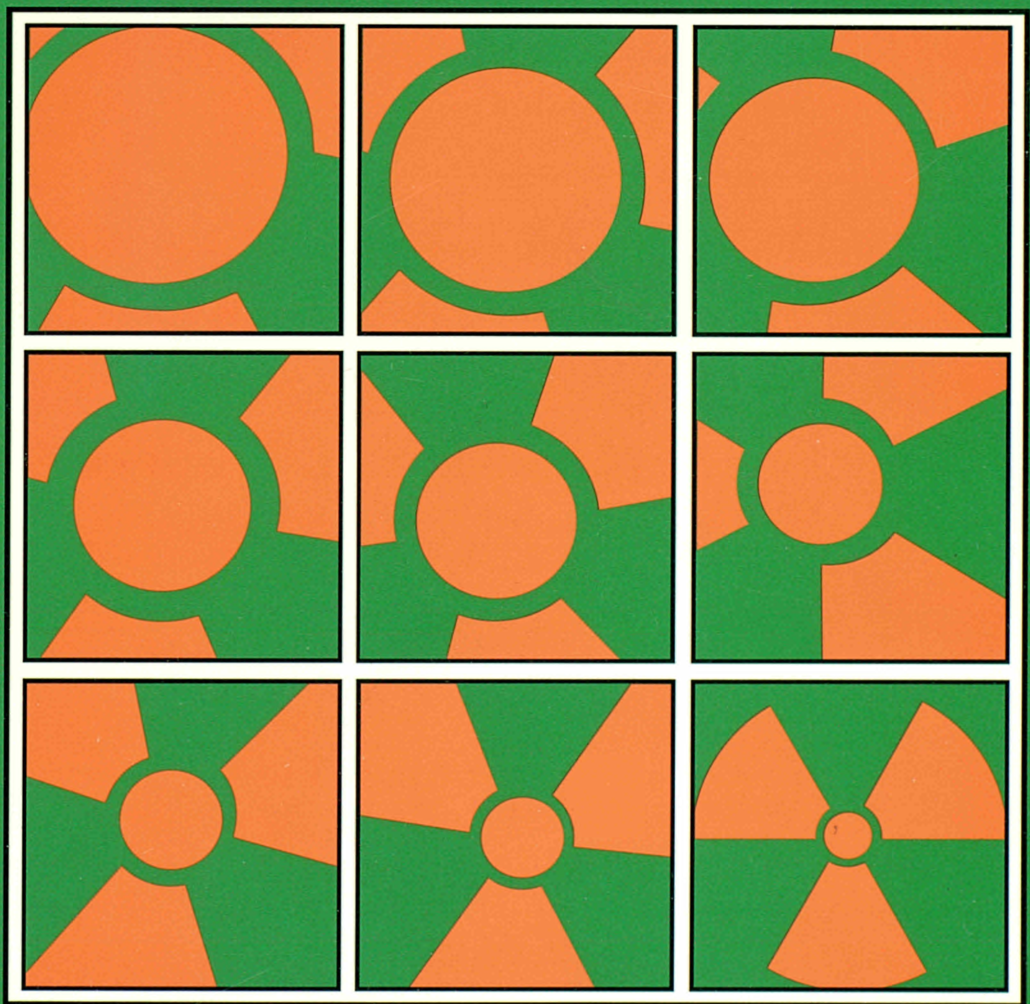
ISSN 1018-5593

European Commission

nuclear science and technology

A review of the situation of decommissioning of nuclear installations in Europe



Report

EUR 17622 EN

European Commission

nuclear science and technology

A review of the situation of decommissioning of nuclear installations in Europe

M. W. Davies

NNC Limited
Booths Hall, Chelford Road
Knutsford, Cheshire, WA16 8QS
United Kingdom

P. J. G. Stoor – AEA Technology
P. Neuhold – ANSALDO
J. M. Dufaud/A. Digiacomi – CEA UDIN
O. Mehling – DETEC
I. Marcelles – Tecnatom

Contract No ETNU-CT94-0123

Final report

Directorate-General
Environment, Nuclear Safety and Civil Protection

1997 EUR 17622 EN

LEGAL NOTICE

Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of the following information)

A great deal of additional information on the European Union is available on the Internet.
It can be accessed through the Europa server (http://europa.eu.int)

Cataloguing data can be found at the end of this publication

Luxembourg: Office for Official Publications of the European Communities, 1997

ISBN 92-828-0192-6

Printed in Luxembourg

CONTENTS

1. INTRODUCTION

A considerable number of nuclear power plants have been built in the European Community since the 1950s ranging from low power materials test reactors, through various medium power prototype/experimental reactors, up to high power commercial stations. In addition, there are a number of fuel fabrication and reprocessing plants associated with the nuclear fuel cycle. Many of these facilities have reached the end of their operating lives and have therefore been withdrawn from service. A list of these nuclear installations, which had been shut down up to and including 1992, and which were being decommissioned, has already been produced /1/.

Decommissioning is the process by which a shut down facility is reduced in size leading, sooner or later, to the complete removal of the radioactive inventory, and thereby, the need for further monitoring and inspection. The process of decommissioning is conveniently divided into three stages and these are described in more detail in § 2. In many cases, the installation will be placed in a Care & Maintenance (C&M) state, and so decommissioning programmes can extend for many decades. Appropriate monitoring and inspection measures will still be needed at a decommissioning site as long as a potential nuclear hazards remain.

A study has been carried out on nuclear facilities being decommissioned in 5 member countries, namely France, Germany, Italy, Spain and the United Kingdom. The organisations which participated in the study, providing information relating to their own country, or their own responsibilities within that country, were the Commissariat a l'Energy Atomique (France), DETEC (Germany), ANSALDO (Italy), TECNATOM (Spain) and NNC/AEA Technology (UK). The purpose of the study has been to:

1. Update the list given in /1/ to include additional nuclear installations shut down in the European Community between 1993 and 1995.
2. Provide information on the decommissioning stage attained at each installation covered and its planned future state. This includes whether or not the facility has been defuelled, what operational wastes remain and what the extent of the radiologically controlled area(s) is.
3. Identify the monitoring and inspection proposals/experience for these installations including where possible the effort involved.
4. Identify relevant codes and standards applicable to decommissioning in member states and to identify where available the relevant licensing requirements.

The objective of this report is to describe and discuss the findings of the study. Chapter 2 gives the three stages of decommissioning as defined by the International Atomic Energy Agency (IAEA), together with the general decommissioning plans and policies and responsible organisations within each country. Chapter 3 gives a summary and description of nuclear installations currently being decommissioned. Chapter 4 provides a summary of the monitoring, inspection and maintenance activities at these installations and Chapter 5 reports on occupational exposure limits and the classification of wastes in each country. Relevant codes and standards are summarised in Chapter 6 and licensing requirements in Chapter 7. Conclusions and recommendations drawn from the study are presented in Chapter 8. The report is completed by five annexes which provide additional information on most of the shut down nuclear installations in the European Community which have been, or are currently being, decommissioned.

2. DECOMMISSIONING OF NUCLEAR INSTALLATIONS

2.1 Definition of decommissioning stages

The IAEA has, in the past, defined three stages of decommissioning which are widely used internationally for clarity and ease of comparison. The definition is reproduced in the following.

The term 'stage' implies a set of conditions at the plant and does not necessarily imply a continuing stepwise procedure.

When a plant is retired from service the nuclear fuel or radioactive material in the process systems as well as radioactive waste produced in normal operation should first be removed by routine operations. However, for plants that handled fissile material the possibility that some residual fissile material still remains must be given serious consideration during decommissioning and suitable precautions taken.

Each of the three decommissioning stages of a nuclear plant can be defined by two parameters as follows:
- The physical state of the plant and its equipment:
- The surveillance, inspection and tests necessitated by that state.

Stage 1 decommissioning

The first contamination barrier is kept as it was during operation, but the mechanical opening systems are permanently blocked and sealed (valves, plugs, etc.). The containment building is kept in a state appropriate to the remaining hazard and the atmosphere inside the building is subject to appropriate control. Access to the inside of the building is subject to monitoring and surveillance procedures. The unit is under surveillance and the equipment necessary for monitoring radioactivity both inside and outside the plant is kept in good condition and used when necessary and in accordance with national legal requirements. Inspections are carried out to check that the plant remains in good condition. If necessary, checks are carried out to see that there are no leaks in the first contamination barrier and the containment building.

Stage 2 decommissioning

The first contamination barrier is reduced to minimum size and all parts easily dismantled are removed. The sealing of that barrier is reinforced by physical means and the biological shield in a reactor is extended if necessary so that it completely surrounds the barrier. After decontamination to acceptable levels, the containment building and the nuclear ventilation system may be modified or removed if they are no longer required for radiological safety. Depending on the extent to which other equipment is removed or decontaminated, access to the former containment building, if left standing, can be permitted. The non-radioactive buildings or equipment in the plant may be converted for new purposes. Surveillance around the barrier can be relaxed but it is desirable for periodic spot checks to be continued as appropriate, together with surveillance of the environment. External inspection of the sealed parts should also be performed.

Stage 3 decommissioning

All materials, equipment and parts of the plant in which activity remains significant despite decontamination are removed. In all remaining parts contamination has been reduced to acceptable levels. The plant and site are released for unrestricted use. From the point of view of radiological protection, no further surveillance, inspection or tests are necessary. In some cases the whole plant, including inactive components, may be dismantled to make room for a replacement facility or other usage.

2.2 General decommissioning plans/policies and responsible organisations

The general decommissioning plans and policies for the country (Germany, Italy, Spain, UK), or for a particular utility or company within the country (CEA, France) are outlined below together with the specific organisations within the country charged with the responsibility of overseeing the important aspects of decommissioning such as safety, radioactivity discharges etc.

FRANCE

Definition of the different stages of decommissioning

The CEA is responsible for the decommissioning of a number of Basic Nuclear Installations (BNIs) in France and follow the international recommendations of the IAEA. Three possible stages of decommissioning are recognised according to the condition of the installation and the type of monitoring. These are as outlined below. Additional information relevant to the decommissioning stages of BNIs is given in Table 1

	Condition of the installation	Monitoring	Status
Stage 1	Removal of fissile materials and radioactive fluids. The various sealing barriers are kept in good condition. Openings and access points are locked up.	Inspections of radioactivity inside and in the surroundings. Inspections and technical checks to ensure the good condition of the installation.	Isolated and under surveillance
Stage 2	Confined area reduced to minimum. Easily dismantled parts removed. Existence of external barrier.	Reduced monitoring inside the containment. Surveillance of surroundings continued. Verification of sealed areas.	Partial or conditional release of site
Stage 3	All materials and equipment with any significant radioactivity removed. Decontamination of remaining parts to render them below the limits for any particular precautions.	No monitoring, inspection or verification deemed necessary.	Total and unconditional release.

TABLE 1 - DECOMMISSIONING STAGES OF BNIs

	STAGE 1	STAGE 2	STAGE 3
	Isolated and under surveillance	Partial or conditional release of site	Total and unconditional release of site
CONDITION OF THE BNI	Condition maintained	Minimisation of areas under containment. Reinforcement of seals and biological shields.	Simple dismantling
CONDITION OF EQUIPMENT	Shielding in good condition. Very limited access. Containment inspected.	One or several shields. Free access around the containment.	Removal of all materials, equipment and other parts of the installation which had any significant residual radioactivity.
SPECIFIC REQUIREMENTS	Removal of radioactive sources. Washing of liquid system circuits.	Decontamination of released areas.	Total absence of radioactivity.
SURVEILLANCE	Continuous	Reduced and periodic	Not necessary
INSPECTION	Periodic and continuous	At intervals	Not necessary
VERIFICATION	Adapted to risk level	Reduced and adapted to risk level	Not necessary
TIMESPAN	20 to 50 years	100 to 200 years	Unlimited
EXAMPLES	Chinon A1	ZOE, EL2, EL3, G2/G3, Chinon A2	Marius, César, Minerve, Néréide, Triton *

* All research reactors

Classification of nuclear installations

Nuclear installations are classified according to a number of criteria. All these criteria are connected with the safety of persons and property and the protection of the environment.

Installations are classified into 3 sorts , according to the risk involved :
1 - basic nuclear installations
2 - installations classified for the protection of the environment and subject to authorisation
3 - installations classified for the protection of the environment and subject to declaration

The criteria for these classifications are set out in the following table :

TABLE 2 - CRITERIA FOR CLASSIFICATION OF A BNI.

All radioactive substances						Special case - sealed sources		
Preparation Transformation Packaging Use			Storage Repository			Use Storage Repository		
Radiotoxicity group			Radiotoxicity group			Radiotoxicity group		
1	2	3	1	2	3	1	2	3
BASIC NUCLEAR INSTALLATIONS								
3.7 TBq	37 TBq	370 TBq	37 TBq	370 TBq	3 700 TBq	370 TBq	3 700 TBq	37 000 TBq
LISTED INSTALLATIONS SUBJECT TO AUTHORISATION								
0.37 GBq	3.7 GBq	37 GBq	3.7 GBq	37 GBq	370 GBq	37 GBq	370 GBq	3 700 GBq
LISTED INSTALLATIONS SUBJECT TO DECLARATION								
3.7 MBq	37 MBq	370 MBq	37 MBq	370 MBq	3 700 MBq	370 MBq	3 700 MBq	37 000 MBq
Threshold activities used in the classification of nuclear installations other than nuclear reactors and particle accelerators.								

CEA decommissioning policy

As a general rule, the CEA prefers to decommission promptly and not to wait while the installation deteriorates, or because it contains long-lived radioelements. French installations are, until completely decommissioned, subject to the official regulations which are applied : decree no. 63-1228 of 11/12/83 modified by decree no. 90-78 of 18/11/90.

Any decommissioning operation in radioactive conditions must satisfy three requirements :

1) optimum protection of workers ; minimum doses for operatives,
2) optimum protection of the environment ; minimum volume and activity of wastes,
3) optimum economics ; least cost commensurate with regulations.

Every decommissioning operation thus requires very thorough preparation :

- detailed radioactivity mapping, identifying the radionuclides present,
- precise definition of the types of wastes and effluents, their processing, packaging and their final disposal or reuse,
- precise definition of the dismantling techniques,
- surveillance and maintenance measures before and during decommissioning operations,
- definition of individual operations, with corresponding doses to be received by operatives,
- study into the characteristics of the site and its possible reuse,
- comparison of technical and financial aspects.

Organisation of decommissioning

The latest decree, no. 90-78 of 19/1/90 which modifies decree no. 63-1228 of 11/12/83, sets out the new obligations on a plant operator who wishes to shut down his installation definitively. He must inform the director of the Nuclear Installations Safety Directorate (DSIN), giving him the following information :

- the status chosen for the installation after final shut-down, showing how it fits into the plan for possible future decommissioning,
- the way in which he intends to achieve this status,
- general rules for surveillance and maintenance which will enable the installation to be kept in satisfactory condition in the chosen status.

The carrying out of the various operations is subject to approval by decree of the Minister for Industry, after approval by the Health Minister, and after consultation of the interministerial commission for BNIs,

The first operations required after the final shut-down, for example, of a nuclear reactor, are :

- complete unloading of fuel,
- elimination of cooling fluids,
- removal of new irradiated fuel to put it outside the installation's boundaries,
- some decontamination and cleaning-up work.

These operations do not affect the nature of the nuclear installation and can be done in conformity with the safety report and the general operating rules. They may possibly involve some changes to the decree authorising construction of the installation.

Once decommissioning work reaches a stage at which the above regulations can no longer be observed and where it actually changes the nature of the installation, the result is the creation of a new nuclear installation which is subject to a new authorisation. Normally the installation then becomes a storage site for its own materials which are left in place.

If decommissioning is pursued to a point at which the total activity of the remaining radioactive substances falls below the limit for classification as a BNI, then the installation can be removed from the list of BNIs. According to the level of residual activity, it may or may not then be subject to the law of 19/7/76 governing Installations Classified for the Protection of the Environment (ICPE). This may be an installation removed from the list of BNIs, and becomes an ICPE subject to authorisation or subject to declaration, according to the quantity and the degree of radiotoxicity of radioelements present at the installation (see Table 2). It may also be another installation without nuclear material, but which represents a risk to the environment.

UDIN : Nuclear Installations Decommissioning Unit

UDIN is attached to the Fuel Cycle Directorate (DCC) and the Dismantling and Waste Reprocessing Department (DRDD). The CEA has charged UDIN with the following tasks :

- to act as its agent in the decommissioning of nuclear installations in accordance with the programmes, budgets and periods defined in the specifications,
- to carry out R&D work required by these activities,
- to feed back experience gained in decommissioning,
- to define the CEA's approach to decommissioning and dismantling and to help in its dissemination.

Functional organisation
- directorate
- technical section including safety in dismantling
- section for gathering of experience and for future projects

Operational organisation
- 1 project head, assisted by 1 quality assurance officer, 1 management controller, 1 safety studies officer, 1 waste works officer, specialist engineers, managers and technicians, and 1 installation manager

The directorate of the centre

The directorate acts on behalf of the general administrator on the site and has the right to examine and to veto all activities which fall under article 9 of the decree of 10/8/84. Only the directorate can make undertakings to the safety authorities. It designs and updates the general safety programme of the establishment.

The directorate sets up a Nuclear Safety Cell (NSC) which is directly under its authority and is responsible for:
- verifying that the BNIs, during all phases of their lives from design to decommissioning, are operated according to the undertakings made as part of the safety policies and objectives of the CEA,
- ensuring the observance of safety regulations at the installation and the preparation of associated paperwork and to assist the director of the installation in crisis situations,
- checking, as far as concerns safety, the consistency and operation of interfaces between work units,
- helping the units in their dealings with the safety authorities,
- identifying generic problems in the centre's BNIs and standardising their treatment,
- contributing to the dissemination of matters relating to the promotion of safety.

In addition to the above duties the directorate of the installation can assign other subjects and activities to the NSC such as quality, criticality, security, surveillance of nuclear substances, physical protection of installations, surveillance of ICPE's, radiological reports and/or releases.

DSIN : Nuclear Installations Safety Directorate

This is answerable to the Ministry of Industry (MOI) and is also at the disposal of the Ministry of the Environment (MOE). It was set up by a decree on 14/5/91 to take over the responsibilities of the Central Service for Safety in Nuclear Installations (SCSIN) which was itself set up by a decree on 13/3/73.

The DSIN's main duties are :

- to look into problems arising from the choice of sites for nuclear installations,
- authorisation procedures relating to BNIs : creation, start of operations, releases,
- organisation and carrying out of surveillance of such installations by BNI inspectors,
- to formulate general technical regulations and to check on their application,
- to set up an organisation to deal with an incident or accident at a BNI,
- to set up public relations channels in order to communicate with the media and the outside world generally,
- observation of research and development work in the field of nuclear safety carried out by organisations reporting to the MOI, such as the CEA and French Electricity (EDF).

DGD : Waste Management Directorate

Its duties are :

- to establish and keep up to date the long-term plans for decommissioning and dismantling of the CEA's civil nuclear installations,
- the analysis of programmes presented by the operations directorates,
- to put in budgetary requests for programmes linked to its activities,
- responsibility for the consistency of resources used,
- relations between the various operational directorates of the CEA and other industries,
- to ensure that actions conform with the industrial policy of the CEA,
- the management of wastes arising from CEA installations,
- to establish relations with similar foreign organisations, in accordance with international agreements.

ANDRA : National Agency for Radioactive Waste Management

The ANDRA was set up on 7/11/79 by the government for the purpose of long-term management of all sorts of short-lived radioactive wastes. It makes proposals to the authorities on the best methods of guaranteeing protection. It also makes safety specifications which conform both to technical requirements and to the regulations, and ensures compliance with these specifications by the producers of waste and the plant operators.

OPRI : Office for Protection against Ionising Radiation

Created by the decree of 19/7/94. This is a public organisation which comprises a board of administration and a scientific council. It has a staff of 150.

Its role is to provide expertise and control on behalf of the ministries of health and labour. It carries out measurements and analyses of radioactivity or ionising radiation in any places where they could constitute a health risk.

There is a very strict control over liquid and gaseous discharges from installations. The OPRI has established an effective network of sampling points throughout the country and about 50000 samples are collected annually. Quality of measurement is guaranteed by comparison with others made in an international network of the World Health Organisation (WHO). The OPRI is the reference point for the WHO and manages this network on its behalf.

DRIRE : Regional Directorate for Industry, Research and the Environment

The responsibilities of the DRIRE in terms of nuclear safety are as follows :

Inspection : in close liaison with the DSIN it organises a certain number of inspections and reports back to the DSIN on matters of importance.
Decentralisation of approval for reactor shutdown programmes.
Relations with local authorities : prefectures and councils are informed of projects and the effects of these in terms of nuclear safety.

IPSN : Institute for Nuclear Protection and Safety of the CEA

This carries out safety analyses which enable evaluation of measures taken by the nuclear plant operators. It employs 1300. The DSIN relies on the IPSN in making its decisions.

GERMANY

The Federal Minister of the Environment, Nature Protection and Nuclear Safety (BMU) is responsible for nuclear safety and radiological protection and issues acts and ordinances as well as rules, guidelines and criteria, and supervises the States, which act on behalf of the Federal Government in the licensing procedure. The BMU can give directives to the States to ensure a legally consistent regulatory framework. The BMU receives advice on all issues concerning nuclear safety and radiation protection from the Reactor Safety Commission (RSK) and from the Commission for Radiological Protection (SSK).

The States act on behalf of the Federal Government as the licensing authorities for construction, commissioning and decommissioning of all nuclear installations. The licensing authorities consult expert organisations for assessment of the Safety Analysis Reports and independent evaluations of all safety issues arising during construction, operation and decommissioning.

Licensing for decommissioning can be achieved within the framework of the existing regulations though only few of them refer specifically to decommissioning. This has been demonstrated by the licensing and implementation of a number of successfully completed decommissioning projects.

The developement of more specific regulations will proceed according to identified needs and will be supported by the experiences already gained.

The same safety goals used in the operational phase will continue in use during decommissioning.

The Federal Government is responsible for the development of final waste repositories.

ITALY

There is no decommission plan in place for nuclear installations in Italy. Any licence owner is responsible for keeping the installation in a safe condition at all stages during decommissioning. The licence owner is also responsible under the existing rules for obtaining approval from the ANPA (National Agency for the Protection of the Environment/Italian Safety Authority) for any proposals/plans relating to decommissioning operations.

SPAIN

Decommissioning is regarded in Spain as another step in the nuclear facility's life cycle, subject to virtually the same licensing framework as that applied to siting, construction and operation.

A significant change has been introduced by the creation of the National Radioactive Waste Company (Empresa Nacional de Residuos Radiactivos - ENRESA), that, according to the Decree 1522/84, is responsible for preparing the different proposals to be submitted in the licensing process for decommissioning. There is no national policy on decommissioning but it is believed that a considerable degree of harmonisation and general optimisation of the whole process can be achieved as ENRESA manages all the decommissioning project for the Spanish nuclear facilities.

Based on the Vandellos I example, the owner/operator will retain responsibility for some time while executing several pre-decommissioning activities e.g. defuelling, operational waste treatment and conditioning. Both parties should co-operate and establish agreements addressing interface issues. In particular, the owner/operator has to provide ENRESA with all the necessary facility information and documentation.

The first step is the preparation and submission of a study of the decommissioning alternatives available, prepared by ENRESA in closed collaboration with the operator. The document generated during this study is submit to the competent authority, the Nuclear Safety Council (CSN). The authority selects one of the alternatives proposed, and a decommissioning plan on the basis of the alternative selected is drawn up.

In Spain there is not yet any officially defined standard content for a decommissioning plan; however, there are two helpful references, namely:

- The redraft of the 1972 Regulation governing the licensing process for Nuclear and Radioactive Installations which is currently under review; and

- The order issued by the Ministry of Industry in the selection of the decommissioning alternative for Vandellos I. Based on this, the decommissioning plan produced by ENRESA for a partial dismantling (equivalent to Stage 2) will include the following documents: Safety Report, Technical Specification, Organisation and Working Programme, Quality Assurance Manual, Waste Management Plan, Radiological Protection Manual, Emergency Plan and Security Plan.

This order also requires that the decommissioning plan for the total dismantling (Stage 3) needed at the end of the safe storage period, be presented well in advance of the scheduled starting date.

Various nuclear and radioactive installations are currently being decommissioned in Spain. In particular, there is one commercial reactor and various experimental reactors. Decommissioning plans have been submitted to the Ministry of Industry, in order to enable the required level to be reached. These are currently awaiting approval by the CSN.

UNITED KINGDOM

Within the UK there are a number of utilities/organisations who own/operate a variety of nuclear installations. These are Magnox Electric (ME), Nuclear Electric (NE), Scottish Nuclear (SNL), British Nuclear Fuels (BNFL), the United Kingdom Atomic Energy Authority (UKAEA) and the Atomic Weapons Establishment (AWE). With the exception of NE, each has one or more installations which have been shut down and which are being decommissioned. ME and SNL are decommissioning large power reactors, BNFL are decommissioning plant generally related to fuel fabrication and reprocessing, the UKAEA are decommissioning mainly prototype and small materials testing reactors and AWE are mainly decommissioning gloveboxes and fume cupboards associated with plutonium and uranium handling.

The decommisioning policy of each is outlined below.

UKAEA

Decommissioning policy

The UKAEA has adopted the following policy with regard to decommissioning :-

- Redundant facilities to be safe and compliant with legislation
- Decommission for safety, environmental or planning requirements
- Defer decommissioning until justified by safety, environmental or planning requirements.
- Choose options that minimise immediate costs.
- Return site to a safe condition that does not require care or monitoring.
- To minimise the cost net present value of the above.

Nuclear liabilities

Decommissioning and **R**adioactive **W**aste **M**anagement **Op**erations (DRAWMOPS) is the programme for the decommissioning of redundant radioactive facilities, the transport of radioactive materials, the reprocessing of fuels and residues, the management through to disposal of all radioactive wastes and any necessary research and development. The programme is managed by UKAEA Government Division (GD) and its current expenditure is £150~200 million/annum. In DRAWMOPS work the relevant UKAEA Government Division components are DRAWMOPS Directorate and Nuclear Site Operations.

DRAWMOPS Directorate is responsible for :-

Agreeing the DRAWMOPS programme with the Department of Trade & Industry (DTI)
Long term planning
Procurement policy
Decommissioning management at Winfrith, Culham, Harwell, Windscale, Springfields etc.
R&D management
Windscale site management

Nuclear Site Operations is responsible for :-

Radioactive waste operations in the UKAEA
Management of radioactive materials transport in the UKAEA
Reprocessing of fuels and residues at Dounreay
Dounreay site management
Operational radioactive facilities management in UKAEA

Drawmops Directorate, Government Division, UKAEA have the following nuclear liabilities:

- Reactors
- Post Irradiation Examination facilities
- Laboratories,
- Reprocessing plant
- Waste stores, Effluent plant
- Waste disposal sites
- Joint European Torus (JET).

In total they number approximately 150 if all the buildings that comprise an installation are counted, for example the Prototype Fast Reactor (PFR) has 10 buildings and the Dounreay Fast Reactor (DFR) 14 buildings. JET will be a significantly different liability in that it has many new materials, the staff are multi-national and will be dispersed across Europe when the project terminates. In anticipation of this GD are already maintaining records on-site in collaboration with JET personnel.

Nuclear Electric and Scottish Nuclear

Magnox Electric's preferred strategy for their Magnox stations (and Nuclear Electric's for their Advanced Gas-cooled Reactors), which is awaiting Government approval, is based on a long term stage by stage approach which provides optimal time for radioactive decay prior to intervention and so reduces radiation dose to staff and minimises waste disposal volumes. Three stages are involved as follows:

Stage 1 Removal of fuel following shutdown, over a 3 year period, followed by a 1-2 year preparation of the site for a 30 year C&M period. This involves the removal, where economic, of various non-radioactive plant and buildings and putting the remaining buildings including the reactor building in a suitable state for C&M.

Stage 2 Construction of an intruder-proof and weather-proof structure around buildings containing active plant. This is called a "Safestore", takes from 2 to 4 years to complete, and permits minimum maintenance over the next 100 years surveillance period.

Stage 3 Complete dismantling and removal of Safestore structures and all plant and buildings to return to a "greenfield" site. This commences approximately 135 years after shutdown and will take about 10 years to complete.

The timing of the construction of the Safestore is not critical. Also, elimination of the initial 30 year C&M period in Stage 1 may be preferrable for some stations.

Scottish Nuclear have adopted a similar strategy.

BNFL and AWE

BNFL and AWE are decommissioning mainly fuel manufacture and reprocessing plants, and plutonium and uranium handling plants. Many of these have been wholly or partially redundant for a number of years and hence there is a greater emphasis on earlier dismantling to meet safety requirements and to minimise inceasing costs of surveillance and maintenance as less robust structures continue to age and deteriorate.

3. NUCLEAR INSTALLATIONS CURRENTLY BEING DECOMMISSIONED

A large number of nuclear installations have already been, or are currently being, decommissioned in the European Community. Tables 3 to 7 give a listing of the installations for each of the 5 countries participating in the study. Annex 1 to 5 provide a brief description of many of the installations, and for each give information where available on the organisation responsible for its decommissioning, its current state, its planned final state, the extent of the radiologically controlled area(s), what monitoring and inspection activities are carried out, and the present and projected staffing levels.

In Table 3 to 7, the following nomenclature is used:

(1) Reactor types:

GCR	=	Gas-cooled Reactor
HWR	=	Heavy Water moderated Reactor
PWR	=	Pressurised Water Reactor
PR	=	Pool-type Reactor
FBR	=	Fast Breeder Reactor
BWR	=	Boiling Water Reactor
HTR	=	High Temperature Reactor
Arg	=	Argonaut Type Reactor
AGR	=	Advanced Gas-cooled Reactor
GR	=	Air-cooled Graphite Reactor
CA	=	Critical Assembly

(2) Decommissioning stage, as defined by IAEA (see § 2.1)

0	Announced to be decommissioned
1	Decommissioned to Stage 1
2	Decommissioned to Stage 2
3	Decommissioned to Stage 3
3*	Decommissioned to Stage 3 with the exception of civil engineering
-	Decommissioning in progress, i.e. -2 means that installation is currently undergoing decommissioning to Stage 2.

a	Partly converted into a museum
b	Converted into a spent fuel storage facility
c	Equipment dismantled : building to be reused for a new vitrification facility
d	Contains damaged fuel
e	"Chimney" being partially dismantled
f	Used as radioactive waste store

Table 3. French nuclear installations finally shut down (to 1995)

Plant/ Installation	Name	Type (1)	Operating Period	Stage (2)
Large power reactor	G1 Marcoule	GCR	1956-68	3*
	G2 Marcoule	GCR	1959-80	-2
	G3 Marcoule	GCR	1960-84	-2
	Chinon A1	GCR	1963-73	1,a
	Chinon A2	GCR	1965-85	
	Chinon A3	GCR	1966-90	-1
	Chooz A	PWR	1967-91	
	Saint Laurent A1	GCR	1969-90	-1
	Saint Laurent A2	GCR	1971-92	
	EL4 Monts d'arrée	HWR	1969-90	-3*
Small reactor plant	EL2 Saclay	HWR	1952-65	2
	EL3 Saclay	HWR	1957-79	2
	PEGASE Cadarache	PWR	1963-74	3,b
	RAPSODIE Cadarache	FBR	1967-83	-2
	TRITON Fontenay	PR	1959-82	3
	MELUSINE Grenoble	PR	1958-88	0
	MINERVE Saclay	PR	1954-76	3*
	ZOE Fontenay	HWR	1948-75	3
	NEREIDE Fontenay	PR	1959-82	3
	PEGGY Cadarache	GCR	1961-75	3
	CESAR Cadarache	CA	1964-74	1
	MARIUS Cadarache	CA	1960-83	1
Other installation	Elan II B La Hague, Source fabrication plant	-	1970-73	3
	Elan II A La Hague, Pilot plant for Elan II B	-	1968-70	3*
	AT1 La Hague, Fuel reprocessing plant,	-	1969-79	-3
	PIVER Marcoule, Waste vitrification plant,	-	1966-80	3,c
	ATTILA, Dry processing pilot cell	-	1968-75	3*
	RM2, Radiometallurgy lab, 13 cells	-	1964-85	3*
	Building 19 Fontenay, Plutonium metallurgy	-	1957-84	3*

Table 4. German nuclear installations finally shut down (to 1995)

Plant/ Installation	Name	Type (1)	Operating Period	Stage (2)
Large power reactor	HDR Großwelzheim	BWR	1969-71	-3
	KKN Niederaichbach	HWR	1973-74	-3
	KRB A Gundremmingen	BWR	1966-77	-3
	KWL Lingen	BWR	1968-77	1
	MZFR Karlsruhe	HWR	1966-84	-3
	VAK Kahl	BWR	1961-85	-3
	AVR Jülich	HTR	1967-88	-1
	THTR 300 Hamm-Uentrop	HTR	1985-88	-1
	KKR Rheinsberg	PWR	1966-90	-3
	KGR1 Greifswald	PWR	1973-90	-3
	KGR2 Greifswald	PWR	1974-90	-3
	KGR3 Greifswald	PWR	1977-90	-3
	KGR4 Greifswald	PWR	1979-90	-3
	KGR5 Greifswald	PWR	1989-90	-3
	KNK-II Karlsruhe	FBR	1978-90	-2
	KWW Würgassen	PWR	1972-94	0
Small reactor plant	Otto-Hahn ship reactor	PWR	1968-79	3
	FR-2 Karlsruhe	HWR	1962-81	2
	FRJ-1 Merlin Jülich	PR	1962-85	-2
	RFR Rossendorf	PR	1957-90	-3
	FRN TRIGA Mk III Neuherberg	TRIGA	1972-82	2
	FRF-2 Frankfurt	TRIGA	1977-83	2
	FRG-2 Geesthacht	PR	1963-95	-3
Other installation	Nukem-Alt fab plant Hanau		1960-88	-3
	WAK reproc plant Karlsruhe		1971-90	-3
	Hobeg fab plant Hanau		1962-92	-3
	U fuel fab plant, Hanau			0
	7 uranium mines/mills			

Table 5. Italian nuclear installations finally shut down (to 1995)

Plant/ Installation	Name	Type (1)	Operating Period	Stage (2)
Large power reactor	Garigliano	BWR	1964-78	-1
	Latina	GCR	1963-86	-1
	Caorso	BWR	1978-86	-1
	Trino	PWR	1964-87	-1
Small reactor plant	Avogadro, Compes	PR	1959-71	2,b
	Ispra-1	HWR	1958-74	2
	Galileo Galilei, Cisam, Pisa	PR	1963-80	2
	Essor Ispra	HWR	1967-83	2
Other installation	Itrec fuel reprocessing plant, Trisaia	-	1975-78	-1
	Eurex fuel reprocessing plant, Saluggia	-	1970-83	-1
	OPEL-1/IPU (Casaccia)			-1

Table 6. Spanish nuclear installations finally shut down (to 1995)

Plant/ Installation	Name	Type (1)	Operating Period	Stage (2)
Large power reactor	Vandellos 1	GCR	1972-89	-2
Small reactor plant	JEN-1 Madrid	PR	1958-84	1
	ARB1	Arg		-1
	ARGOS	Arg		1
	CORAL	FBR		1

Table 7. UK nuclear installations finally shut down (to 1995)

Plant/ Installation	Name	Type (1)	Operating Period	Stage (2)
Large power reactor	DFR Dounreay	FBR	1963-77	-1
	WAGR Windscale	AGR	1962-81	-3
	SGHWR Winfrith	HWR	1968-90	-1
	PFR Dounreay	FBR	1975-94	-1
	Berkeley 1	GCR	1961-89	-1
	Berkeley 2	GCR	1961-88	-1
	Hunterston A1	GCR	1964-90	-1
	Hunterston A2	GCR	1964-89	-1
	Trawsfynydd 1	GCR	1965-93	-1
	Trawsfynydd 2	GCR	1965-93	-1
Small reactor plant	Windscale Pile 1	GR	1950-57	d,e
	Windscale Pile 2	GR	1951-58	e
	Merlin Aldermaston	PR	1959-62	1
	BEPO Harwell	GR	1948-68	1
	DMTR Dounreay	HWR	1958-69	1
	Dragon Winfrith	HTR	1965-76	1
	ZEBRA	ZPF	1967-82	2
	DIDO Harwell	HWR	1956-90	-1
	PLUTO Harwell	HWR	1956-90	-1
	GLEEP	GR	1947-90	2
	Nestor	Arg	1961-95	1
Other installation	B212 Caesium plant (S)	-	1956-58	-3
	B206 solvent recovery plant (S)	-	1952-63	-3
	B29 fuel storage plant (S)	-	1952-64	-1
	B205 pilot fuel reprocessing plant (S)	-	1957-68	-3
	B204 fuel reprocessing plant (S)	-	1952-73	-3
	B207 uranium purification plant (S)	-	1952-73	-3
	Co-precipitation plant (S)	-	1969-76	
	Uranium enrichment (diffusion) plant (C)	-	1953-82	-3
	B100-B103 uranium recovery plant (S)	-	1952-85	3,f
	B209 plutonium finishing plant (S)	-	1953-86	-3
	B203 plutonium residues recovery plant (S)	-	1956-86	-3
	B30 fuel storage pond (S)	-	1960-86	-2
	B277 fast reactor fuel production plant (S)	-	1970-88	-3
	B205 plutonium corridors (S)	-	1964-88	-3

(S) Sellafield (C) Capenhurst

4. MONITORING, INSPECTION AND MAINTENANCE

It can be seen from the definition of decommissioning stages given in §2.1 that until stage 3 decommissioning has been completed, there is a need to carry out sufficient monitoring and inspection of contamination barriers and equipment to ensure that no leaks have occurred or are likely to occur over the decommissioning period. Such activities are necessary while decommissioning work is underway and also, and perhaps more importantly, during the potentially long period(s) of relative inactivity that might occur in between decommissioning stages i.e. if the installation has been placed in a C&M phase. In addition, in order to guarantee the long term integrity of structures and individual components internal to the sealed barriers, as would be required during a lengthy C&M period, it is important that adequate monitoring of the environmental conditions inside the barrier, such as temperature and humidity is carried out.

The monitoring and inspection requirements at a given installation will depend on the timescale for decommissioning i.e. is the plant to be decommissioned to stage 3 quickly or will there be long periods of C&M or 'safestore' in between each stage, by the size and complexity of the contamination barriers, by the type of waste contained within the barriers and by the need to maintain specific environmental conditions within the containment. This chapter provides information on the activities being carried out in this area in the various countries.

FRANCE

The regulations which apply during decommissioning are the same as those for a nuclear installation in operation.

General

According to the law of 2/8/61 the conditions for the creation, operation and surveillance of nuclear installations are fixed by decree of the council of state. The decree of August 1963 established the principle of authorisation of any new BNI by decree, and provided for the drawing up of technical regulations to apply to such installations. An interministerial committee for basic nuclear installations (ICBNI) was set up to examine all projects regarding these installations and a BNI inspectorate was created to inspect them at all times during their lives : construction, operation and decommissioning. The authority for nuclear safety is the nuclear installations safety directorate (DSIN), which in turn relies on the regional directorates (DRIRE) for surveillance of nuclear installations in their particular regions. It relies also on the institute for nuclear protection and safety (IPSN) for safety analyses. (Further information on these organisations is provided in §2.2)

The DSIN must report on its activities to several organisations :

- ICBNI
- CSSIN (Superior Council for Nuclear Safety and Information)
- OPECST (Parliamentary Office for the Evaluation of Scientific and Technical Choices)

Safety rules at the CEA

The CEA nuclear safety manual is a collection of texts which serve as a reference for BNIs, as well as for the ICPEs. The manual includes two sorts of texts :

- Circulars ; these lay down rules and procedures which are obligatory.
- Recommendations : these are for guidance.

Circular no. 2 deals with :

- requests for authority to create BNIs and ICPEs and the emission of effluents,
- public enquiries,
- procedures for going active and startup,
- requests for modifications,
- procedures for final shutdown and decommissioning of installations.

Circular no. 8 relates to the surveillance of BNIs.

Recommendation no.1 concerns the documentation for a BNI.

Recommendation no.2 describes the establishment of general operating rules (GORs) for a BNI.

Summary of Current Practice

The CEA are responsible for decommissioning a number of the shut down facilities in France. Many of these have reached Stage 3 (with the exception of civil work) and most of the remainder have reached Stage 2. Two of the facilities have been either wholly or partly converted for other uses. Those that are classified as BNIs are subject to the BNI regulation checks and surveillance by Operating and Health Physics teams. Some have been removed from BNI classification and been reclassified as an ICPE, and these are in general subject to Health Physics monitoring only.

GERMANY

The current position of installations undergoing decommissioning is as follows:

- 2 announced to be decommissioned
- 2 in progress to stage 1
- 1 decommissioned to stage 1
- 2 in progress to stage 2
- 3 decommissioned to stage 2
- 16 in progress to stage 3
- 1 decommissioned to stage 3

The nuclear power plant KWL is the only (large) installation which is being operated in a C&M state (safe enclosure (SE); Stage 1 decommissioning).

The installation is remotely surveyed by TV, alarm systems etc., from the site entrance cabin, which is permanently occupied. The SE part of the plant comprises the reactor building, the process building, and the building connecting these two. An unmanned air conditioning and switch station was set up outside the SE. The air conditioning system circulates about 2,500 m^3/h of air which is filtered and dried by condensation to avoid corrosion by water condensing in cold spots of the SE. The condensate is collected in tanks located inside the SE. An additional air dryer, working by absorption, was installed in order to intensify drying of the SE atmosphere at low temperatures. The system also discharges about 600 m^3/h of air through the stack after HEPA filtering. Aerosols in the atmosphere of the SE are continuously sampled on filters and measured fortnightly.

The air conditioning and switch system is inspected weekly, and the SE is inspected quarterly. Various tests are performed periodically, namely yearly measurements of the leak-rate from the SE as a function of the differential pressure.

ITALY

In Italy, the 4 large power reactors and 3 other installations are currently in progress to Stage 1. The 4 small reactor plants have been decommissioned to Stage 2. All the large and small reactors have been defuelled although in many cases irradiated fuel is still stored in the fuel ponds. Due to the lack of a disposal route, it is current practice at each site to store all operational active wastes in the existing ponds, tanks and vaults, as well as in suitable steel drums, boxes etc.

Because of the significant quantities of active wastes which are still stored on the sites, routine monitoring and inspection of the radioactively controlled areas is carried out. Only at some of the reactors is it considered necessary to monitor humidity and temperature levels, and to maintain a negative pressure across the primary containment.

SPAIN

The table below shows the activities which are currently being carried out in the field of monitoring, inspection and maintenance. No specific system has yet been put in place for the monitoring of the Spanish nuclear installations currently in the decommissioning phase.

The future inspection needs of Vandellós I NPP have not yet been defined. The objective pursued in relation to the other installations is to free them for other uses. Consequently, once the decontamination process has been completed, these installations will require no further inspection or monitoring other than those implied by their new use. The current level of monitoring, inspection and maintenance at each installation is summarised below.

Installation	Monitoring	Inspection	Maintenance
Vandellós I	The values of depression, humidity and temperature inside the reactor pile and the values of activity in the gaseous effluent discharge stacks are monitored from the Control Room. The monitors used are those which existed during Plant operation.	The inspections are included in the Maintenance Plan.	All the equipment included in the Technical Specifications are subject to maintenance, a Maintenance Plan being in place for this purpose. The frequency and type of maintenance to which the equipment is subjected depend on the nature of the equipment, their conditions of use, their safety-related importance, etc. The items of equipment not required in the current operating mode are in the operating or definitive tagged-out condition.
Arbi	Equivalent dose rate measuring device.	Sampling of accessible zones to determine the activity of the materials.	
Argos	Radiological surveillance of the source storage area.		
CIEMAT installations: JEN-1, CORAL, etc.	Radiological surveillance of areas pending decontamination or in service.		

UNITED KINGDOM

Installations are monitored as required by the site licence conditions. This is referred to by Licence Condition 2 that refers to the Marking of the Site Boundary, and Licence Condition 28 that deals with Examination, Inspection, Maintenance and Testing. The specific plant safety case also details the monitoring and inspection that is required to support it, and takes into account the state/condition of the plant. All maintenance schedules are agreed as part of the safety case with the NII. The NII agree, inspect and comment on them according to their categorisation. For example DIDO (a Materials Test Reactor at Harwell) has been moved from a Category 1 to a Category 2 and finally to a Category 3 plant, and the NII have approved this at every stage. The operations of nuclear installations involve regulations that have been evolved and set by :-

- Health and Safety Executive (HSE)
- Nuclear Installations Inspectorate
- Her Majesty's Inspectorate of Pollution (HMIP)
- Ministry of Agriculture Fisheries and Food (MAFF)
- National Rivers Authority (NRA).

The structural condition of plant is assessed by continuous monitoring of the plant's integrity, and by performing inspections at fixed periods that are agreed with the NII. These inspections are Non Destructive Testing (NDT) and corrosion mapping, and may be carried out at fixed intervals, for example ten years. The Steam Generating Heavy Water Reactor and Dragon (a high temperature reactor), both at Winfrith, are two facilities that are in a C&M state that would require this form of monitoring. In addition there are requirements for reactor monitoring, ventilation, fire safety etc. Site monitoring for radiological material discharges is carried out at specific sampling points within and outside the site boundary, for example beaches and rivers. The site boundary is also marked and maintained for protection and restricted access.

The amount of effort involved depends upon the specific type of plant and what stage of decommissioning it is in, for example PFR which is in Stage 1, still has intact its operational teams and has a very high allocation of effort. DFR has 31 staff, 2 of which are performing Health Physics duties, while Nestor and Dimple (both research reactors at Winfrith) have no permanent staff. Some indication of the effort involved is given in Annex 5.

At the Magnox station at Berkeley, pre-oxidised steel specimens have already been installed in the reactor vessel. These specimens will be periodically checked to monitor how the internal steelwork is changing with time (with regard to oxidation) over the C&M period. They will therefore provide an early indication if any changes to the atmospheric conditions are required in order to guarantee the long term integrity of steel structures.

5. OCCUPATIONAL DOSES AND CLASSIFICATION OF WASTES

This Chapter provides information relating to the classification of radioactive wastes in the various countries and on the occupational dose limits for personnel working at nuclear installations in those countries

.

FRANCE

Personnel classification.

People are classified into 3 categories according to their work :

Category A
Those who work directly in radiation. No worker may be classed in this category without a medical certificate of aptitude which must be renewed every 6 months. These workers are likely to exceed 30% of the annual exposure limits.

Category B
Those who do not work directly in radiation. Their normal working conditions do not lead them to exceed 30% of annual limits.

Category C
Unexposed workers. Their normal working conditions do not lead them to exceed 10% of annual limits.

No worker may be classified in one of the latter two categories without a medical certificate of aptitude, which must be renewed every year. The annual exposure limits shown in the following table are maxima which must not be exceeded : limitation principle. The annual limit for category A can be lowered by the director of the establishment (generally 20 mSv). Any activity involving exposure to ionising radiation must be justified by the advantages it entails : principle of justification. All exposures must be maintained at the lowest possible level : principle of optimisation.

According to regulations, dosimetry relies on a photographic film worn at chest level to record the body dose and another worn on the wrist for the extremity dose. A control dosimeter similar to the individual dosimeters, is kept at each site. It must stay under cover from radiation and serves as a reference when all the individual dosimeters are analysed in the laboratory.

Personnel records must always be kept up to date to account for personnel movements and changes of address and personal circumstances. The OPRI calculates cumulative doses and compares them to the allowed limits. If the limit is exceeded an enquiry is initiated by the official industrial doctor. Cumulative doses are recorded month by month, firm by firm in order to provide a permanent record of the working life of any worker exposed to ionising radiation.

Annual exposure limits.

In the following table the various exposure limits are listed and expressed in dose equivalents received during 12 consecutive months for the three categories of personnel.

ANNUAL EXPOSURE LIMITS

PARTS EXPOSED	CATEGORY A in mSv	CATEGORY B in mSv	UNEXPOSED WORKERS in mSv
- Whole body	50	15	5
- Skin, bones	500	150	50
- Other internal organs	150	45	15
- Hands, forearms, feet, ankles	500	150	50
- Eyes (lenses)	150	45	15

Waste products

Dismantling operations produce large quantities of solid, liquid and gaseous materials. These materials can have three different final destinations :
- recycling in general industry,
- recycling in designated locations (nuclear industry),
- storage in specialised centres.

An intermediate solution is possible by interim storage of the low level waste, in anticipation of a technical or administrative decision on long term disposal of wastes.

The law of July 1991 requires nuclear wastes to be rendered non-reusable. This law, together with CEAs research into minimising costs, makes it desirable to reduce the volume of dismantling products and to concentrate their radioactivity.

The materials which cannot be further processed and are destined for storage sites are called wastes. Nuclear wastes are classified into three categories, A, B and C, according to the radioelements they contain. They must be packaged prior to dispatch to the appropriate storage centres. Secondary wastes are consumables such as gloves and overshoes which have been used in dismantling operations.

Different types of waste.

Type A nuclear waste :

This is of low and medium activity and makes up 90% of the total volume of nuclear waste produced each year. At the CEA the main action taken consists of reducing the volume of these wastes and packaging them so as to minimise the effects of their radioactivity. This low level activity will completely disappear within 300 years, at which they will be considered as ordinary industrial waste. These waste packages are stored in the Manche (now closed) or the Aube repositories. ANDRA manages these surface storage sites.

Type B nuclear waste :

This contains alpha emitters which do not radiate but have an extremely long life. They are currently stored on CEA sites. Current procedures involve storage in secure conditions for several decades. Studies, particularly into storage, will enable legislation to be passed within a reasonable time.

Type C waste :

This contains long-lived actinides and high activity fission products and cannot be stored on the surface. They are in interim storage at CEA sites awaiting legislation, which could provide for storage deep underground.

Processing of dismantling products.

The objective of processing is to put the materials into a concentrated and stable form (insoluble and unreactive). One of the conditions for success in this is that the dismantling products have to be sorted at source according to their final destinations.

The main processing operations are :
- melting of low activity materials,
- incineration of inflammable materials having beta and gamma contamination (gloves, cloths, oil, etc.),
- evaporation of aqueous effluents,
- compaction of non-inflammable materials (glass, cables, etc.).

Packaging of dismantling products.

The packaging of reusable materials depends only on the processing applied and the possibilities for re-use.

Wastes, on the other hand, must be packaged according to the type of waste and the relevant storage site. Wastes are first sorted into those which will be encapsulated and those which will not. The different types of standardised packaging are :
- drums,
- metallic containers,
- concrete containers.

Waste management requires planning of dispatches of the normalised packages. Annual and five-yearly plans are required by the ANDRA. The contents and the activity of the packages must be determined before their dispatch. This is done using methods which are approved by the ANDRA

GERMANY

The specification for occupational doses is that no worker within a plant should receive an annual dose equivalent of greater than 10 mSv. This is a maximum limit value and the normal operation of plant should result in dose levels far lower than this.

Radioactive waste is divided into two basic classes, these being:

- heat generating waste (e.g. spent nuclear fuel of power reactors, high active waste concentrates etc.)
- non-heat-generating waste.

Heat generating waste and nuclear fuel has to be disposed of in the (planned) Gorleben repository; non-heat-generating waste can be disposed of in the Morsleben repository (available), in the Konrad repository (in licensing process) or in the Gorleben repository.

ITALY

The following operator dose rates have been taken from Legislative Decree No.230, 17/3/1995.

1. Total dose for exposed workers is 100 mSv for any 5 consecutive years and not more than 50 mSv in any one year.
2. Furthermore in any one year:
   (a) not more than 150 mSv for eyes (lens)
   (b) not more than 500 mSv for skin
   (c) not more than 500 mSv for hands, forearms, feet and heels
3. Special considerations are also prescribed for inhalation of radionuclides (not reported)

There are 3 Categories of radioactive waste which are classified by Technical Guide No.26:-

Category 1 wastes

These are wastes which require times of the order of months, with a maximum of some years, to decay to concentrations less than those reported in DM 14 July 1970, Article 6, points 2b & 2c.

Category 2 wastes

These are wastes which require times between some tens and some hundreds of years to reach radioactivity concentrations of the order of some hundreds of Bq/g, as well as long life radionuclides but at concentrations of the same order of magnitude.

Category 3 wastes

These are wastes which do not belong to Category 1 and 2, in particular those which require times of the order of a thousand years or more to reach radioactivity concentrations of the order of some hundreds of Bq/g.

SPAIN

The doses received by the personnel and the off-site emissions have in all cases been within the values permitted by the Spanish legislation and those recommended by the international organisations. The dose limits (in mSv/year) are as follows:

	Entire body	Crystalline	Skin	Hands, feet, ...	Other organs	Abdomen	Foetus
Exposed worker	50	150	500	500	500		
E.W women						13	
E.W women in pregnancy							10
Students	30	90	300	300	300		
Public	5	15	50	50	50		

In all cases, the As Low As Reasonably Achievable (ALARA) principle is observed. Some plants have reduced the exposure limits.

- Vandellós I NPP

The doses received at Vandellós I NPP since initiation of decommissioning of the installations have been as follows:

Year	Personnel	Collective dose (mSv)	Average individual dose (mSv)
1990	300	46.1	0.15
1991	286	40.00	0.14
1992	273	31.10	0.11
1993	249	40.49	0.16
1994	311	238.47	1.13

In no case has there been any accidental release off site. The controlled releases of effluents have in all cases been within the values authorised by the administration.

- Argos and Arbi reactors

The doses involved in removing the fuel from these reactors have been zero. It is estimated that those involved in the dismantling processes will be insignificant. There have been no significant off-site releases of effluents.

- CIEMAT installations

A strict radiological protection plan has been put into place at these installations, in order to avoid a collective dose of 10 mSv being exceeded during performance of any task. If it is estimated that this value will be exceeded, the CIEMAT Nuclear Safety, Radiological Protection and Environmental Committee will carry out an analysis.

The values established by the Regulatory Authority for wastes from the CIEMAT nuclear installations in the decommissioning phase are classified in three groups:

- Exempted are contaminated materials having low toxicity beta and alpha surface contamination amounting to less than 0.4 Bq/cm^2 and high toxicity alpha of less than 0.04 Bq/cm^2, along with activated materials having beta-gamma mass activities of less than 0.2 Bq/cm^2 and high toxicity alpha values of less than 0.04 Bq/cm^2.

- Restricted, and subject to controlled dumping or recycling, are materials having beta-gamma mass activities of less than 1 Bq/cm^2 and high toxicity alpha values of less than 0.2 Bq/cm^2.

- Radioactive wastes, with ENRESA responsible for disposal and subsequent treatment.

UNITED KINGDOM

Records of exposure are kept as part of the site licence requirements for Health Physics and Safety, but these are not published. In the case of the Windscale Advanced Gas-cooled Reactor (WAGR), whose decommissioning is funded partly by the CEC, papers have been supplied to the CEC giving instances of specific decommissioning jobs and the doses received, for example the cutting of the standpipes using plasma arc cutting tools. It has been noticed on two installations that the way a task is approached significantly affects the dose received. At WAGR the dose is generally related to the management of a task, not the task itself. There is a natural tendency for personnel to stand and watch a task being performed. A lower dose is received if the personnel are removed from the task once their role ceases to be necessary. At SGHWR the supervisors were picking up a high dose. This was because they frequently had to show the workers where the job was and what it entailed. This was solved by using a simulation of the facility running on a personal computer to "walk through" the plant and see the layout of the plant and the pipe-work. The simulation cost £80K, but was considered worth the expense (based upon a value of £/Sv from mortality studies)

Reported levels during decommissioning and any abnormalities arising are dealt with by Licence Condition 7 - Incidents on the Site. Records of all Category A, B, C and D incidents are held by the Corporate Safety Directorate of GD, UKAEA including copies of appropriate documents notifying, reporting and investigating incidents on site. The unit responsible keeps evidence of completion of agreed recommendations.

The limits of dose are stricter than those recommended by International Commission on Radiological Protection (ICRP), and by operating ALARP principles the dose is kept to the following limits:

- Members of the public cannot under any circumstance receive more than 0.3mSv in any one year.
- In new plants, non-radiation workers cannot receive a dose greater than 5mSv in any one year. - Radiation workers will not receive an individual dose equivalent of more than 20mSv in any one year, or an average dose equivalent of 15mSv/year over any 5 consecutive years.
- In new plants, no individual worker within plant should receive an annual dose equivalent of greater than 10mSv.

The definition of dose equivalent is: the sum of effective dose equivalent (from external dose) and committed effective dose equivalent (from internal dose) to the whole body.

The above are maximum limit values and the normal operation of plant should result in dose levels far lower than these.

6. CODES AND STANDARDS

This Chapter provides information relating to the Codes and Standards applicable to decommissioning in the various countries.

FRANCE

Regulations for the decommissioning of BNIs result from the decree 63-1228 of 11/12/63 as modified by the decree no. 90-78 of 19/01/90 and the recommendations of the IAEA.

When the owner intends his facility to go into final shutdown he must inform the head of the central authority for nuclear safety which and provide him with:

1. a safety report for the final shutdown,

2. general rules for surveillance and maintenance,

3. updates of internal emergency plans for the facility,

4. details of how the arrangements set out in the report will be applied.

The dossier is then sent to the interministerial committee in application for the decree authorising the procedures for final shutdown to be carried out.

When these procedures have been completed, another decree is called for to authorise dismantling work to begin. On completion of dismantling another safety dossier must be prepared in application for declassification of the installation or its removal from the list of BNIs.

GERMANY

The hierarchy of codes and standards applicable to decommissioning is structured in a legal and a technical level.

Legal level

- Act on the Peaceful Utilisation of Atomic Energy and the Protection Against its Hazards (Atomic Energy Act) as promulgated on July 15, 1985 and amended on December 21, 1992

The decommissioning of a nuclear installation as well as the safe enclosure of a finally decommissioned installation or the dismantling of the installation or parts thereof shall require a licence (§7(3) Atomic Energy Act).

Any person who constructs, operates, otherwise holds, materially modifies, decommissions or disposes of installations in which nuclear fuel is handled shall make provisions to assure that radioactive residues as well as disassembled or dismantled radioactive components are utilised without harmful effects or are disposed of as radioactive wastes in an orderly manner if utilisation is not possible (because of economic or safety considerations). (§9a(1) Atomic Energy Act).

Such radioactive wastes for which no special disposal is required for the purpose of protecting life, health and property shall not be considered as radioactive substances and can be disposed of conventionally (§2(2) Atomic Energy Act).

- Act on the Precautionary Protection of the Population against Radiation Exposure (Precautionary Radiological Protection Act) as promulgated on December 19, 1986.

- Ordinance on the Protection against Damage and Injuries Caused by Ionising Radiation (Radiological Protection Ordinance - RPO) as promulgated on June 30, 1989 and corrected on August 2, 1994.

The aspects relating to radiation exposure are governed by the RPO, which applies to the operating phase as well as to the decommissioning phase. Any unnecessary radiation exposure or contamination of persons, property or the environment has to be avoided. All types of radiation exposure or contamination, even below the established limits, have to be kept as low as possible. Details of the calculation of the public exposure are prescribed in an Administrative Ordinance. Furthermore, there are guidelines for the radiological protection of occupationally exposed people.

- Ordinance Relating to the Procedure for the Licencing of Facilities in Accordance with §7 of the Atomic Energy Act (Nuclear Licencing Procedures Ordinance - NLPO) as promulgated on February 3, 1995.

The NLPO states to what extent the public shall be involved in the licencing procedures. When an application for the decommissioning of a nuclear facility as well as for the safe enclosure of a finally decommissioned facility is made, a public notification and access to the application documents may be omitted, if there will be no significant dismantling operations (§4(5), (2) NLPO).

Technical Level

Criterion 2.10 of the Safety Criteria for Nuclear Power Plants (issued by the Federal Minister of the Interior, 1977) requires a concept for the dismantling of the plant in the frame of existing regulations on radiological protection.

Guidelines for Light Water Reactors, produced by the Commission for Reactor Safety (RSK), establish the feasibility of decommissioning already in the design phase.

The Nuclear Safety Standards Committee (KTA) prepare safety standards concerning nuclear engineering. Those standards concern radiological and work protection, activity control, ventilation techniques etc.

The (German) Commission for Radiological Protection (SSK) issued a recommendation on the reuse and recycling of ferrous scrap from nuclear power plants.

Other Safety Standards of relevance are as follows:

- Principles Relating to the Provision to be Made for the Handling and Disposal of Spent Fuel of Nuclear Power Plants (1980).

- Safety Criteria for the Final Disposal of Radioactive Wastes in a Mine (1983).

- Model Rules for the Use of the State Collecting Facilities for the Radioactive Wastes in the Federal Republic of Germany (1981).

- Decommissioning Guide (Draft: February 1995). The guide has the rank of a safety standard.

ITALY

The Codes and Standards applicable to the decommissioning of Italian installations are set out in a single document, UNI 9498, which contains 8 sections covering individual topics. The contents of the individual sections of the document are summarised below.

In general the present standard pertains explicitly to the following type of plant:
- nuclear reactors
- nuclear subcritical units
- nuclear power plants
- nuclear research plants
- nuclear plants for spent fuel reprocessing
- plants for preparation and fabrication of special fissile materials and of nuclear fuel
- storage of special fissile materials and of nuclear fuel
- installations for reprocessing, conditioning or temporary storage of radioactive wastes.

The present standard is not applicable to:
- uranium mines
- storage of final disposal of radioactive wastes
- plant where during the operation, no radioactivity has been produced
- plants which have been converted to a new nuclear related use.

UNI 9498/1 - General criteria

The present standard shows a general picture including principles and factors which have to be considered for the decommissioning of a nuclear plant. All the procedures, whether of a management, accounting and administrative type, or of a technical type, must be planned and done in a controlled and documented way.

The standard provides to the operator of nuclear plants to be decommissioned and, usually, to people responsible for the planning and execution of decommissioning operations, indications and recommendations about the methods and the technical options which are convenient in order to maintain an adequate sanitary protection for workers, public and environment, and finally to reach the total elimination of the residual radiological risk associated to the plant.

In the present standard it is explicitly indicated that the decommissioning process cannot be thought of as terminated if it does not result in a situation without radiological constraints for the plant and its site (unconditional use). Such a situation can be reached in a single phase, or in a number of phases, with potentially significant amounts of time between each.

The scope of the present standard begins at the decision of the owner/operator to permanently shut down the plant, and terminates when a situation without radiological constraints is reached. The status of the plant taken as a reference in the present standard is the configuration existing at the moment the decision is made to permanently shut down. The radioactive substances present are those associated with the normal operation of the plant itself. The standard does not deal with decommissioning activities following a severe accidents.

The aspects related to processing, conditioning, transportation and disposal of radioactive wastes are not included in the scope of the present standard. The numerical definition of radioactivity limits for materials free from radiological constraints are also not included. nor the management, accounting and administrative aspects. Even if these aspects have to be accurately taken into account in planning the decommissioning activities, they have not to be discussed in a specific way. The present standard does not exempt the user from observing the rules and authorising procedures in force.

UNI 9498/2 - Decontamination techniques

The section shows the principles and the methodologies which have to be considered for the planning and execution of decontamination activities at a nuclear plant being decommissioned, for the case of either immediate or deferred dismantling.

It provides technical information and recommendations necessary to the owner/operator of the plant and to people responsible for the planning and execution of all the decontamination procedures which are useful in improving the conditions of radiological protection at the plant as well as in achieving the optimum management of wastes.

It is not applicable to plants which, following an accident, show a generalised contamination of components, structures and buildings and of the site itself. In this case specific decontamination techniques will be have to set up, and they are allowed to be different to those described in the present standard.

UNI 9498/3 - Storage and surveillance

This section identifies the fundamental activities which are necessary to be done on a nuclear plant at the end of operation, to leave it in a safe condition for an adequate period of time.

It is concerned in particular with plants where the existing radioactivity, after the complete removal of all fissile materials, is due primarily to radioisotopes which have decay times which justify placing the plant in a C&M state for appropriate period, in order to allow the plant to be completely dismantled with a greatly reduced level of radioactivity.

UNI 9498/4 - Dismantling of structures and components

This section describes the principles and the factors which have to be taken into account for the dismantling and removal of structures and components which have become contaminated and/or activated during the operation of the plant.

UNI 9498/5 - Radioactive inventory

This section specifies the methodologies to be followed in the evaluation of the remaining radioactivity and of the associated radiation fields in order to carry out the radiological characterisation of the nuclear plants to be decommissioned. Such methodologies must be programmed and performed in a checked and documented way.

UNI 9498/6 - Radiological characterisation and classification of materials

This section deals with the factors which have to be taken into account to characterise and classify the materials produced during the decommissioning of nuclear plants. It provides the criteria against which the most appropriate methodology for characterisation and classification of materials as a function of type is to be chosen, as well as providing guidance for the choice of measurement instrumentation appropriate to define the radiological state of the materials.

UNI 9498/7 - Criteria for partial release of a nuclear plant and/or site

This section deals with those nuclear plants to be decommissioned for which a decision has been made to delay final dismantling for a sufficiently long period of time, such that they will have to be placed in a C&M state.

The decision of putting a part of a nuclear plant in a C&M state depends on the requirement to release some zone where other activities of a non nuclear type can continue to be performed. Usually the part of the plant that will be put in a C&M state will be that part where the radioactivity cannot be easily removed but can be confined for long periods of time in well defined and sealable zones. Usually these are areas where the major part of the radioactivity is coming from neutron activation.

UNI 9498/8 - Requirements for the temporary storage of radioactive wastes and materials

This section gives the criteria to be followed in the design of a temporary store for the radioactive wastes resulting from the operation and dismantling of the nuclear plants. It also provides the general technical requirements which have to be satisfied either in the design and management of the new temporary store, or in the modification of already existing facilities.

Furthermore it provides the criteria for protection of the environment against pollution resulting from management of radioactive wastes, in order to minimise the individual and collective doses of population and workers, and to preserve the quality of the environment for the present and future uses of the site.

The radioactive wastes mentioned above are those that, even if arising from reprocessing and/or conditioning activities, are solid and satisfy the radioactivity concentration limits according to present standards for temporary storage or for disposal at an appropriate site.

SPAIN

The Spanish nuclear legislation, although conceived for the construction and operation of installations, is applicable also to dismantling. The following are particularly applicable:

- Nuclear energy act 25/1964.
- Law 15/1980, governing creation of the Nuclear Safety Council.
- Royal decree authorising the creation of ENRESA (RD 1522/1984, modified by orders issued on 30-12-88 and 20-12-94).
- Regulation governing Nuclear Risk (D 2864/1988).
- Regulation governing Nuclear and Radioactive Installations (D 2869/1972).
- Regulation governing Protection against Ionising Radiations (RD 53/1992).
- Regulation governing Coverage of Nuclear Risks (D 2177/1967).

The legislation assumes dismantling to be a phase of plant operation, consequently responsibility for the process is to the owner of the installation. Nevertheless, the Spanish administration created a company having its own legal standing, the Empresa Nacional de Residuos Radiactivos (ENRESA), to take charge of radioactive wastes in general, including those generated during operation and also those of interest here: the wastes produced during the dismantling process.

In certain installations, ENRESA is responsible for performance of the decommissioning plan and takes over the installation on approval of this plan. In any case, responsibility for the decontamination processes currently being performed is still to the owner organisations, with collaboration by certain service companies which undertake part of the technical activities under the direction and supervision of the owner, and by ENRESA, which manages the radiologically contaminated materials, removing them from the site and undertaking their subsequent processing or disposal.

UNITED KINGDOM

The Quality Assurance (QA) systems of the owner/operators of nuclear installations in the UK must meet the requirements of BS5882 (1990) - A Specification for "A total quality assurance programme for nuclear installations". It specifies principles for QA for nuclear installations from design through to decommissioning, and covers the whole plant. For the provision of services and equipment, including the construction of new plant, the BS 5750 or equivalent ISO documents are applied. Part 1 (specification for design/development, production, installation and servicing), 2 (specification for production and installation), and 3 (specification for final inspection and test) are to be specified as necessary. Associated documents include BS 5781, BS 4778, USA 10 CFR 50 and ANSI/ASME NQA-1, and IAEA 50-C-QA.

The UKAEA also employ Corporate Safety Instructions (CSIs) which cover all aspects of operations and safety, and decommissioning. In particular CSI 80 deals with radiological protection and sections 1.3 and 1.4 deal with dose limits to personnel. Section 1.7 deals with identified personnel, their monitoring, recording and when to inform the Health and Safety Executive (HSE). Section 1.8 specifies that records must be kept for 50 years and that personnel must be informed of their exposure record, including contractors.

Legislation specifically applicable to decommissioning includes :-

The Health and Safety at Work act 1974 (HSW74)
The Nuclear Installations Act 1965 (NIA65)
The Nuclear Installations (Dangerous Occurrences) Regulations 1965
The Nuclear Installations Regulations 1971
The Nuclear Installations Act (repeals and modifications) Regulations 1990
The Ionising Radiations Regulations 1985 (IRR85)
The Public Information for Radiation Emergencies Regulations 1992 (PIRER92)
The Management of Health and Safety at Work Regulations 1992 (MHS92)
The Radioactive Substances Act 1993
The Ionising Radiations (Outside Workers) Regulations 1993 (OWR93)

In addition there are other regulations and acts of Parliament that apply to safety in the workplace.

7. LICENSING REQUIREMENTS

This Chapter provides information relating to the Licensing requirements for decommissioning nuclear installations in the various countries.

FRANCE

Applications for permits

Conditions

Decree no. 90-78 of 19/1/90, which modified the decree no. 63-1228 of 11/12/63, sets out the steps to be taken by a plant owner prior to undertaking procedures for final shutdown and subsequent decommissioning.

From the technical point of view it is useful to identify the various phases which follow the end of operation of a facility (e.g. last shut down of a reactor):

The first phase, leading to the permanent cessation of operation, involves those tasks which can be done by the owner under the terms of the initial permit for construction of the facility. These tasks are carried out according to the general operational regulations and the safety report for the initial installation and comprise the removal of new and irradiated fuel, fissile and nuclear materials, radioactive sources and wastes, inflammable materials, the cleaning and washing of equipment and the replacement of filters and resins.

The following phases involve:

The procedures for final shutdown of the facility which are principally:

- dimantling of equipment outside the nuclear island and not concerned in the maintenance and surveillance of its safetv,

- maintenance or reinforcement of the confinement shields,

- preparation of a report on radioactivity inventory.

When completed, these procedures result in stage 1 decommissioning as defined by the IAEA and are generally carried out by the owner using his own resources.

Dismantling, in the true sense of the word, may begin straight after final shutdown or may be postponed to take advantage of the radioactive decay of some active or contaminated materials. Dismantling leads to stage 2 or 3 decommissioning according to the final state chosen.

Regulations

Six months before the end of operation, a safety dossier must be sent to the central authority for nuclear safety. This dossier concerns the first phase tasks preceding permanent cessation of operation which are contained in the initial permit for construction. The authority is kept informed of the progress of these works by periodic interim reports and officially recognises their completion on delivery of the final report.
Article 6.3 of decree no. 63-1228 as modified sets out permit requirements prior to starting procedures for final shutdown and subsequent dismantling. Thus a permit must be issued by decree based on the Ministry of Industry report after examination of the interministerial committee for BNIs and after the favourable opinion of the Health Ministry.

In applying for this permit, a dossier must be delivered to the head of the central authority for nuclear safety. The dossier must include certain supporting documents:

- a paper justifying the future chosen for the facility and showing the different steps in its decommissioning,

- a safety report dealing with the tasks for final shutdown and dismantling and setting out the arrangements for ensuring the safety of the facility,

- general rules for surveillance and maintenance which must be observed in order to preserve a satisfactory safety level during the works and operations,

- an update of the internal emergency plan for the site concerned.

Provided the relevant decree has been issued in time, there is nothing to prevent the procedures for final shutdown beginning before the permanent cessation of operation. This would not be the case for dismantling operations, however, which by their nature involve the nuclear island itself.

At the end of decommissioning three situations are possible:

- the installation has been entirely dismantled and can be removed from the list of BNIs,

- the installation is classified for the protection of the environment and must be authorised or simply declared according to the procedures laid down for this type of installation,

- the installation ends up as a new basic installation which must be authorised by decree after a public enquiry as provided for by decree no. 63-1228 as modified.

In this last alternative, it is desirable that the permit should also cover the entirity of operations for final shutdown and the dismantling works, which are then regarded as contributing to the creation of a new BNI. The safety report which forms part of the dossier for the head of the central authority for nuclear safety then becomes the preliminary safety report for the new BNI.

GERMANY

A licence is required for the decommissioning of an installation, the safe enclosure of a finally decommissioned installation or the dismantling of the installation or parts thereof (Atomic Energy Act).

A decommissioning concept (not a plan) is required for the initial licencing of installations. The Commission for Radiological Protection (RSK) recommended special design features for Light Water Reactors to establish feasibility of decommissioning.

Separate licences are needed for:

1. withdrawal from service
2. safe enclosure
3. dismantling.

An application must include a safety analysis report and decommissioning plan. Announcement and public inspection may be dispensed with if no harmful impact to third persons is expected. Concerning the existing licences a public inspection has been dispensed for each, with the exception of dismantling of KKN (Nieder-aichbach). For this project a technical or judicial argument for public inspection, which had taken place, is not anticipated.

For example, the decommissioning of KKN consisted of six phases:

- establishment of the dismantling site,
- dismantling of the non-radioactive plant components
- dismantling of the contaminated plant components,
- remote-controlled dismantling of the activated moderator tank and its internal components and dismantling of the thermal shield,
- demolition of the biological shield,
- demolition of the building.

The authorisation of Safe Enclosure (SE) is limited to

- 25 years (KWL)
- 30 years (THTR 300: filed in the application)
- 35 years (FR-2)
- no limitation declared (AVR: in the safety report a period of 20 to 30 years is quoted)
- no limitation (FRF-2)
- no limitation (FRN).

For the following installations in the C&M state a concept for total dismantling is to be submitted by 1998 for KWL and 2010 for FR-2.

ITALY

Up to the present time there is no official legislation about Licensing requirements for decommissioning nuclear plant in Italy. A new legislation decree has recently been issued concerning nuclear plants, where three articles (55, 56, 57) are devoted to this subject. These are as follows:

Art 55. - Authorisation for the decommissioning of nuclear facilities.

1. After a request by the owner of the licence, the execution of the operations to be carried out in connection with the decommissioning of a nuclear facility has to be authorised by the Ministry of Industry, after a hearing with the Ministries of the Environment, of Internal Affairs, of Work and of Health, with the interested region and with ANPA. This authorisation is granted, if necessary, for single phases with respect to the last expected status of the facility.
2. The subdivision into intermediate phases has to be justified as a part of a global plan of decommissioning, to be attached to the request of authorisation connected to the first phase.
3. For each phase, a copy of the request of authorisation has to be sent to the administration of item (1) above and to ANPA, jointly of the plan of the operations to be done, a description of the conditions of the facility, including also the inventory of the present radioactive materials, an indication of the condition of the facility at the end of the phase, the safety analyses related to the operations to be done and the conditions of the facility at the end of the operations, an indication of the destination of the radioactive materials, an evaluation of the effects on the outside environment and a programme of radioprotection for a possible emergency. In the plan, the owner of the operating licence also proposes the timescale for carrying out the above.

Art 56 - Procedure for the granting of the authorisation for the proposed sequence of decommissioning operations.

1. The Administration mentioned in Art. 55 sends to ANPA the requested documentation outlined in Art. 55, within 60 days of their receipt, together with their own observations and comments.
2. ANPA, having seen the request of authorisation and the related documentation and taking into account the observations/comments as per item (1) above, prepares and sends to the same Administration a document with its own evaluation and also an indication of the possible limits and conditions to be fulfilled.
3. The Administration sends its final observations/comments to ANPA, within 30 days of receiving the documentation. ANPA, after a hearing with the technical commission, then prepares and sends to the Ministry of Industry its own opinions together with an indication of possible limits and conditions to be fulfilled.
4. The Ministry of Industry grants the Authorisation as per Art. 55, subject to the possible limits and conditions to be fulfilled as defined by ANPA.
5. The execution of the decommissioning operations happens under the supervision of ANPA which monitors their progression and, on the basis of a specific request of the owner of the authorisation, verifies if all the requirements of the authorisation have been fulfilled.

Art 57. - Final report.

1. The owner of the Authorisation, at the end of the operations outlined in Art 56, sends to ANPA one or more reports to document the operations carried out and the conditions of the facility and of the site.
2. The Ministry of Industry, after a hearing with the interested Administrations and ANPA, issues, by its own decree, the possible prescriptions connected with the conditions of the facility and of the site at the end of the operations.

SPAIN

According to the Ministerial Order issued by the Ministry of Industry and Energy on 31st July 1990, in order for dismantling to be performed it is necessary for a "Dismantling and Decommissioning Plan" to be approved by the competent Authority. In addition, it is necessary for the fuel to have been unloaded and removed from the site and for the unloading and removal of operating wastes to have been completed.

The installations have to draw up the Dismantling and Decommissioning Plan. In the case of Vandellós I NPP, the responsibility for this plan lies with ENRESA, which will take charge of the installation as responsible owner once it has been approved by the Ministry of Industry and Energy. The plan is to include the following documents:

- Safety Study: Description of the installation, General Project, Safety Study and Environmental Impact study.
- Technical Specifications.
- Plan organisation and schedule.
- Quality Assurance Manual.
- Dismantling Waste Management Plan.
- Radiological Protection Manual.
- Emergency Plan & Physical Safety Plan.

For other installations, such as the Argos and Arbi reactors, a fuel removal permit has been required along with another for decommissioning, with a view to declassifying the installation. In both cases a dismantling project has been submitted to the Administration (CSN); in the case of the Arbi reactor, this has given rise to a crossfire of questions and clarifications followed by an audit, a second version of which is currently being prepared.

CIEMAT has established a General Dismantling Plan for Nuclear and Radioactive Installations (PGD) which contemplates the following aspects for each facility:

- Dismantling of active and/or contaminated equipment, these being rendered radiologically clean.
- Elimination of active and/or contaminated materials and of the conventional scrap produced during the decommissioning phase.
- Decontamination of surfaces and structural elements of the areas previously housing the installations, in order for them to be used for other purposes.

UNITED KINGDOM

In the UK, the licence to construct nuclear plant includes a requirement to ensure safety throughout life including decommissioning. Therefore for a recent station such as the PWR at Sizewell B, the licence requires that arrangements covering the principles to be adopted for decommissioning are in place at start up. In the case of the Magnox stations, there was no such requirement to declare arrangements for decommissioning when licences were originally granted and the utility must apply for the existing operating licence to be extended to include decommissioning.

The licence to build, operate and finally decommission a nuclear power station or processing facility in the UK is granted by the Nuclear Installations Inspectorate (NII) of the Health and Safety Executive (HSE).

The NII does not prescribe any design or operating criteria with which the utility must comply. In words used by NII, '*The Inspectorate does not prescribe detailed standards or codes for nuclear plant*'. It expects each applicant for a new licence or an existing licensee wishing to change the terms of a licence to develop its own design and operating safety criteria and operating rules and provide the justification of its safety case. The criteria may make reference to national and international standards, such as those of the IAEA, the British Standards Institution or the American Society of Mechanical Engineers to demonstrate that they incorporate good practice. Although the proposed criteria may be accepted by NII, they are never formally approved or promulgated as standards or codes.

The NII assesses applications for nuclear licences. The HSE have issued two key documents relating to safety of nuclear installations, one of which provides guidance to the Inspectors of the NII on the principles to be used when making assessments. These are:

(i) The tolerability of risk from nuclear power stations - 1991 (introduces assessment of risk, the legal limits of radiation dose in UK and the principle of 'as low as reasonably practicable').

(ii) Safety assessment principles for nuclear plants - 1992 (Guidance to Inspectors when making assessments and including reference to decommissioning).

The overall guiding principle in assessment is that '*the risk should be reduced as far as reasonably practicable*'. The applicant is expected to develop his own criteria to demonstrate his safety objectives and how he expects to be able to achieve them. This is consistent with the application of British law to both safety at work and responsibility for nuclear risk.

In practice, a utility requiring to build, operate and decommission a nuclear power station must submit a request for a licence to the NII and propose the way in which it intends to satisfy the very broad principles set out in the NII documents. The NII will consider the proposals and, if satisfied in a preliminary way, will then enter a more detailed dialogue with the utility, increasing the detail as the assessment process continues.

Each request for a licence is treated separately and there is no certain assurance that criteria accepted for a previous plant will automatically be accepted for a later plant. Improvements will be sought as experience accumulates. Discussion will devolve around what is achievable taking account of experience and advances in technology, within the remit of keeping radiation `*as low as reasonably practicable*'. Experience is therefore developed case by case and a general understanding of acceptable practice is built up by the utility.

Decommissioning is still in the early stages of planning and execution. Practice will evolve over several years and the licensing procedure and working plans will be reviewed as experience accumulates.

The application for a nuclear licence is supported by a sequence of Safety Reports related to distinct stages of the project. When a licence is granted, the utility will be required to make arrangements to ensure that at all stages from start of construction through to completion of decommissioning, the safety case is justified by Safety Reports and that the safety case they describe is never violated.

The NII, in general, require the following stages of documentation in justification of the safety case for the plant.

- Design safety principles and criteria
- Preliminary Safety Report (PSR)
- Pre-construction Safety Report (PCSR)
- Pre-operation Safety Report (POSR)
- Pre-decommissioning Safety Report (PDSR)

For new stations, the PSR and POSR must include an outline decommissioning plan. This will be developed in detail and become a full decommissioning plan for inclusion in the PDSR at least two years before commencement of decommissioning.

For existing Magnox stations, the original licence did not make provision for decommissioning. Therefore the licence has to be extended and for this purpose, the NII require preparation of a Pre-decommissioning Safety Report which incorporates a Decommissioning Plan. It is recognised that decommissioning may extend over many years and be divided into stages such as defuelling, safe keeping of radioactive plant and final dismantling. Therefore a licence is likely to be granted subject to hold points on the work at predetermined stages and further consent by the NII before starting the next stage.

When granting the licence for a construction of a new station or decommissioning an existing station, the NII attach conditions with which the utility must comply. The principles of compliance with these conditions are identified by the utility in `Arrangements Documents' which they must prepare and to which they then relate their formal Operating Rules and Operating Instructions. The NII specifies those Arrangements Documents it wishes to see and those which will require its approval.

An 'Arrangements Document' will be required for decommissioning and be subject to approval by the NII. Typically, it will identify arrangements to be in place to ensure the production and implementation of:

(i) A decommissioning plan with documentation to justify safety at all stages
(ii) Decommissioning programmes.

These will subject to:

(i) Approval by NII of such parts of the arrangements it specifies
(ii) Prohibition of changes to such approved parts without further consent by the NII
(iii) Specification of stage points in decommissioning which require NII consent before proceeding.

The principles covered by the Arrangement Document for Decommissioning are expected to include:

(i) The responsibility for satisfying the licence condition
(ii) The existence of appropriate Management Procedures and Operating Rules
(iii) The Pre-Decommission Safety Report and Decommissioning Plan (the latter defining technical proposals and overall plan)
(iv) Decommissioning programmes for stages within the overall plan and hold points for NII approval
(v) Quality Assurance programmes for all safety related activities
(vi) Interim decommissioning of redundant irradiated plant
(vii) Disposal of radioactive waste
(viii) Appointment of a Decommissioning Safety Committee
(ix) Lifetime design, manufacturing and operational records relevant to decommissioning.

The decommissioning process is evolving and procedures are being developed both for licensing and management. However, the UK planning for Magnox stations involves a total span of 130 years from station shutdown to clear site. A decommissioning safety case was not made at the time of the original licence and the future safety arrangements have to be kept under continuing scrutiny and review to take account of any consequential absence of important data or of problems of access for monitoring and demolition. All activity will subject to NII scrutiny applying the principle of keeping radiation '*as low as reasonably practicable*' and practice with the utilities will be developed on a case by case basis.

<u>Site Licence</u>

The site Licence contains the following schedules :-

Schedule 1

Part 1 - Definition of the Site
Part 2 - Description of the Nuclear Installations

Schedule 2 Licence Conditions

1 Interpretation
2 Marking of the Site Boundary
3 Restriction on Dealing with the Site
4 Restrictions on Nuclear Matter on the Site
5 Consignment of Nuclear Matter
6 Documents, records, Authorities and Certificates
7 Incidents on the Site
8 Warning Notices
9 Instructions to Persons on the Site
10 Training
11 Emergency Arrangements
12 Duly Authorised and Other Suitably Qualified and Experienced Persons
13 Nuclear Safety Committee
14 Safety Documentation
15 Periodic Review
16 Site Plans, Designs and Specifications
17 Quality Assurance
18 Radiological Protection
19 Construction or Installation of New Plant
20 Modification to Design of Plant
21 Commissioning
22 Modification or Experiment on Existing Plant
23 Operating Rules
24 Operating Instructions
25 Operational Records
26 Control and Supervision of Operations
27 Safety Mechanisms, Devices and Circuits
28 Examination, Inspection, Maintenance and Testing
29 Duty to Carry out Tests, Inspections and Examinations
30 Periodic Shutdown
31 Shutdown of Specified Operations
32 Accumulation of Radioactive Waste
33 Disposal of Radioactive Waste
34 Leakage and Escape of Radioactive Material and Radioactive Waste
35 Decommissioning

Schedule 3

Continuing valid Approvals

The licence holder's Safety Instructions generally follow the above format. The documents that are generated must be held for 30 years after the document ceases to be in force.

Standard Licence Condition 35 - Decommissioning

Condition 35 has the following sub-sections :-
(List taken from "Regulatory Issues in Decommissioning " by CR Willby HSE)

1. The licensee shall make and implement adequate arrangements for the decommissioning of any plant or process which may affect safety
2. The licensee shall make arrangements for the production and implementation of decommissioning programmes for each plant
3. The licensee shall submit to the HSE for approval such part or parts of the aforesaid arrangements or programmes as the HSE may specify
4. The licensee shall ensure that once approved no alteration or amendment is made to the arrangements or programmes unless the HSE has approved such alteration or amendment
5. The aforesaid arrangements shall where appropriate divide the decommissioning into stages. Where the HSE so specifies the licensee shall not commence nor thereafter proceed from one stage to the next of the decommissioning without the consent of the HSE. The arrangements shall include a requirement for the provision of adequate documentation to justify the safety of the proposed decommissioning and shall where appropriate provide for the submission of this documentation to the HSE
6. The licensee shall, if so directed by the HSE where it appears to them in the interests of safety, commence decommissioning in accordance with the aforesaid arrangements and decommissioning programmes
7. The licensee shall, if so directed by the HSE, halt the decommissioning of the a plant and the licensee shall not recommence such decommissioning without the consent of the HSE

8. CONCLUSIONS

8.1 A study has been carried out on nuclear installations being decommissioned in a number of member states, namely France, Germany, Italy, Spain and the United Kingdom. The purpose of the study has been to (i) update the list given in /1/ to include additional nuclear installations shut down in the above countries between 1993 and 1995 (ii) provide information on the decommissioning stage attained at each installation and its planned future state, (iii) identify the monitoring and inspection proposals/experience for these installations including where possible the effort involved, and (iv) identify relevant codes and standards applicable to decommissioning in the above countries and to identify where available the relevant licensing requirements. Information gathered from the named countries on the above subjects is presented in the report. Additional information has also been included on the general decommissioning plans/policies for the named countries (or particular utility or company within a country) and the specific organisations within these countries charged with overseeing the important aspects of decommissioning such as safety, radioactivity discharges etc.

8.2 Up to the end of 1995, at least 42 large power reactors, 34 small reactors and 34 other nuclear industry related installations had already been, or were in the process of being, decommissioned. (These include installations in Belgium, Denmark and the Netherlands which were not covered by the study). In general, the actual or planned time taken to complete each decommissioning stage for an installation depends on the planned final state/use for the installation and the current policy of the organisation/country reponsible for its decommissioning. For example, some organisations/countries prefer to quickly decommission their installations to Stage 3, whilst others prefer a more long term approach in which the installations are placed in a lengthy C&M state after Stage 2 (and in some cases after Stage 1) decommissioning.

8.3 During, and also between, the three decommissioning stages, it is important that all containment buildings should be kept in a state appropriate to the remaining hazard, and the atmosphere inside the buildings should be subject to appropriate control. In addition, appropriate monitoring and inspection procedures should be in place to cover man-access and to ensure the all plant and monitoring equipment remain in good condition. For each of the installations currently being decommissioned, the information obtained indicates that monitoring and inspection activities are being carried out, the level of such activities appearing to vary from one installation to another. For example, within the containment barriers, humidity and temperature levels are monitored and controlled in some but not all cases. It is assumed that the intensity and frequency for such activities required at each installation has been pre-determined by the organisation responsible for its decommissioning, that they have been agreed with the appropriate regulatory body, and that they are sufficient to adequately cover the radiological risks at all times.

8.5 During fast decommissioning to Stage 3, there will generally be a continous large staffing level and the necessary monitoring and inspection will be carried out by specialist teams as dismantling progresses. If, however, there are to be long periods between stages in which the installation is to be placed in a C&M state, only small teams of specialists will be required to carry out any monitoring and inspection of the radiologically controlled area(s).

REFERENCES

/1/ Policies, regulations and recommendations for decommissioning of nuclear installations in the European Community. EUR 15355.

ANNEX 1

SUMMARY OF SHUTDOWN NUCLEAR FACILITIES IN FRANCE

The nuclear installations currently being decommissioned in France and which are the responsibility of the CEA are detailed below.

- G1, G2 and G3 Marcoule.

  G1 was the first industrial-scale Plutonium producing reactor which ran from 1956 to 1968. It was graphite moderated and gas cooled. It has been decommissioned to stage 3 except for civil engineering (reactor block), and a 100m high chimney. The extent of the radiologically controlled area(s) is the reactor block and chimney. The buildings are being used for other purposes. Radiological surveillance was carried out by the Health Physics department. G2 and G3 are similar but larger plants which ran from 1959 to 1980 and 1960 to 1984 respectively. It is expected that stage 2 decommissioning of both will be completed during 1996. The radiologically controlled areas have been reduced by about 5%. A Centralised Radiological Control System (TCR) is mainly used for the melting facility. Periodic atmospheric and surface checks in the rest of the installation are carried out together with surveillance of the reactor block confinement.

- EL2 and EL3, Saclay & EL4, Monts d'Arree.

  These are heavy water moderated, gas cooled reactors which operated between 1952-1965, 1957-1979, and 1966-1993 respectively. EL2 and EL3 are currently undergoing stage 2 decommissioning which is planned to take 3 and 4 years to complete respectively. The extent of the radiologically controlled area(s) for each is the reactor block. The expected completion of stage 3 dismantling for EL4 (excluding civil engineering) is the end of 1997. Both have been removed from BNI classification, with EL3 now classified as an Installation Classified for the Protection of the Environment (ICPE) no. 88.

- Pegase & Rhapsody, Cadarache.

  Pegase was a pool type reactor which operated between 1963 and 1975. It has been decommissioned to stage 3, except for civil engineering. It has been a new BNI for waste storage since 1980. Periodic inspections are carried out under the new BNI regulations by the operating and health physics teams. The extent of the radiologically controlled area(s) are the same as at the start of the project (due to it becoming a new BNI). Rapsodie is an experimental fast reactor which operated between 1967 and 1983. Stage 2 decommissioning began in 1987. The radiologically controlled area has been reduced by 20% compared to the original. The reactor block has been confined and a new TCR has been installed.

- Triton, Fontenay.

  This was a pool type reactor which operated between 1959 and 1982. Decommissioning activities were carried out between 1983 and 1986 and it is now operated as ICPE No. 87. As a result the health physics department will continue to be responsible for radiological surveillance and controls. Work on fixed structures: infrastructure, works, pool, and ventilation are subject to prior agreement and are checked in situ by the health physics department.

- Melusine, Grenoble.

  This was a pool type reactor which operated between 1959 and 1988. Decommissioning of the installation will be to stage 3 with the exclusion of civil engineering. Specifications are currently being drawn up and authorisation for dismantling is expected in 1996. The extent of the radiologically controlled area(s) is the reactor block and annexes. BNI regulation checks are being carried out by the operating team.

- Other installations.

  These are the Elan II B source fabrication plant at La Hague, the AT1 fuel reprocessing plant at Trisaia and the PIVER waste vitrification plant at Marcoule. Elan II B comprises several shielded cells for manufacturing Caesium 137 and Strontium 90, and operated between 1970 and 1973. Dismantling work involving the removal of process equipment was carried out between 1979 and 1993. There has been no change to the extent of the radiologically controlled area(s) since the beginning of the project. The installation is maintained in a safe condition. The TCR has been overhauled and the ventilation system is kept running. It is now classed as BNI no 47 and periodic BNI regulation inspections are carried out. Preparation for stage 3 decommissioning is currently being carried out.

  AT1 was a pilot plant for reprocessing irradiated fuel from fast reactors and operated between 1969 and 1979. Areas subjected to surveillance have been reduced by about 30% since dismantling was started. The confinement ventilation system and Very High Efficiency filters are kept in operation. Completion to stage 3 decommissioning (excluding civil engineering) is expected during 1996.

  PIVER was a waste vitrification plant and operated between 1966 and 1972, and between 1978 and 1980. Only the vitrification equipment has been dismantled to date. There has been a relocation of buildings for other uses and these are now controlled zones. For the new use of the cell, ventilation under pressure is maintained and periodic radiological checks are carried out by the operating and health physics teams.

SUMMARY OF SHUTDOWN NUCLEAR FACILITIES IN GERMANY

The nuclear installations currently being decommissioned in Germany are detailed below.

- HDR, Grosswelzheim.

  This was a boiling water reactor which operated between 1969 and 1971. The installation was converted into an experimental facility: non-nuclear experiments for reactor safety, e.g. simulation of accidents. The installation is in progress to Stage 3 decommissioning until the year 2001. At present, the radiologically controlled area envelopes the reactor building, the waste management building and the interim store. HDR and VAK are situated on the same site. Both installations share a permanent staff to provide security and surveillance.

- KKN, Niederaichbach.

  This was a heavy water reactor which operated between 1973 and 1974. All nuclear fuel and operational wastes have been removed from the installation and all nuclear systems of the installation have been dismantled and decontaminated. In August 1994 the installation was released from the Atomic Energy Act. The conventional dismantling of the building started in October 1994 and will be finished in 1995. The installation is in progress to Stage 3 decommissioning.

- KRB A, Gundremmingen.

  This was a boiling water reactor which operated between 1966 and 1977. The plant is completely defuelled. The operational wastes are stored in the buildings. The dismantling of low-contaminated peripheral systems such as the solid materials store and the components of the turbine hall has been completed. In a second phase the redundant components in the reactor building have been dismantled. In this and in the next years until 1998 the activated components, i.e. the reactor pressure vessel and its internals and the biological shield will be dismantled. Dismantling of the installation is planned to be completed by 2000. It is intended to re-use the buildings, e.g. the workshop as a hot workshop for KRB B. The installation is in progress to Stage 3 decommissioning. At present, the installation has one radiologically controlled area which envelopes the reactor building and the turbine hall. KRB A, KRB B and KRB C are situated on the same site. All three installations share a permanent staff to provide security and surveillance.

- KWL, Lingen.

  This was a boiling water reactor which operated between 1968 and 1977. The plant is completely defuelled. The essential radioactivity inventory consists of the reactor vessel and internals, core elements (control rods etc.) and operational wastes (unconditioned ion exchange resins etc.). These wastes are stored in the plant. In 1985 the licence for C&M state was granted. The C&M period started in 1988. The authorisation of C&M or Safe

Enclosure (SE) is limited to 25 years. (Stage 1). After ten years, a concept for dismantling is to be submitted, which is then to be updated every five years. The SE part of the plant comprises the reactor building, the process building, and the building connecting these two. There is only one entrance to the SE.

At present, the SE and the off-air duct are controlled areas. The storeroom for solid materials, the flood tank building and some laboratories were decontaminated and released from the radiologically controlled area. No forced cooling is required within the reactor vessel. An unmanned air conditioning and switch station was set up outside the SE. An additional air dryer, working by absorption, was installed in order to intensify drying of the SE atmosphere at low temperatures. A small negative pressure inside the SE is maintained. Humidity and temperatures levels are also maintained within specific limits to limit steelwork corrosion. During the SE period the installation is remotely surveyed by TV, alarm systems etc., from the site entrance cabin, which KWL shares with two operating power plants, and which is permanently occupied. The air conditioning and switch station is inspected weekly and the SE is inspected quarterly. The leak-rate of the SE as a function of the differential pressure is measured yearly.

- MZFR, KNK-II & FR-2, Karlsruhe.

MZFR was a heavy water reactor which operated between 1966 and 1984. All nuclear fuel and operational wastes have been removed from the installation. Most auxiliary systems have been dismantled. The next partial licence will be applied for dismantling of the reactor pressure vessel. The installation is in progress to Stage 3 decommissioning. The complete dismantling of the installation is planned by 2005. At present, the installation has one radiologically controlled area, which envelopes the reactor pressure vessel and the D_2O circuit. Security / surveillance of the site is carried out by the KfK staff.

KNK-II was a sodium cooled fast breeder reactor which operated between 1978 and 1990. All nuclear fuel has been removed from the installation. The installation has been finally shut down in 1991. Partial licences for decommissioning were granted in 1993, 1994 and 1995. At present, primary and secondary circuit are still filled with sodium. A filling station for secondary sodium is to be established, operated and decommissioned. It is intended to place the installation in a SE state until 2005 (in progress to Stage 2 decommissioning). At present, the installation has one radiologically controlled area which envelopes the reactor building. Security/ surveillance of the site is carried out by the KfK staff.

FR-2 was a heavy water reactor which operated between 1962 and 1981. All nuclear fuel has been removed from the installation. The primary reactor containment is in a SE state (Stage 2 decommissioning). It is intended to maintain the reactor containment in the SE state for 35 years. KfK has to submit a concept for total dismantling by 2010. The cooling pond building and the ventilation building will be dismantled by 1997. The hot workshop will be used by KfK. The radiologically controlled area envelopes the reactor building, the cooling pond building, the ventilation building and the hot workshop. A small negative pressure inside all sealed radioactivity barriers and the reactor building is maintained. Humidity and temperatures levels are also maintained within specific limits to limit steelwork corrosion. Monitoring and maintenance are carried out periodically by KfK staff. Security / surveillance of the site is carried out by the KfK staff.

- VAK, Kahl.

  This was a boiling water reactor which operated between 1961 and 1985. All nuclear fuel has been removed from the installation. The operational waste is stored in the reactor building. The contaminated systems in the reactor building have been dismantled. The next step is to dismantle the reactor pressure vessel and its internals by 2000. The installation is in progress to Stage 3 decommissioning. The conventional demolition of the buildings will be finished by 2005. At present, the installation has one radiologically controlled area which envelopes the reactor building. The turbine building is released from the controlled area. HDR and VAK are situated on the same site. Both installations share a permanent staff to provide security and surveillance.

- AVR & FRJ-1 Merlin, Julich.

  AVR was a prototype High Temperature Reactor which operated between 1967 and 1988. It is planned to defuel the reactor by 1997. The operational wastes are stored in a separate storage hall. A licence for preparation and hold of C&M was granted in 1994. The decommissioning activities have been started to prepare the C&M. It is planned to reach the C&M state in the year 1999 (Stage 1). In 1995 concepts are being investigated for total dismantling (Stage 3). At present, the installation has three radiologically controlled areas. The first envelopes the reactor building and the hot workshop , the second the turbine building. The third envelopes the storage hall with the operational wastes. As the heat generation of the fuel is low no forced cooling is required within the reactor vessel. A small negative pressure inside all sealed barriers is maintained and this is to be continued during the C&M period. Humidity and temperatures levels are also maintained within specific limits to limit steelwork corrosion. During the C&M period the initial intention is to have 3 permanent staff to provide continuous (24 hour) monitoring of pressure, temperature and humidity levels within the controlled area. Security/surveillance of the site will be carried out by own staff. After a given period of time monitoring will be carried out periodically although security staff will remain throughout the C&M period. Additional staff will be deployed as necessary to carry out any maintenance.

  FRJ-1 was a pool reactor which operated between 1962 and 1985. All nuclear fuel has been removed from the installation. The operational wastes are stored inside the reactor building. A licence has been applied for C&M period (Stage 2). FRJ-2, which shares a common pool system with FRJ-1, remains in operation. As all the fuel has been removed no further cooling is required within the reactor. A small negative pressure inside all sealed barriers is maintained and this is to be continued during the C&M period. Humidity and temperatures levels are also maintained within specific limits to limit steelwork corrosion. During the C&M period the initial intention is to have 3 permanent staff to provide continuous (24 hour) monitoring of pressure, temperature and humidity levels within the controlled area. Security/surveillance of the site will be carried out by own staff (FRJ-2). After a given period of time monitoring will be carried out periodically although security staff will remain throughout the C&M period. Additional staff will be deployed as necessary to carry out any maintenance.

- THTR 300, Hamm-Uentrop.

The installation is completely defuelled. An amount of nuclear fuel of not more than 2.5 kg remains in the reactor for technical reasons. The operational wastes have been removed from the reactor systems and processed for disposal. HKG has applied for authorisation for a SE. The licence is expected in October 1995. It is intended to start the C&M state in 1997 for 30 years. The installation is in progress to Stage 1 decommissioning. At present, the installation has two radiologically controlled areas. The first envelopes the reactor hall, the reactor process building and the reactor auxiliary building. The second envelopes the environmental laboratory.

As all the fuel has been removed no further cooling is required within the reactor. A small negative pressure inside all sealed barriers is maintained and this is to be continued during the C&M period. Humidity and temperatures levels are also maintained within specific limits to limit steelwork corrosion. During the C&M period the initial intention is to have 3 permanent staff to provide continuous (24 hour) monitoring of pressure, temperature and humidity levels within the controlled area. Security/surveillance of the site will be carried out by an appointed Company. After a given period of time monitoring will be carried out periodically although security staff will remain throughout the C&M period. Additional staff will be deployed as necessary to carry out any maintenance.

- KKR, Rheinsberg.

The reactor is completely defuelled. Operational wastes include ion exchange resins and sludges which are currently stored in underground vaults. In April 1995 a licence was granted for a permit to hold and decommission the plant, and dismantle plant components. The decommissioning activities started in June 1995. The first milestone is to reconstruct the turbine building to a shipping hall for conditioned waste packages. The installation is in progress to Stage 3 decommissioning by 2009. The installation currently has three radiologically controlled areas. The first envelopes the reactor building with the reactor containment and the fuel cooling pond. The second envelopes the underground vaults which store the fluid radioactive residues and the solid radioactive residues. The third envelopes the turbine building.

- KGR1,2,3,4,5 & 6, Greifswald

These are all PWRs which operated between 1973 (KGR1) and 1990. The nuclear fuel in KGR1 to KGR5 has not yet been removed. (KGR6 was never fuelled.) To some extent the fuel is stored in the cooling pond (in the lower level) inside the reactor building. The fuel in the reactor pressure vessel and in the upper (second) level of the cooling pond will be transferred to the ZAB (fuel pond storage) or into CASTOR containers, which will be stored inside the same reactor hall. ZAB is situated on the same site. Operational wastes (mainly evaporator concentrates, ion exchange resins, sludges, solid wastes) are stored in the reactor hall and in the buildings SG1, SG2, and GSG.

In December 1990 the decision was taken to decommission KGR1 to KGR4; the same decision for KGR5 was taken in 1991. The construction of KGR6 was halted. The reactors of KGR5 and KGR6 share a common reactor hall and some safety relevant equipment. A first application has been filed with the authorities for a permit to hold and decommission the plant, and dismantle plant components. That permit is expected to be issued on time to allow decommissioning activities to be started in November 1995. The decisive point in waste management is the existence of an interim store of sufficient capacity to accept both the nuclear fuel and the plant waste and the considerable volumes of radioactive residues arising in dismantling. Current major activities include planning for decommissioning and demolition, and drafting of the licencing documents; removal of the fuel elements from the reactor units; construction of the northern interim store (ZLN) for fuel elements and residues. The installation is thus in progress to Stage 3 decommissioning. It is estimated that the total demolition of the nuclear part will be finished by 2009 and the conventional demolition of the buildings by 2012.

- KWW Wurgassen.

This reactor was shut down in 1994 and it has recently been decided that it will remain shut down and will eventually be decommissioned. No further details are available at present.

- Otto-Hahn ship reactor.

All nuclear fuel and operational wastes have been removed from the installation. All materials, equipment and parts of the nuclear installation in which activity remained significant despite decontamination were removed. The reactor vessel with inlets and outer shielding tank were removed undismantled. The unit was shipped to GKSS for post-investigations. In all remaining parts contamination has been reduced to acceptable levels. The installation has been released for unrestricted use (Stage 3 decommissioning). The ship is being reused with conventional propulsion.

- RFR Rossendorf

The nuclear fuel is stored in the reactor and in the two cooling ponds. The operational wastes include ion exchange resins, sludges and components from former reconstruction. The wastes are stored in the two cooling ponds. The installation has been finally shut down. A first application has been filed with the authorities for a permit to hold and decommission the plant. A first milestone will be to store nuclear fuel in one cooling pond and operational wastes in the other cooling pond. After having dismantled the plant components it is intended to re-use the building. The installation is being decommissioned to Stage 3. The radiologically controlled area envelopes the reactor building with the primary reactor containment and the two cooling ponds.

- FRN TRIGA Mk III, Neuherberg.

All nuclear fuel and operational wastes have been removed from the installation. A licence for a SE has been granted for an unlimited period. The installation has been decommissioned to Stage 2. At present, the SE is a controlled area, which envelopes the primary reactor containment, inside an outer wall containment. During the SE period no further cooling and no negative pressure are required and the installation is not surveyed.

- FRF-2, Frankfurt.

  All nuclear fuel and operational wastes have been removed from the installation. A licence for a SE has been granted. The installation has been decommissioned to Stage 2. At present, the SE is a controlled area, which envelopes the primary reactor containment, inside a closed outer containment. During the SE period no further cooling and no negative pressure are required. The installation is not surveyed during the SE period. The regulatory authority measures the activity release yearly.

- FRG-2, Geesthacht.

  The reactor FRG-2 has been completely defuelled. More than 90% of the fuel elements have been removed from the site. The remaining fuel elements are stored in the cooling pond which is common for FRG-1 and FRG-2. The operational wastes of both reactors are stored together on site. After final shut-down of FRG-2 the following parts, which were necessary only for the operation of FRG-2, were dismantled: parts of the reactor protection system, instrumentation, contaminated parts of the primary cooling circuit and some parts of the secondary cooling circuit. At present, the decommissioning activities have been almost completed. The installation is being decommissioned to Stage 1. Buildings which have been used only for FRG-2 will be used for non-nuclear purposes. FRG-1, which shares a pool system with FRG-2, is likely to remain in operation for another 15 years. The monitored area of FRG-2 has been reduced. Security/surveillance of the site is being carried out by the common staff.

- Other installations. These are the Nukem-Alt, Hobeg and U-Brennelementework Uranium fuel fabrication plants at Hanau, and the WAK reprocessing plant at Karlsruhe.

  At the Nukem Alt plant, all nuclear fuel and operational wastes have been removed from the installation. At present, systems and components are being demolished and dismantled. Licences have been applied for demolition of the buildings and restoration of the soil. The installation is being decommissioned to Stage 3. It is planned to complete the decommissioning activities in 1997. At present, the installation has three radiologically controlled areas in three separate buildings. Security /surveillance of the site is continuous (24 hour) carried out by own staff.

  At the Hobeg plant, all nuclear fuel and operational wastes have been removed from the installation. All process systems have been completely decommissioned and removed. At present, the building and the soil will be exempted. In 1995 the installation will be discharged from the Atomic Energy Act. The installation is being decommissioned to Stage 3. The building will be used for non-nuclear purposes. At present, the fabrication building is still a restricted access area. Security /surveillance is carried out by the staff of the SIEMENS-Brennelementewerk fuel fabrication plant on the same site.

For the U-Brennelementewerk, the operator SIEMENS announced that the installation shall be finally shut down in October 1995. In the first phase of the decommissioning activities the inventory of uranium will be reduced under the limit of 80 kg in order to diminish the expenses for security and surveillance. A new installation for operational waste management has to be established, operated and decommissioned. In 1995 a licence has been granted to decommission some fabrication systems at the Karlstein site. The decommissioning period is estimated to be about 5 years or more.

At the WAK plant all nuclear fuel has been removed. The heat generating high active waste concentrate (HAWC) is stored in LAVA (installation for storage and evaporation of high active wastes). The non-heat generating operational wastes have been removed from the installation. LAVA/HWL (main waste storage) and the related auxiliary systems are in normal operation. The radioactive materials containing systems of the reprocessing plant in the process building have been rinsed. The current decommissioning activities include dismantling and demolishing of systems and components in the process building. The next step is to vitrify the HAWC either in the PAMELA plant in Mol (Belgium) or on site (alternative concept). In the latter case a new vitrification plant has to be established, operated and decommissioned. The filling station for HAWC (HAWA) has to be established, operated and decommissioned. The installation is being decommissioned to Stage 3 by the end of 2005. At present, the installation has one radiologically controlled area which envelopes the process building and the buildings HWL, LAVA, and ELMA (annex for storage of intermediate-level waste solutions).

ANNEX 3

SUMMARY OF SHUTDOWN NUCLEAR FACILITIES IN ITALY

The nuclear installations currently being decommissioned in Italy are detailed below.

- Garigliano.

The reactor has been completely defuelled. The operational wastes remaining are stored resins (203 m^3), sludges (40 m^3), concentrated solutions and decontaminating solutions (70 m^3), 1076 overpack barrels (320 litres each) of low level wastes (gloves, rags, paper), 29 carbon steel boxes (1000 litres each) of low level incompressible wastes (iron huge pieces etc). Several decommissioning activities are currently underway. These are:

1. The conditioning of high level wastes. This has lead to the production of 6 concrete shielded containers (50 tons each) for metallic wastes. (Total activity at 31/5/95 was 20000 Ci)
2. The GECO (Garigliano Estrazions e Condizionamento) Project which is investigating the conditioning of low level wastes (resins, concentrates, sludges). The first operational tests are likely to take place in early 1996.
3. A project to put the (spherical) reactor building in a passive and protective state of care, approved by the Italian Safety Authority (ANPA/DISP) on 17/5/95. It will be completed by late 1996.
4. A detailed project for the controlled dismantling of the stack which is under approval.
5. A project to put the Radwaste Building in a passive and protective state of care.

The extent of the radiologically controlled area(s) has been increased to allow the conditioning operation of metallic wastes (concrete shielding containers). A complete routine monitoring activity is on-going. In particular there is a continuous control of airborne and liquid releases and an environmental surveillance of milk, air, water, grass etc. After the completion of the passive and protective care of the cylindrical pressure vessel there will be no maintenance of negative pressure, but there will be a ventilation system which will keep the humidity at 40-50%. Staff are present to provide 24 hour coverage.

- Latina

The reactor was completely defuelled in July 1991. There are 1690 barrels (135 ton) of low level waste stored together with 30 ton of sludges in a special purpose tank. The plant is currently in a C&M stage. In particular the primary circuit is empty and has been depressurised since 1987. The calculation of radioactive inventory has also been performed. The radiologically controlled areas have been substantially reduced as compared with operation although no details are known. A complete routine monitoring activity is on-going. Humidity and temperature levels are not maintained within specific limits nor is a negative pressure maintained across the primary containment barrier.

- Caorso

There are 1248 fuel elements remaining in the pool. Stored elsewhere are about 1000 barrels of paper, rags gloves (0.5% w/o), about 5800 barrels of resin (82% w/o), about 300 barrels of sludges (3% w/o) and about 500 barrels (15% w/o) of other wastes. The plant is in a C&M stage. An overall project of decommissioning activities, has been performed. Detailed projects for different areas/components of the plant are underway. The extent of the radiologically controlled area(s) is the same as in operation. A complete routine monitoring activity is on-going. Humidity and temperature levels are maintained within specific limits. A small negative pressure is maintained across the barrier. Radioactivity releases to the environment are maintained under the following limits: liquid - 0.22 TBq/y, noble gas - 740 TBq/y, iodine 7.4 GBq/y, particulate - 0.26GBq/y. Staff are present to provide 24 hour coverage.

- Trino

In the pool are 125 fuel elements: 43 new, 47 irradiated and 36 just contaminated. The composition of the stored waste is as follows: paper (in a cement matrix, 7.8% w/o), rags and gloves (with also insulator material, 23.3% w/o), iron filings (3.9% w/o), resins (18.5% w/o), sludges (in cement matrix, 13.1% w/o), filters (liquid and gas, 5.9% w/o), and mixed wastes (super compactor, 27% w/o). The plant is in a C&M stage. The extent of the radiologically controlled area(s) is the same as in operation. Temperature levels are maintained within specific limits. Humidity levels are not taken into account. A small negative pressure is maintained across the barrier. Staff are present to provide 24 hour coverage.

- Avogadro, Salugga

The reactor has been completely defuelled. In 1981 it was converted into a spent fuel store. In the pool there are 322 fuel elements from the Garigliano plant and 49 from the Trino plant. The only waste present is some 50 m of piping from the primary circuit. This is slightly contaminated and no neutron activation is present. Due to a large flood which occurred in 1994, the plant experienced a complete power black-out. (The only outcome was an increase of the pool water temperature from about 20°C to 30°C, the equilibrium temperature for natural convection.) As a consequence the construction of independent emergency diesel supplies is planned for the future. The extent of the radiologically controlled area(s) is the primary reactor containment.

Cooling of the pool maintains the temperature at 18-22 °C. The volume of the pool is about 600 m^3 of water. Water is routinely analysed: when the activity is more than 3 Bq/cm^3 a purification is done by means of resins (this occurring about every 4 months). Up to now, no spent resins have been released. The ventilation is provided with filters and released to a stack where noble gasses are continuously monitored. (No activity was ever detected). Alarms to indicate high activity in the air are provided. A small negative pressure is maintained inside. Personnel are present 8 hours per day. Continuous monitoring is provided also with cameras checked afterwards by an appointed company. Personnel present at the site in other plants can carry emergency situations on automatic alarms.

- Ispra-1

The reactor was completely defuelled about 20 years ago. Some neutron activated materials are still in the pool together with core internals, control rods and resins from the pool water purification. Cleaning activities are underway as well as the removal of the materials concerning a number of performed experiments. It is planned to decommission firstly the outside of the containment, and then the containment itself. The extent of the radiologically controlled area(s) is the primary reactor containment. The activity in the air above the pool water and the Tritium activity at the stack are routinely monitored. Periodically, a check on various alarm devices is carried out (pool water level, water leakage, fire). Personnel are present 8 hours per day. Personnel present at the site on another plant (ESSOR) can deal with emergency situations on automatic alarms.

- Galileo Galilei, Pisa

The reactor was finally shut down in 1980 and was completely defuelled by 1986. Neutron activated control rods and internals are stored in the pool. In a dry area only 35 fuel elements are stored. The plant is currently in a C&M stage. The slightly contaminated pool water (750 m^3) is currently being discharged after monitoring. The primary reactor containment is a controlled area as well as the area under the pool. The water pool is at room temperature as no heat source is present (the decay heat from neutron activated walls is negligible). The purification of the water is routinely performed by means of activated carbon filters and 3 resin filters. Up to now, no spent filters have been released due to the extremely low activity of the water (a few Bq/cm^3). The level of the water and the activity in the air above the pool are continuously monitored. Ventilation is provided and the air is eventually released to a stack. A small negative pressure is maintained inside. Personnel are present 24 hours a day although sometimes only for security.

- Essor, Ispra

The reactor was completely defuelled by 1983. The heavy water is been stored in tanks. The reactor is in long term shut-down according to 1985 Italian law. The extent of the radiologically controlled area(s) is the same as during operation. All the conventional equipment is in operation, even if only partially. Staffing levels are the same as when the reactor was operational.

- Other installations

These are the Itrec fuel reprocessing plant at Trisia, the Eurex fuel reprocessing plant at Saluggia and the OPEL-1/IPU plant at Casaccia.

The Itrec plant at Trisia currently stores 1679 kg of spent fuel from the US Elk river reactor in the form of 64 elements. There are also 6 kg of depleted Uranium, 1115 kg of natural Uranium, 1699 kg of Thorium, 2.8 kg of low enrichment Uranium, 18.2 kg of high enrichment U. The 20 spent Elk river fuel elements that have been processed resulted in 3.3 m^3 of 'final product' and is stored at the plant. Liquid waste: LLW - 30m^3 (2.5mCi/l) remain of the original 80m^3. Cementation by a MOWA machine is currently underway and will be completed by April 1997. 250 drums (400 litre, 50% active solution) have been produced so far and a further 150 drums will be produced by the end of April 1997: HLW - This waste (2.7 m^3, 1.8 Ci/l) will be treated in a MOWA system, optimised for this purpose. 400 litre drums (15 Ci) located in a specially shielded cylindrical container, will be produced. Humidity levels and temperatures do not have any specific limits and a negative pressure is not maintained. Monitoring, inspection and maintenance are routine activities and staff provide 24 hour coverage per day.

The Eurex plant at Saluggia also currently stores spent fuel. There are 150 fuel elements (altogether 39 kg of total Uranium), 52 elements (1931 kg) from Trino, 1 element (63 kg) from Garigliano together with 146 kg of depleted Uranium, 1081 kg of natural Uranium, 0.1 kg of Thorium, 4.9 kg of Plutonium (PuO_2), 5.4 kg of low enrichment Uranium and 6.9 kg of high enrichment Uranium (as concentrated uranyl nitrate solution). There is also 112 m^3 of high activity liquid waste and 201 m^3 of high activity solid waste in barrels, 109 m^3 of aqueous low activity waste and 28 m^3 of organic waste in tanks, and 1118 m^3 of low activity solid waste in barrels. The decommissioning of the fuel cycling plant is underway. Humidity levels and temperatures do not have any specific limits and a negative pressure is not maintained. Monitoring, inspection and maintenance are routine activities and staff provide 24 hour coverage per day.

At the OPEC plant at Casaccia there are only some irradiated fuel pins (90 kg). In IPU (Impianto Plutonio) nuclear materials are present as scrap from former activities: a total of 3.4 kg of Pu and ~200 kg of low enrichment Uranium, 3.5 kg of highly enriched Uranium and 32 kg of natural Uranium. Approximately 57 m^3 of solid waste are stored in metallic drums, containing a total of 1.6 kg Pu, 55 kg of natural Uranium and 3 kg of depleted Uranium. No liquid waste is stored, other than 0.4 m^3 of solvent waste contaminated with Pu. In OPEC, the three hot cells of the plant have already been decontaminated. In IPU the dismantling of glove boxes is underway. Humidity levels and temperatures do not have any specific limits and a negative pressure is not maintained. Monitoring, inspection and maintenance are routine activities and staff provide 24 hour coverage per day.

FN SpA.

ENEA, the most important shareholder has decided to stop all fuel fabrication activities and to concentrate on advanced technical and scientific services. The fuel fabrication line will be dismantled in the next 2 years. Nuclear material is actually stored on site, waiting for evacuation.

ANNEX 4

SUMMARY OF SHUTDOWN NUCLEAR FACILITIES IN SPAIN

The nuclear installations currently being decommissioned in Spain are as follows:

- Vandellós I .

  This is the only Spanish commercial reactor in the decommissioning phase. The reactor is owned by HIFRENSA and is located in Vandellós (Tarragona). Vandellós I was a 480 MWe graphite moderated, CO_2 cooled reactor using natural uranium as fuel. The process of defuelling the reactor was completed in October 1994, with dispatch of the remaining fuel elements to the reprocessing centres taking place in November of that year. As regards the radioactive wastes generated during the operating phase, the authorisation for start-up of the installation to be used for the process of extracting, segregating and preconditioning the wastes held in the graphite silo is pending licensing by the administration.

  The following post-operational activities have now been completed:
  - Defuelling and shipment to a reprocessing facility.
  - Treatment and conditioning of operational radioactive wastes (special case of graphite sleeves).

  The following activities are expected to be performed in the future, with a view to total decommissioning:
  - Implementation of new electric supply and distribution.
  - Withdrawal from service of all systems not required.
  - Isolation of the primary barrier, cutting and sealing of PCRV penetrations.
  - Dismantling of all conventional buildings and contaminated buildings no longer required.
  - Initiation of the safe storage surveillance period.

  The radiologically controlled zone has been reduced, the reactor hall having been declassified. By the year 2000, the date foreseen for completion of Stage 2 decommissioning and creation of the "Safety Enclosure", the controlled zone will be reduced to the reactor building. On completion of total decommissioning of the installation (Stage 3), scheduled for the year 2035, the entire site will be declassified.

  The Plant has reached a condition of safe passive storage. The previously operational cooling, pressure suppression , etc. systems are currently being used, no new systems having been installed. Radiological protection monitors are distributed throughout the installation, with alarm signals in the Control Room. The values of negative pressure, humidity and temperature inside the reactor pile are also watched over from the Control Room, as are the values of activity in the gaseous effluent removal stacks. It has not, however, been necessary to develop any specific monitoring system since the current monitors already existed in the Plant. All the equipment included in the Technical Specifications are subject to maintenance, a Maintenance Plan being in place. The equipment not required in the current operating mode is in the operating or definitive tagged-out condition. Apart from the personnel working a normal timetable, there is a closed shift operating team and a permanent team of security people. The supervisor, panel operator and auxiliary operator making up this shift previously belonged to the Plant operating personnel.

- ARBI and ARGOS reactors.

  These are Argonaut type reactors located in the Industrial Testing and Research Laboratories (LABEIN) attached to the Bilbao University College of Engineering and the Polytechnic University of Cataluña, respectively.

  The nuclear fuel was completely removed from the ARBI reactor in 1974 and delivered to ENRESA in 1992 for reprocessing. The only radioactive materials present are the start-up sources and parts of the activated structures remaining. An initial dismantling study has been submitted to the CSN. A second version of the study is currently being prepared. Consequently, the dismantling process has not yet been initiated. Given the small size of this reactor, the extent of the radiologically controlled zone continues to be the same as during the operating phase. The reactor consists of an annular space formed by two cylindrical aluminium tanks. The core is lined inside and out with graphite. The shielding is reinforced concrete with some steel profiles providing support for the structure of the reactor. An equivalent dose rate measuring device is in permanent operation. On two occasions the accessible zones have been sampled in order to determine the activity of the materials. The installation is closed and is being supervised by the personnel of LABEIN.

  The fuel was removed from the reactor and delivered to ENRESA in 1992 for reprocessing. The operating wastes and radioactive materials (fundamentally the start-up source) have not yet been removed. The dismantling project has been submitted to the authority and is currently pending approval and authorisation. The radiologically controlled zone has been reduced to the installation's source storage area. The installation has currently reached a condition of safe passive storage, as a result of which the only controls in place are administrative, restricting access to the reactor. The source storage area is subject to radiological surveillance. No specific personnel is on site, the radiological surveillance being carried out at varying frequency by the staff of the University.

- JEN-1 and CORAL reactors and other installations.

  These experimental reactors belong to CIEMAT and are located in Madrid, in the installations of the aforementioned body's Institute of Nuclear Technology. The first is a pool-type reactor and the second an experimental fast reactor. From the administrative point of view, CIEMAT is a unique nuclear installation including different research laboratories. The decommissioning process has consisted basically of removing the fuel elements from the two reactors: CORAL and JEN-1, and the ingots of natural uranium and UO_2 pellets previously stored. The different laboratories currently in existence are being decontaminated since a number have been dismantled in previous years for use for conventional activities. At present, the process of decontaminating the laboratories and installations covers around 50% of the total.

  The CORAL experimental fast reactor and certain other radioactive installations have now been decommissioned. When the dismantling process has been completed, all these installations will be used for whatever conventional activities CIEMAT deems to be appropriate. At present, certain installations have been completely decontaminated and consequently require no monitoring, while others will continue in normal operation, with surveillance accomplished using the same systems as were employed prior to initiation of the decommissioning process. Certain of the CIEMAT installations will continue to be used for irradiation tests, etc., while others will disappear as nuclear or radioactive installations. The research personnel continues to work in the installations of the aforementioned Centre.

SUMMARY OF SHUTDOWN NUCLEAR FACILITIES IN THE UNITED KINGDOM

The nuclear installations currently being decommissioned in the United Kingdom are as described below:

The following installations are the responsibility of the DRAWMOPS Directorate, Government Division, UKAEA:

- Dounreay Fast Reactor

  The reactor was closed in 1977. Most of the breeder fuel remains in the reactor. A small amount of the driver fuel remains in place. This is all HLW. The primary coolant (NaK) is in situ and is classified as LLW, although it is contaminated with radionuclides which will have to be removed before disposal. The reactor is in Stage 1 decommissioning with another seven years of fuel removal planned (completion planned for 2002). Within the existing structure a new plant is being built to process, treat (convert the coolant to a stable form from which the fission products can be removed) and dispose of the primary coolant (NaK). The original plant will be put into C&M (Stage 2) for between 50 and 100 years with a ventilation plant operating. Although unspecified at present it is anticipated that complete dismantling will take place during Stage 3.

  The installation is moderate in size. The containment is a steel sphere reactor containment building. Only existing structures are to be used and these are sealed. No new temporary structures are to be erected. Breeder and some driver fuel elements are in situ and therefore the primary coolant is being circulated by the primary pumps. Negative pressure is being maintained in the controlled area and there are HEPA filtration systems on the inlet and ventilation stack. The humidity of the reactor cover gas (Nitrogen) is monitored. Temperatures are being monitored and controlled. The Managing Agency (RR&A) has 7 staff. There is an Operations team of 12 staff , 4 managerial and 8 general workers. A maintenance and installation team of 12 staff, 4 managerial and 8 craftsmen. There is a Health Physics team of 2 staff that are supplied from the Dounreay site.

- Prototype Fast Reactor, Dounreay

  The reactor was shut-down on 31st March 1994. Defuelling of the reactor is underway (50% completed) and is planned to be completed in 1996. This is all HLW. The fuel will be reprocessed in the existing D1206 plant on site. The primary and secondary coolant (Na) is in situ and is not significantly contaminated. The reactor is in Stage 1 decommissioning with two years of fuel removal planned (completion planned for 1996). Within the existing turbine hall structure (after the turbines and ancillary equipment have been removed) a new plant will be built to process (clean up), treat and dispose of the primary and secondary coolant (Na). Stage 1 will be completed in 2004. The decay heat removal plant contains NaK which will require treatment and disposal. The plant will be put into C&M (Stage 2) for between 50 to 100 years with a ventilation plant operating. Although unspecified at present it is anticipated that complete dismantling will take place during Stage 3

The installation is moderate in size. The containment is a primary and secondary (leak jacket) steel reactor construction within a steel reinforced concrete containment building. Only existing structures are to be used (for clean-up) and these are sealed. No new temporary structures are to be erected. 50% of the fuel elements are in situ and therefore the primary coolant is being circulated by the primary pumps. Negative pressure is being maintained in the controlled area and there are HEPA filtration systems on the inlet and ventilation stack. The reactor cover gas (Argon) is monitored. Humidity and temperatures are being monitored and controlled. The pumps help remove decay heat, but also help keep the sodium from freezing. The reactor is still considered as an operational station, therefore all the operational staff including the shift teams are still working at the plant.

- Windscale AGR

The reactor was shut-down in 1981. Decommissioning was started in 1985. Defuelling of reactor and removal of activated or contaminated fuel stringer components is complete. The fuel arrestor assemblies (ILW) have been crushed and stored in the core region awaiting a waste packaging route. The bioshield (LLW) has Tritium migrating and decaying within it The reactor is in Post Stage 1 decommissioning. Within the existing structure (the steel containment dome) the top biological shield and the reactor pressure vessel (RPV) top dome have been removed. Two of the four 175 tonne heat exchangers were initially raised to create space for sentencing, waste packaging and maintenance. A remote dismantling machine has been installed to dismantle the RPV and internals. An ILW store has been constructed along-side the reactor containment sphere. All four heat exchangers have now been lifted through the containment and road transported to Drigg for disposal. Stages 2 and 3 will be combined. Dismantling will begin soon. The bioshield may be left until 2005. Any changes in regulations concerning specific nuclides may alter waste disposal strategies. It is anticipated that complete dismantling will take place during Stage 3.

The installation is moderate in size. The containment is a steel sphere. Existing structures are to be used where possible. A Waste Packaging Plant and Waste Store have been built; these are sealed structures. No other temporary structures are to be erected. No forced cooling is required. Negative pressure is being maintained in the controlled area via HEPA filtration systems. It is not known if humidity or temperatures are being monitored and controlled. Staffing levels are currently low. Security is provided since it is on the Windscale site.

- SGHWR, Winfrith

The reactor was shut-down in 1990 when Stage 1 decommissioning was started. Defuelling of the reactor was completed by 1993, with the fuel to be reprocessed by BNFL at Sellafield's THORP. The heavy water moderator was sent to AECL. The ponds have not yet been drained. HLW, ILW, LLW and VLLW remain The reactor is still in Stage 1 decommissioning. Current work is pond clean-up and preparation for C&M. Decommissioning of the fuel ponds and drying of the circuits together with rationalisation of the ventilation and other services is planned to be complete by 1997. The plant will then be put into Stage 2 C&M until 2050~2100. It is anticipated that the site will be completely dismantled during Stage 3.

The installation is moderate in size. The containment is steel, Zircaloy and concrete. The secondary containment is concrete. Existing structures are to be used. The structure and ventilation plant is sealed. No other temporary structures are to be erected. No forced cooling is required. Negative pressure is being maintained in the controlled area via HEPA filtration systems. It is not known if humidity or temperatures are being monitored and controlled. Staffing levels are low.

- Windscale Pile 1

The reactor was shut-down in 1957 following a fire. Fuel (~15 tonnes HLW) still remains in the core and fuel transfer channel ~5 tonnes. ILW, LLW and VLLW remains in the graphite core and the Chimney. The reactor is in Stage 1/Stage 2 decommissioning. The filter gallery has been removed from the chimney. Pile 1 has been isolated from its chimney. Routine C&M is being done and a new closed circuit forced draught core ventilation system has been built and is operating. Planned immediate work is for the fissile material to be removed from within the biological shield, for the ponds and water ducts to be cleared of fuel and sludge, and for engineered safeguards to be implemented ready for Stage 2. Dismantling of the core will take until 2000. Post 2000 a decision will be made to either completely dismantle the structure or put the structure into long term C&M.

The installation is moderate in size. The containment is concrete and steel with a steel ventilation plant. Existing structures are to be used. The structure and ventilation plant is sealed. No external structures are to be erected other than an ILW store. No forced cooling is required. Negative pressure is being maintained in the controlled area via HEPA filtration systems. It is not known if humidity or temperature levels are being monitored and controlled. Staffing levels are not available.

- Windscale Pile 2

The reactor was shut-down in 1957 following a fire in Pile 1. Fuel may still remain in the fuel transfer channel (HLW). ILW, LLW and VLLW remains in the Chimney. The reactor is in Stage 1/Stage 2 decommissioning. The filter gallery has been removed from the chimney. Pile 2 has been isolated from its chimney. Routine C&M is being done and an existing ventilation system is being modified and will soon commence operation. Planned immediate work is for the ponds and water ducts to be cleared of fuel and sludge, any remaining HLW to be removed from the air ducts and for Engineered safeguards to be implemented ready for Stage 2. The planned timescale for C&M is 50 years. Until a repository is built no long term plans beyond this C&M phase can be made.

The installation is moderate in size. The containment is concrete and steel with a steel ventilation plant. Existing structures are to be used. The structure will be sealed. No external structures are to be erected other than an ILW store. No forced cooling is expected to be required. Negative pressure is being maintained in the controlled area via HEPA filtration systems. It is not known if humidity or temperature levels are being monitored or controlled. Staffing levels are not known.

- BEPO, Harwell

The reactor was shut-down in 1968 and has been completely defuelled. HLW, ILW, LLW and VLLW remain in the reactor block , and LLW is outside the core in the gas ducts and may also be in the chimney. The reactor is Post Stage 1 (nearly completed) and into Stage 2. All ancillary equipment, pumps etc., have been removed. Only routine C&M is being done to ensure that the building is structurally intact. Stage 3 will not be until 2050 and will await a decision on a long term waste repository by NIREX.

The installation is medium to small in size with only the reactor block left. It is intended to reduce the site to green field at the end of Stage 3. The containment is concrete, sealed, and exists within a larger building that is heated and in use. No forced cooling is required. There is no negative pressure being maintained in the controlled area. There are no filtration systems, and humidity/temperatures levels are not being monitored or controlled.

- DIDO, Harwell

The reactor was shut-down in 1990 and has been completely defuelled. ILW remains in the reactor and storage block in the form of sealed irradiation rigs. The reactor is Post Stage 1 (nearly completed) and into Stage 2 (routine C&M). The ventilation plant was fitted in 1995 and is being run, and some routine Health Physics and Safety is being carried out. No decommissioning work is being done. Stage 3 will probably not be until 2050 and will await a decision on a long term waste repository by NIREX.

The installation is medium to small in size with only the reactor block left. It is intended to reduce the site to a "green field" state at the end of Stage 3. The containment is a steel building and is sealed. No new structures have been built other than the ventilation plant. No forced cooling is required. Negative pressure is being maintained in the controlled area, via a ventilation system using HEPA filtration systems. It is not known if humidity or temperature levels are being monitored or controlled.

- Dragon, Winfrith

The reactor was shut-down in 1976 and has been completely defuelled although the fuel (HLW and ILW) is stored adjacent to the building. The reactor has been in Stage 2 (routine C&M) for 10 years. The building has been refurbished and repainted. No decommissioning work is being done. Stage 3 will probably not be until 2050 and will await a decision on a long term waste repository by NIREX.

The installation is medium in size. It is intended to reduce the site to a "green field" state at the end of Stage 3. The containment is a steel pressure vessel, a concrete and steel bioshield and a reinforced concrete building. The primary containment is sealed. No new structures have been built. No forced cooling is required. It is not known if negative pressure is being maintained in the controlled area, or if humidity or temperature levels are being monitored or controlled.

- GLEEP, Harwell

  The reactor was shut-down in 1990 and has been completely defuelled. Control rods remain (ILW) and are being removed to a vault storage on-site. The reactor is in Stage 2 (routine C&M). Stage 3 is awaiting a decision on whether to dismantle or leave in passive C&M. Current activities include removing the control rods and reducing the structure to the shield block. No further decommissioning work is being done or being planned.

  The installation is small in size. The containment is a concrete bioshield within an existing weatherproof building. The primary containment is sealed. No new structures have been built. No forced cooling is required. Negative pressure is being maintained in the controlled area, via a ventilation system using HEPA filtration systems. It is not known if humidity or temperatures are being monitored or controlled.

- ZEBRA, Winfrith.

  The reactor was shut-down in 1982 and has been completely defuelled. LLW components remain within the reactor building. The reactor is in Stage 2 (routine C&M). No decommissioning work is being done or being planned. A decision is awaited on whether to dismantle completely (Stage 3) or leave in passive C&M.

  The installation is medium to small in size. The containment is an aluminium clad concrete and steel building. The primary containment is sealed. No new structures have been built. No forced cooling is required. It is not known if negative pressure is being maintained in the controlled area, or if humidity or temperature levels are being monitored or controlled.

- Nestor, Winfrith.

  The reactor was shut-down in 1995 and has been defuelled. Most of the waste will be LLW and VLLW components and coolant water. The control rods will probably be ILW. The reactor is in Stage 2 (routine C&M) at a very low level. No decommissioning work is being done. A study has been completed on the greenfield site option. A decision is awaited on whether to dismantle completely (Stage 3) or leave in passive C&M.

  The installation is small in size. The containment is an aluminium vessel with concrete shielding. The building is not sealed. No new structures have been built. No forced cooling is required. The building is controlled and monitored for temperature (humidity unknown). It is not known if negative pressure is being maintained in the controlled area, or temperature levels are being monitored or controlled.

The following installations are the responsibility of Nuclear Electric.

- Berkeley

  The twin reactors were shut-down in 1989 and have been defuelled. All the lifetime ILW has been accumulated on site (pond sludge, activated steel components, charge chutes and control rods). All LLW is contained within the plant. The plant is in Stage 1 and the fuel has been removed. The reactor building has been reduced down to the pile-cap level. The ducts have been removed and sealed. The ponds have been drained and are being decontaminated by removal of the surface layer of concrete. Over the next two years conventional plant is being scrapped or sold for re-use. The boiler house has been demolished and the turbine hall is being demolished. The heat exchangers are being stored on their sides awaiting a decision to either store or dispose of them. The buildings will be put into C&M Phase 1 for 30 years. A waste recovery plant is to be built and the wastes are to be retrieved and packaged over the next five years. For Stage 2 a safe-store will be built over 2 years and the buildings put into C&M Phase 2 for 100 years. Complete dismantling will commence 135 years after shutdown (Stage 3).

  The installation is large in size. The containment is a steel pressure vessel with concrete bio-shield and a containment building The building is not sealed. No new structures have been built, but a large "permanent" safe-store structure will be built. New structures are to be avoided except for the temporary waste recovery plant. The ponds may be converted to take the packaged waste, but this depends upon a decision on the NIREX repository. The building is not controlled nor monitored for temperature or humidity. A ventilation in the controlled area is being maintained using HEPA filtration systems. There are 12 Nuclear Electric staff on site with managerial and health and safety duties. There are two site licences for Berkeley at present and the intention is to combine them into one licence.

- Trawsfynydd

  The twin reactors were shut-down in 1993 and have been defuelled. All the lifetime ILW has been accumulated on site (splitter blade debris, activated steel components, pond sludge charge chutes and control rods). All LLW is contained within the plant. The plant is in Stage 1. The ponds are full and the water treatment plant is operational. The ventilation plant is still running. Over the next 7 years asbestos, non-active plant, transformers and storage tanks will be removed. The buildings will be put into C&M Phase 1 for 30 years. For Stage 2 a safe-store will be built over 2 years and the buildings put into C&M Phase 2 for 100 years. Complete dismantling for Stage 3 will commence 135 years after shutdown.

  The installation is large in size. The containment is a steel pressure vessel with concrete bio-shield and a containment building. The building is not sealed. No new structures have been built, but a large "permanent" safe-store structure will be built. New structures are to be avoided. Existing buildings will be re-used e.g. for packaged waste. The building is not controlled or monitored for temperature or humidity. Ventilation in the controlled area is being maintained using HEPA filtration systems. The manning levels are approximately 140. About half of the staff are involved in decommissioning work, with the remainder employed for security, administration and maintenance work.

The following installations are the responsibility of British Nuclear Fuels. For reasons of confidentiality, the individual installations (all of which are at Sellafield) are only referred to as large/small plants or facilities.

- Large Storage Pond

  The facility (pond and decanning) is large and in 1985 decommissioning began and is due for completion by 2006. All types of waste (reactor fuel and miscellaneous debris/sludge) are contained within the pond (VLLW, LLW, ILW, and HLW). The plant is in C&M. The pond is full and the water treatment plant is operational. Work is proceeding to install plant to sort the pond's contents and empty it. The pond will be drained and decontaminated. The pond is an open-topped concrete walled structure within a containment building The building is not sealed. No new structures will be built, only new equipment. The building is controlled and monitored for temperature. There is a slight negative pressure due to the building extract system. A HEPA filtration system is being used. The manning levels are 10 BNFL staff, and 15 contract staff who do the operational work.

- Small Plant

  The facility is small and in 1989 decommissioning began and is due for completion by 2005. Waste contained within the plant (VLLW, LLW, and ILW) includes solid contaminated material such as stainless steel, glass and PVC tubing, All HLW has been removed. The plant is in C&M. Work is proceeding to install plant to allow decommissioning to start in 1997. The building has limited sealing. The primary containment is lead and brick within a larger building. Some new structures will be built to facilitate decommissioning. There is no temperature or humidity control or monitoring. There is a limited negative pressure through a HEPA filtration system. The manning levels are 3 BNFL managerial staff, and contractor's staff of between 10 and 40 depending on the stage of work. Installation requires 40 contractors and operation will require 10 contractors.

- Large facility

  The facility is large and in 1990 decommissioning began and is due for completion by between 1997 and 1999. The wastes have been partially removed. No HLW remains, but there is ILW, LLW and VLLW within the plant in the form of solid oxides in kilogram quantities and 200 litre drums. The facility is split into 3 parts. The first part of the plant is finished. Decommissioning is complete with free access. The second part of the plant is in C&M. Work is proceeding on the third part to complete decommissioning. The major on-going activity is cutting and removing glove-boxes. The primary containment is glove-boxes within a larger building. Some new temporary structures (glass fibre panels) will be built for waste handling to facilitate decommissioning. A permanent waste store with concrete block shielding will exist until 2015. The building has limited sealing. Temperature and humidity are controlled and monitored. Negative pressure is maintained through a HEPA filtration system. The manning levels are 11 BNFL staff covering the full range of duties, with contractor's staff until the waste store has been built.

- Large Cell Facility

The facility is large and in 1990 decommissioning began. No HLW remains, but there is ILW, LLW and VLLW within the plant in the form of contaminated plant - pipes and vessels. Dismantling has started. Four cells are under C&M, one cell is still operating and one cell is being decommissioned. By 2004 all six cells will be decommissioned. The primary containments are concrete cells with pipe-work and vessels. Some new temporary structures will be built for waste export. The building housing the facility is being used and is sealed. Negative pressure is maintained through a HEPA filtration system. The manning levels are 3 BNFL staff covering management duties, with 12 contract staff doing the decommissioning work.

- Large Structure

The structure is large and in 1990 decommissioning began and is due for completion by 2001. There is no HLW but there is ILW, LLW and VLLW within the shaft and there is an ILW store at the base of the structure. The project is in Stage 3 with demolition work being done. The rest of the structure is in C&M. The main shaft will remain since it is too costly to take down, but it will be cleaned. The primary containments is the concrete and bricks that comprise the structure. The structure is not sealed but breathes through filters. The existing structure is being used, also a Waste Export facility is being built at the base with a permanent ILW store (the old ILW store is being updated). Limited negative pressure is maintained through a HEPA filtration system whilst demolition and building work is in progress. There is no control or monitoring of either temperature or humidity. The manning levels are 11 BNFL staff covering management and direct work duties, with approx. 18 contract staff doing the decommissioning, installation and management work.

- Large Facility

The facility is large and in 1989 decommissioning began and is due for completion by 2005. There is no HLW but there is residual ILW, LLW and VLLW within the building in the form of liquors, pipe-work, vessels, and the cell fabric (bricks). The project is in Stage 3 with demolition work in the form of plant stripping being done. An export route with hot cutting and packaging equipment is being installed. It is planned that by 2005 the building will be an empty shell. The primary containment is the pipe-work and vessels concrete and brick cells. The building is not sealed but breathes through filters. The existing structure is being used. A new ventilation system is being installed. Negative pressure is maintained through a 2 stage HEPA filtration system. There is no control or monitoring of temperature, but there is humidity control and heating to prevent ice formation in cold weather. The manning levels are 9 staff covering management and direct work (demolition and installation). Contractors will be used when necessary. The whole plant is under C&M with criticality monitoring being done.

- Very Large Facility

  The facility is very large (10 storeys high and 50m by 30m) and in 1989 decommissioning began and is due for completion by 2006. There is HLW in the form of dissolved fuel, also ILW, LLW and VLLW within the pipe-work and vessels. The project is in C&M and approx. 1% decommissioned. Plant washout is underway and decommissioning equipment is being commissioned. By 2006 the building will be empty and able to be re-used. The primary containment is the stainless steel pipe-work and vessels concrete within concrete cells. The building is not sealed but breathes through filters. The existing structure is being used. A new ventilation system and waste export facility is being installed. Negative pressure is maintained through a 2 stage HEPA filtration system. There is no control or monitoring of temperature, but there is humidity control and heating to prevent ice formation in cold weather. For C&M the manning levels are 6 staff. For decommissioning 22 staff cover management and direct work. This will increase to 50 staff (Contractors will be used when necessary for demolition and installation).

The following installations are the responsibility of the Atomic Weapons Establishment at Aldermaston . For reasons of confidentiality, the individual installations are only referred to as large/small plants or facilities.

- Large Production and R&D facility

  The facility is very large and shut-down in 1985. Decommissioning is due for completion by 2000. There is no HLW in the facility, but there is ILW, LLW and VLLW dispersed throughout glove-boxes and fume cupboards. Machine tools contain hold-up and the facility is irradiated. The project is in Stage 2/3, it is between Post Operations Maintenance and Operational Decommissioning (C&M). No active decommissioning is being done now, and all services are active. Stage 3 will be completed by 2000 and a decision will be made on the future use of the building. The primary containment is the steel glove boxes with glass and perspex within the brick structure. The building is not sealed but breathes through filters. Temporary containment is to be built around the items to be reduced in size in situ. The existing structure is being used. Negative pressure is maintained through a HEPA filtration system. There is control and monitoring of temperature and humidity. No forced cooling is required. The manning levels are 10 staff, covering Project Management, Health Physics, and Maintenance.

- Medium Production and R&D facility

  The facility is of medium size and decommissioning is due for completion before 2000. There is no HLW in the facility, but there is ILW, LLW and VLLW dispersed throughout glove-boxes and fume cupboards. Machine tools contain hold-up and the facility is irradiated. The project is in Stage 2/3, it is between Post Operations Maintenance and Operational Decommissioning (C&M). No active decommissioning is being done now, and all services are active. Stage 3 will be completed before 2000. This is a free-standing building that will be demolished by civil engineering contractors once it has been fully decommissioned. The primary containment is the steel glove boxes with glass and perspex within the brick structure. The building is not sealed but breathes through filters.

Temporary containment is to be built around the items to be reduced in size in situ. The existing structure is being used. Negative pressure is maintained through a HEPA filtration system. There is control and monitoring of temperature, but not of humidity. The manning levels are 5 staff covering Project Management, Health Physics and Maintenance.

- Small Production and R&D facility

The facility is small in size and decommissioning is due for completion before 2000. There is no HLW in the facility, but there is ILW, LLW and VLLW dispersed throughout glove-boxes and fume cupboards. Machine tools contain hold-up and the facility is irradiated. The project is in Stage 2/3, it is between Post Operations Maintenance and Operational Decommissioning (C&M). No active decommissioning is being done now, and all services are active. Stage 3 will be completed before 2000. This is a free-standing building that will be demolished by civil engineering contractors once it has been fully decommissioned. The primary containment is the steel glove boxes with glass and perspex within the brick structure. The building is not sealed but breathes through filters. Temporary containment is to be built around the items to be reduced in size in situ. The existing structure is being used. Negative pressure is maintained through a HEPA filtration system. There is control and monitoring of temperature, but not of humidity. The manning levels are 4 staff. 2 staff covering project management, 1 on Health Physics Monitoring, and 1 on Maintenance.

- Large Waste Treatment Facility

This plant is still in operation. Parts of the plant are however in C&M. A plan is being written for decommissioning. Decommissioning is due for completion before 2007. There is no HLW in the facility, but there is ILW, LLW and VLLW. A decision is awaited for the NIREX and Drigg facilities in order to resolve waste storage facilities on the site. On completion of decommissioning by 2007 there will be a combination of "green field" state with certain remaining structures. A new replacement facility should also be operational by 2007. The primary containment is the steel and brick structures. No new structures are to be built for decommissioning use, the existing structure will be used. Negative pressure is maintained through a HEPA filtration system. There is control and monitoring of both temperature and humidity in the various parts of the facility that require it. A full operational team is in post.

- Reactor

The facility is medium size and was shutdown in 1990. Decommissioning is due for completion before 2045. There is no HLW in the facility and it has been drained of water. There is ILW, LLW and VLLW in the form of irradiated components and structure. This plant is in C&M and is being monitored. Phase 2 is planned for 2000 and Phase 3 for 2045. The reactor will be demolished to ground level. The primary containment is the steel vessel and reinforced concrete bioshield with a secondary concrete containment and lead shielding. Temporary structures are to be built, for example, a vent system to dry the core region. The existing structure is used and sealed. Negative pressure is maintained through a HEPA filtration system. There is control and monitoring of both temperature and humidity. The manning levels are 4 staff. (This facility shares resources with the remainder of a very large plant.)

CORDIS

The Community Research and Development Information Service

Your European R&D Information Source

CORDIS represents a central source of information crucial for any organisation - be it industry, small and medium-sized enterprises, research organisations or universities - wishing to participate in the exploitation of research results, participate in EU funded science and technology programmes and/or seek partnerships.

CORDIS makes information available to the public through a collection of databases. The databases cover research programmes and projects from their preparatory stages through to their execution and final publication of results. A daily news service provides up-to-date information on EU research activities including calls for proposals, events, publications and tenders as well as progress and results of research and development programmes. A partner search facility allows users to register their own details on the database as well as search for potential partners. Other databases cover Commission documents, contact information and relevant publications as well as acronyms and abbreviations.

By becoming a user of CORDIS you have the possibility to:

- Identify opportunities to manufacture and market new products
- Identify partnerships for research and development
- Identify major players in research projects
- Review research completed and in progress in areas of your interest

The databases - nine in total - are accessible on-line free of charge. As a user-friendly aid for on-line searching, Watch-CORDIS, a Windows-based interface, is available on request. The databases are also available on a CD-ROM. The current databases are:

News (English, German and French version) - Results -
Partners - Projects - Programmes - Publications -
Acronyms - Comdocuments - Contacts

CORDIS on World Wide Web

The CORDIS service was extended in September 1994 to include the CORDIS World Wide Web (WWW) server on Internet. This service provides information on CORDIS and the CORDIS databases, various software products, which can be downloaded (including the above mentioned Watch-CORDIS) and the possibility of downloading full text documents including the work programmes and information packages for all the research programmes in the Fourth Framework and calls for proposals.

The CORDIS WWW service can be accessed on the Internet using browser software (e.g. Netscape) and the address is: http://www.cordis.lu/

The CORDIS News database can be accessed through the WWW.

Contact details for further Information

If you would like further information on the CORDIS services, publications and products, please contact the CORDIS Help Desk :

CORDIS Customer Service
B.P. 2373
L-1023 Luxembourg

Telephone: +352-401162-240
Fax: +352-401162-248
E-mail: helpdesk@cordis.lu
WWW: http://www.cordis.lu/

European Commission

EUR 17622 — A review of the situation of decommissioning of nuclear installations in Europe

M. W. Davies, P. J. G. Stoor, P. Neuhold, J. M. Dufaud, A. Digiacomi, O. Mehling, I. Marcelles

Luxembourg: Office for Official Publications of the European Communities

1997 — IV, 75 pp. — 21.0 x 29.7 cm

Nuclear science and technology series

ISBN 92-828-0192-6

Price (excluding VAT) in Luxembourg: ECU 13.50

A considerable number of nuclear power plants have been built in the European Community since the 1950s, ranging from low power materials test reactors, through various medium power prototype/experimental reactors, up to high power commercial stations. In addition, there are a number of fuel fabrication and reprocessing plants associated with the nuclear fuel cycle. Many of these facilities have reached the end of their operating lives and have therefore been withdrawn from service.

A study has been carried out on nuclear facilities being decommissioned in five member countries, namely France, Germany, Italy, Spain and the United Kingdom. The purpose of the study has been to:

(i) Provide a list of nuclear installations shut down in the named countries between 1993 and 1995.

(ii) Provide information on the decommissioning stage attained at each installation covered and its planned future state. This includes whether or not the facility has been defuelled, what operational wastes remain and what the extent of the radiologically controlled area(s) is.

(iii) Identify the monitoring and inspection proposals/experience for these installations, including where possible the effort involved.

(iv) Identify relevant codes and standards applicable to decommissioning in Member States and to identify where available the relevant licensing requirements.

15

CR-NA-17622-EN-C

NOTICE TO THE READER

All scientific and technical reports published by the European Commission are announced in the periodical **'euro abstracts'**, published every two months, and in the R&TD publications database of CORDIS, the Community Research and Development Information Service.
For subscription (1 year: ECU 65) please write to the address below.

Price (excluding VAT) in Luxembourg: ECU 13.50

ISBN 92-828-0192-6

9 789282 801925 >

OFFICE FOR OFFICIAL PUBLICATIONS
OF THE EUROPEAN COMMUNITIES

L-2985 Luxembourg