes produced in the CENTRACO incineration unit.

### 3.4.4.2.3 Description of service

SOCODEI provides the following services for steel melted down at CENTRACO:
- recycling by centrifugation,
- cleaning and surface preparation (cooling, cutting, and shotblasting),
- assembly and fabrication of finished products,
- preparation for shipment.

### 3.4.4.5 SOCODEI commitment and main references

SOCODEI holds contracts for processing metallic waste produced by nuclear power stations operated by EDF (including waste resulting from dismantling of the G2 and G3 gas cooled reactors at Marcoule) and by COGEMA facilities (reprocessing of spent nuclear fuel).

Concerning reusable products, SOCODEI works in close collaboration with its customers (EDF, CENTRACO) to design products that meet their individual needs.

The products recycled by CENTRACO are fabricated under a Quality Assurance program complying with the ISO 9001 standard.

### 3.4.5 Experience feed-back of CENTRACO operation since 1999

#### 3.4.5.1 Statistics

The CENTRACO installation has been in operation since 1999 with an increasing processing capacity:
Waste incinerated in CENTRACO from 1999 up to the end of 2004 (metric tons)

<table>
<thead>
<tr>
<th></th>
<th>Solid waste</th>
<th>Ion exchange resins</th>
<th>Aqueous liquids (concentrates, scrubbing and decontamination solutions, ...)</th>
<th>Organic liquids (solvents, oils, ...)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8 800</td>
<td>660</td>
<td>1 940</td>
<td>10 800</td>
<td>13 200</td>
</tr>
</tbody>
</table>

Waste melted in CENTRACO from 1999 up to the end of 2004 (metric tons)

<table>
<thead>
<tr>
<th></th>
<th>Carbon steel</th>
<th>Stainless steel</th>
<th>Non ferrous</th>
<th>Scrap recycled</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7 000</td>
<td>3 040</td>
<td>65</td>
<td>95</td>
<td>10 200</td>
</tr>
</tbody>
</table>

Radioactive waste produced by the operation of CENTRACO per year

<table>
<thead>
<tr>
<th></th>
<th>Carbon steel</th>
<th>Stainless steel</th>
<th>Non ferrous</th>
<th>Scrap recycled</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shotblasting, cleaning residues, filters, …</td>
<td>50 to 70 tons</td>
<td>50 to 100 tons</td>
<td>50 to 100 tons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refractory coating of incineration equipments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refractory coating of melting and recycling equipments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Activity of waste received in CENTRACO – figures 2002)

<table>
<thead>
<tr>
<th>Waste delivered</th>
<th>Total activity (GBq)</th>
<th>Specific activity (Bq/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>α</td>
<td>βγ</td>
</tr>
<tr>
<td>Solid waste</td>
<td>0,8</td>
<td>1 537</td>
</tr>
<tr>
<td>Liquid waste</td>
<td>0,2</td>
<td>1 240</td>
</tr>
<tr>
<td>Metal waste</td>
<td>0,0</td>
<td>395</td>
</tr>
<tr>
<td>Total</td>
<td>1,0</td>
<td>3 172</td>
</tr>
</tbody>
</table>

Activity distribution in final products in %

<table>
<thead>
<tr>
<th></th>
<th>α</th>
<th>βγ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incineration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinker</td>
<td>84%</td>
<td>44%</td>
</tr>
<tr>
<td>Ashes</td>
<td>16%</td>
<td>56%</td>
</tr>
<tr>
<td>Melting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal bath</td>
<td>23%</td>
<td>83%</td>
</tr>
<tr>
<td>Slag</td>
<td>76%</td>
<td>9%</td>
</tr>
<tr>
<td>Dust</td>
<td>1%</td>
<td>8%</td>
</tr>
</tbody>
</table>

The α emitters are concentrated in clinker for the incineration unit and in slag for the melting unit.

It appears that, concerning metallic radioactive waste, the melting process has a good decontamination power concerning alpha emitters (around 75%) and a limited one concerning βγ emitter (around 15%).

3 Slag : residue which floats on the surface of the melted metal.

3.4.5.2 Licensing

According to the French regulation, the operator presented nuclear safety reports in order to obtain the design license, the building license and the operation license.

These nuclear safety reports have been reviewed by IRSN acting as technical support of the French Nuclear Safety Authority\(^4\) for civil installations (DGSNR).

One remark of IRSN concerning the direct uncontrolled release in the environment of fumes without filtration in case of an emergency inside the incineration facility conducted to a modification of the fumes treatment of the incineration unit.

\(^3\) Slag : residue which floats on the surface of the melted metal.

\(^4\) IRSN works as technical support for the Nuclear Safety Authority (DGSNR) in charge of civil nuclear installations and for the Nuclear safety Authority (DSND) in charge of nuclear installations related to defence.
Other remarks concerned the radiological protection of workers (lack of indications concerning the implementation of the ALARA principle in operation and high exposure of workers in some working places); the operator modified these working places and the corresponding operative procedures.

According to these remarks and to the conclusions of the permanent group of experts which reviewed the first version of the safety assessment report produced in support to the application for the operation license of CENTRACO in 1997, the DGSNR decided to postpone the delivery of the license up to the production of a new safety assessment report taking in account the corrective measures; this report was reviewed one year later and the Nuclear safety Authority issued the operation license.

3.4.5.3 Impact

3.4.5.3.1 Radiological environmental impact
The CENTRACO nuclear installation has to comply with the French regulations concerning radiological protection of public and workers (ICRP 60 limits) and with the radiological effluent release limits fixed in the license for the operation of the facility.

According to the environmental impact assessment of the effluent releases of CENTRACO presented in support to the license request, 100% of the radioactive releases authorised per year would conduct to a dose for public located within 1 km from the facility of 0,03 mSv/year (to be compared to ICRP limit of 1 mSv/year).

The effective radioactive releases of CENTRACO are much lower than the authorized ones, excepted for tritium in gaseous effluents (review of the license underway according to the very low level of tritium releases in liquid effluents) and Alpha emitters.

Concerning Alpha emitters, no detection over the detection limit of the measurement devices used has been registered. The activities declared correspond to the volume of liquid and gaseous releases multiplied by the detection limit.

<table>
<thead>
<tr>
<th>Radioactive releases in GBq</th>
<th>Tritium</th>
<th>Cs 137</th>
<th>C 14</th>
<th>Other βγ emitters</th>
<th>Alpha emitters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid effluents</td>
<td>authorized</td>
<td>10 000</td>
<td>4</td>
<td>26</td>
<td>0,006</td>
</tr>
<tr>
<td></td>
<td>Realised 2003</td>
<td>1,68%</td>
<td>0,26%</td>
<td>5,92%</td>
<td>58,67%</td>
</tr>
<tr>
<td>Gaseous effluents</td>
<td>authorized</td>
<td>2 000</td>
<td>2 000</td>
<td>1</td>
<td>0,0002</td>
</tr>
<tr>
<td></td>
<td>Realised 2003</td>
<td>54,6%</td>
<td>0,87%</td>
<td>0,31%</td>
<td>39,53%</td>
</tr>
</tbody>
</table>

The impact of the radiological releases of CENTRACO is equivalent to 5% or the natural radiological background of the site.

3.4.5.3.2 Radiological impact on workers
Due to the design of the installation and to the use of insulation masks and protective suits in areas with potential atmospheric contamination), the main risks are external irradiation.

The results obtained in 2003 for external irradiation are the following ones:
### All doses in mSv/year

<table>
<thead>
<tr>
<th>Total number of workers involved</th>
<th>Annual collective dose</th>
<th>Average annual individual dose</th>
<th>Maximal annual individual dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200</td>
<td>500</td>
<td>0.4 to 0.5</td>
<td>5 to 6</td>
</tr>
</tbody>
</table>

These results are to be compared to following limits:
- annual average individual dose < 5mSv/year (CENTRACO objective),
- maximal individual dose < 20 mSv/year (ICRP 60).

About 60% of the exposition is due to maintenance activities, mainly cleaning of the incineration and melting furnaces and replacement of their refractory coating.

### 3.4.5.3.3 Chemical impact

As for radiological effluents, CENTRACO has to stick to global yearly limits and limits of concentration per cubic meter fixed in the license for the release of chemical substances in the environment.

Concerning liquid releases, these limits concern chlorine, sodium and sulphate as well as limits for the releases of the sewage water treatment installation. Concerning gaseous releases (fumes), they concern hydrochloric acid, carbon monoxide, sulphur dioxide, dioxin (with very low limits) and furan.

### 3.4.5.4 Difficulties

As for each nuclear installation, CENTRACO has to face a lot of difficulties. Some of them are presented.

#### 3.4.5.4.1 CENTRACO is a “prototype”

In spite of its industrial operation, the CENTRACO facility is a “prototype (new processes) and is obliged to adapt its installations to the requests and the needs of waste producers.

For example, the CENTRACO facility was initially designed for an automatically feeding of the incineration furnace (combustible waste conditioned in incinerable drums). But waste producers are reluctant to send such waste in incinerable drums due to fire security concerns and too many metallic pieces are mixed in the waste.

For this reason, CENTRACO has been obliged to modify the process by including a strict control of the incoming combustible waste with sorting (detection and elimination of metallic pieces) and reconditioning in incinerable drums.

#### 3.4.5.4.2 Difficulties concerning the incoming waste

As illustrated above, one of the major difficulties encountered by CENTRACO concerns the real characteristics of incoming wastes (physicochemical characteristics, activity) due to differences between the declarations of waste producers and the reality. This can oblige to stop a process line (water contained inside metallic pieces sent for melting due to the risk of explosion) or a line of the sorting workshops (activity higher than declared and exceeding the licensed limits for the workshop used).
3.4.5.4.3 Nuclear safety culture
The major part of the CENTRACO work craft is issued from the iron and steel industry and was not aware, at the beginning, of the operation of the facility, of the specificities of the work in a nuclear installation (constraints regarding nuclear safety and radiological protection).

It has been necessary to train these people and to verify by inspections their knowledge in nuclear safety and radiological protection.

3.4.5.4.4 Public acceptance
In the field of public acceptance, CENTRACO concentrates the negative image of a nuclear installation and of an industrial facility which incinerates waste.

An important communication policy of the staff of CENTRACO has been established, based on openness, local information cells, communication centre, public visits, yearly public report on the survey of the environmental impact, close contacts with the local administration and the media.

4 Conclusion
The operation of the CENTRACO facility in France since 1999 demonstrates the possibility to treat low-level radioactive waste with proven industrial processes which allow reducing the volumes and storing chemically stable final waste.

The volume reduction, the conditioning and the precise characterisation of final packages resulting of the process implemented by SOCODEI in CENTRACO optimise the various networks available for waste producers, lying upstream of storage centres.

The building of such facilities in the Russian Federation, or the adaptation of existing facilities, would be an important contribution to the solution of the management of the important volumes of combustible and metallic radioactive waste which will be produced in the coming years by the increasing of decommissioning activities.

If the laws of the Russian Federation allow the use of exemption limits, the recycling of important quantities of low level radioactive waste generated by the dismantling of ships and metallic parts of nuclear installations would be possible.

More information?
- IRSN website www.irsn.org
- SOCODEI website www.socodei.fr

Contact persons in IRSN:
- International relations department Christian.deregel@irsn.fr,
- Safety of plants, laboratories, transports and waste division, laboratories, irradiators, accelerators and under-decommissioning reactors department veronique.leroyer@irsn.fr

Contact persons in SOCODEI
- Financial and commercial director julien.faugieres@socodei.fr
- Commercial engineer jean-francois.rives@socodei.fr

**References:**

2. CENTRACO nuclear safety annual report 2003 sent to the French Nuclear safety Authority, copy to IRSN (DGSNR) DDX/V5-4.1429 (SQE 9.3) of August 9 2004
3. CENTRACO information sheets for public information
4. CENTRACO public annual report 2002