# HOW THE **ALARA** OPTIMISATION PRINCIPLE IS BEING APPLIED TO DECOMMISSIONING WORK AT BRENNILIS NUCLEAR POWER PLANT

*Jean-Christophe Houplain (CEA) and Yves Desbazeille (EDF)*
*Site des Monts d'Arrée, 29290 Brennilis, France.*

## BACKGROUND

The Monts d'Arrée Nuclear Power Plant at Brennilis in the county of Finistère was commissioned in June 1966 and was operated jointly by the French Atomic Energy Commission and Electricité de France until July 1985. With a generating capacity of 75 MWe, EL4 was the industrial prototype for a series of reactors moderated by heavy water and cooled by carbon dioxide.

Under Decree 96-978 dated 31 October 1996, the French Atomic Energy Commission, in its capacity as nuclear operator, was licensed to partially decommission Major Nuclear Installation 28, which has since become Major Nuclear Installation 162 (Stage 2 as defined by the International Atomic Energy Agency). In the three years that followed, all the nuclear buildings on the site were demolished, with the exception of the reactor building where temporary measures were taken pending the final decommissioning date (Stage 3).

## FOREWORD

In order to ensure that the Stage 2 decommissioning and clean-up operations to be carried out in the Brennilis installations would be closely monitored, a special optimisation study was carried out, covering all stages of the work from the creation of operating procedures to the institution of an experience feedback file. This study resulted in the creation of a work organisation method, making it possible to:

- ensure that the safety of workers and operations would be taken into account,
- ensure that equipment and human resources were used economically.

The framework of decommissioning work organisation is based on meeting a number of fundamental objectives, established on the grounds of the following two principles: industrial and nuclear safety principles, set down in the regulations, and dose minimisation principles advocated by the ALARA concept. By applying terms and conditions of contractual monitoring of the worksite, based on the above objectives, it is possible to ensure that the latter are met.

This overall approach is also applied to organisational and exposure management aspects, in the Optimisation Method for Decommissioning and Clean-up Worksites (a method created and developed for decommissioning of the Brennilis installations).

## FUNDAMENTAL OBJECTIVES

There are four fundamental objectives associated with the organisation of the work:

- **Safety objectives**: these are aimed at reducing risks and minimising their effects, as well as guaranteeing that work is executed when the installation is operating normally.

  Safety depends on:

  - application of the texts relating to major nuclear installations operated by the French Atomic Energy Commission and the protection of workers against ionising radiation,
  - the safety standard for the installation (safety analyses, waste studies and General Operating Rules),
  - the codes, manuals and procedures specific to the Monts d'Arrée Nuclear Power Plant.

- **Objectives relating to effective worksite management**: these are aimed at optimising work in terms of resources and time (prioritising and scheduling).

- **Objectives relating to the structuring of worksite dat**a: these are aimed at rationalising data acquisition channels by the implementation of a tree structure which is common to the various project activities.

- **Objectives relating to worksite monitoring**: these are aimed at establishing the resources to be used to check and monitor the various contractual stages against forecasts, to ensure that the actions taken can be traced.

# ORGANISATIONAL STRUCTURE OF THE PROJECT

## TREE STRUCTURE FOR DESIGN AND TASKS

To ensure that the fundamental objectives are taken into account, the organisation of studies and work is based on the principle of breaking down activities in order to analyse the project in a detailed and thorough manner. The contract work is broken down into packages and then further divided into basic work units. This gives the following tree structure:

- A contract is divided into homogeneous service **packages** known as **operations**.

- Each **package** in a contract is divided into different **phases**, which correspond to generic types of activities which are carried out in an order determined by safety options. The phases therefore depend on the design and when they are being carried out; they are governed by the safety requirements resulting from the dose minimisation objective.

- These phases are further divided into homogeneous activity **stages**.

- Finally, the stages include homogeneous activity **tasks**, "unity of action", characterised by where they are carried out, "unity of place" (room or set of rooms), the time taken to carry them out, "unity of time" and the risk level (work category) involved. They are also characterised by a dedicated operating procedure or standard which describes in detail the technical conditions in which they are to be carried out. All the information concerning completion of the tasks is recorded in **"task sheets"**.

**Tasks** are therefore the basic working units of the project and can be characterised by the following three elements:

- the exact geographical location and the planned duration of work,

- the level of radiological risk involved,

- the relevant operating procedure. The operating procedure takes the form of a series of elementary actions which are described step-by-step in the order in which they are to be carried out. Each step can give rise to comments or the creation of a hold point.

## TASK SHEETS

During the study phase, a file summarising the information required to assess whether the fundamental objectives have been taken into account is created for each basic work unit. This file is known as a "task sheet" and includes:

- the information necessary for identifying the task and assessing what it involves (waste zoning, specific quality requirements etc.).

- Information on how allowance is made for the ALARA principle (projected dose analysis, comparing solutions, best solutions in the light of radiological, industrial safety, waste and economic constraints).

- Protection measures which ensure that radiological and or conventional risks are taken into account and that their consequences are minimised.

- The scheduled operating procedure in the form of a detailed quality plan.

- Additional elements in the procedure in the form of prerequisite checking sheets, descriptions of arrangements taken to ensure industrial safety, photographs, explanatory drawings and references to Generic Operating Techniques. The General Operating Techniques for the basis of the operating procedures since they give all the information specific to a certain technique.

- Waste management terms and conditions.

## DETERMINING AND LOCATING TASKS – THE STUDY APPROACH

The block diagram appended summarises the approach adopted for determining tasks.

A radiological inventory is made prior to the studies and complements that made by the nuclear operator when the closure decree was granted.

This inventory is used to:

- identify and locate particular radiological points where special protection measures have to be taken,

- identify zones with the same radiological constraints (or which will become so in the light of the previous point),

- make a qualitative list of the tasks to be carried out.

The physical inventory made at the initial reconnaissance stage makes it possible to determine the "original state" of the installations before work begins; it is based on process diagrams, the background and the radiological inventory and is also used to determine more accurately what work has to be carried out. The work is characterised by its degree of technical complexity and the radiological risk level involved. Assessment of the work is based on the notion of basic work units.

Location of work: Three geographical zones have been identified within the boundary of the installations to be decommissioned; they are described in the safety analysis reports for each building. These zones correspond to the three main nuclear buildings of the major nuclear installation and to the associated installations and galleries; they are divided into rooms according to the waste zoning principle. The initial reconnaissance, and therefore the description and location of decommissioning and clean-up work, complies with this geographical division, in line with the latest maps of the Monts d'Arrée Nuclear Power Plant.

## CATEGORISATION OF WORK

The CATEGORIES OF WORK table appended is used to divide clean-up and decommissioning work into four categories, depending on what is involved and the associated risks. The work is divided into categories depending on the equivalent dose rates and the amount of contamination measured in the workplace.

The colours used in the regulations (*arrêté* of 7 July 1977, in application of Article 16 of Decree 75-306) to describe radiological protection zones, i.e. orange, yellow, green and blue, are also found in

the table. These colours and the corresponding limit values take up the radiological protection values as they appear in the regulations but, while in no way altering their meaning or importance, they are used to refer to real risks in the workplace as opposed to potential risks in rooms.

The following approach is used to divided the work into categories:

- depending on the physical and radiological inventories, the most probable technique for carrying out the work is determined.

- a fictitious task is devised on the basis of this technique. The fictitious task is determined before any thought is given to optimising the means of protecting the operators (but allowance is nonetheless made for the likely position of the operators in the workplace in relation to the sources measured on contact during the original radiological inventory). A theoretical exposure value is determined for the task. This theoretical value is used a priori to categorise the task (indicator) to ensure that categorisation is conservative.

Two cases can be observed:

*The fictitious task lasts less than one hour*

The exposure value is considered as being acquired in one hour; it corresponds to an equivalent dose rate per hour which is directly recorded in the work category table.

For example, the probable exposure value for a fictitious task lasting 10 minutes with an equivalent dose rate of 60 $mSv.h^{-1}$ leads to a value of 10 $mSv.h^{-1}$ being entered in the work category table.

*The fictitious task lasts more than one hour*

The fictitious exposure value expressed as an equivalent dose rate is directly compared to the work category table.

## TASKS

At this stage in the project, the work to be carried out is accurately located and put into a category and may also be described in a given procedure; the work to be carried out becomes a task. It is described in a task sheet.

Tasks in Categories 1 and 2 have dedicated operating procedures

Tasks in Categories 3 and 4 have standard operating procedures

### Tasks in Categories 1 and 2

When a task falls into Category 1 or 2, its task sheet (and all the elements therein) is studied in depth and carefully prepared:

- The operating procedure specific to it (the dedicated operating procedure) is included in it.

- The ALARA principle is shown to have been taken into account since it is described and three work options are put forward highlighting the cost/benefit ratio from the technical, waste management, industrial safety and nuclear safety points of view (to make this comparison, the costs used are those commonly employed by EDF, i.e. 0.5 MF/man.Sv to 2.3 MF/man.Sv depending on the average individual dose ranges. Given the exposure objectives of the decommissioning worksite, the single value of 0.5 MF/man.Sv is used). However, if only one solution is possible, checks are made to ensure that the ALARA principle is implemented when optimising the process.

### Tasks in Categories 3 and 4

When a task falls into Category 3 or 4, its task sheet (and all the elements therein) is studied and prepared in the normal way:

- The operating procedure specific to it (the standard operating procedure) is included in it.

- The three options put forward for carrying out the work to do not have to be compared to assess whether or not the ALARA principle has been taken into account. Indeed, the exposure corresponding to operations in Categories 3 and 4 is due exclusively to equivalent dose rates in the atmosphere which cannot be optimised, except by cutting down on the time taken to carry out the work. Proper sequencing of the operation and step-by-step monitoring of the work on the worksite (daily supervision and monitoring of the quality plan) ensure that the process is properly controlled.

### Control of modifications required when the work is in progress

If, when the work is in progress, a task sheet has to be modified for technical reasons or because the radiological conditions or the physical inventory have changed, there are two possibilities:

- The task category remains the same:

  The process modification is appended to the task sheet in the form of a change sheet. Once it has been approved, the task continues as planned.

- Modification of the task means that the category changes:

In this case, the task in progress is halted in the conditions in force for the worksite and a new task sheet is created.

## PRIORITISATION OF WORK

In order to comply with the risk minimisation objective, work has to be carried out in decreasing order of risk and in zones where the risks are homogeneous.

This means that work is prioritised in such a way that:

- the tasks are grouped to form groups of activities with the same levels of risk (stages),

- by organising the tasks within a given group, personnel exposure can be reduced.

This overall organisation of work per building, presented in the form of a PERT schedule, is transmitted to the contractor (Monts d'Arrée Nuclear Power Plant) for approval; it also assesses the optimisation approach adopted by the company for the various sequences possible.

## LIMITING THE AMOUNT OF INTERIM STORAGE

In view of the requirements described above, it is inconceivable that zones with potential risks be created by storing radioactive or contaminating waste generated by decommissioning in the vicinity of work zones or areas transited by personnel. The study of the work to be carried out therefore makes allowance for external constraints enabling products to be removed quasi-continuously from the production zones to interim storage areas outside the buildings.

## RATIONALISATION OF WORK

### Input data

The location and identification of risks and the prioritising of work make it possible to establish a schedule for carrying out the tasks in a building, or even the entire major nuclear installation, in zones.

In order to make allowance for the objective of limiting spurious interim storage, steps should be taken to structure the generation of decommissioning waste in line with the capacity of the waste measurement benches.

### Carrying out work in phases

Rationalisation of the work is justified by the need for economy as regards resources and time; indeed, safety objectives could be complied with fully without the organisation of the worksite being at its best.

In order to meet the optimisation objective, the organisation of work in phases consists of:

- grouping tasks into categories over time,

- arranging them within these categories so that tasks requiring measures to prevent similar risks are carried out at the same time,

- prioritising them so that the risks (and their prevention constraints) decrease as the work progresses,

- superimposing certain tasks in clearly defined work areas at certain times to reduce the duration of the work as a whole.

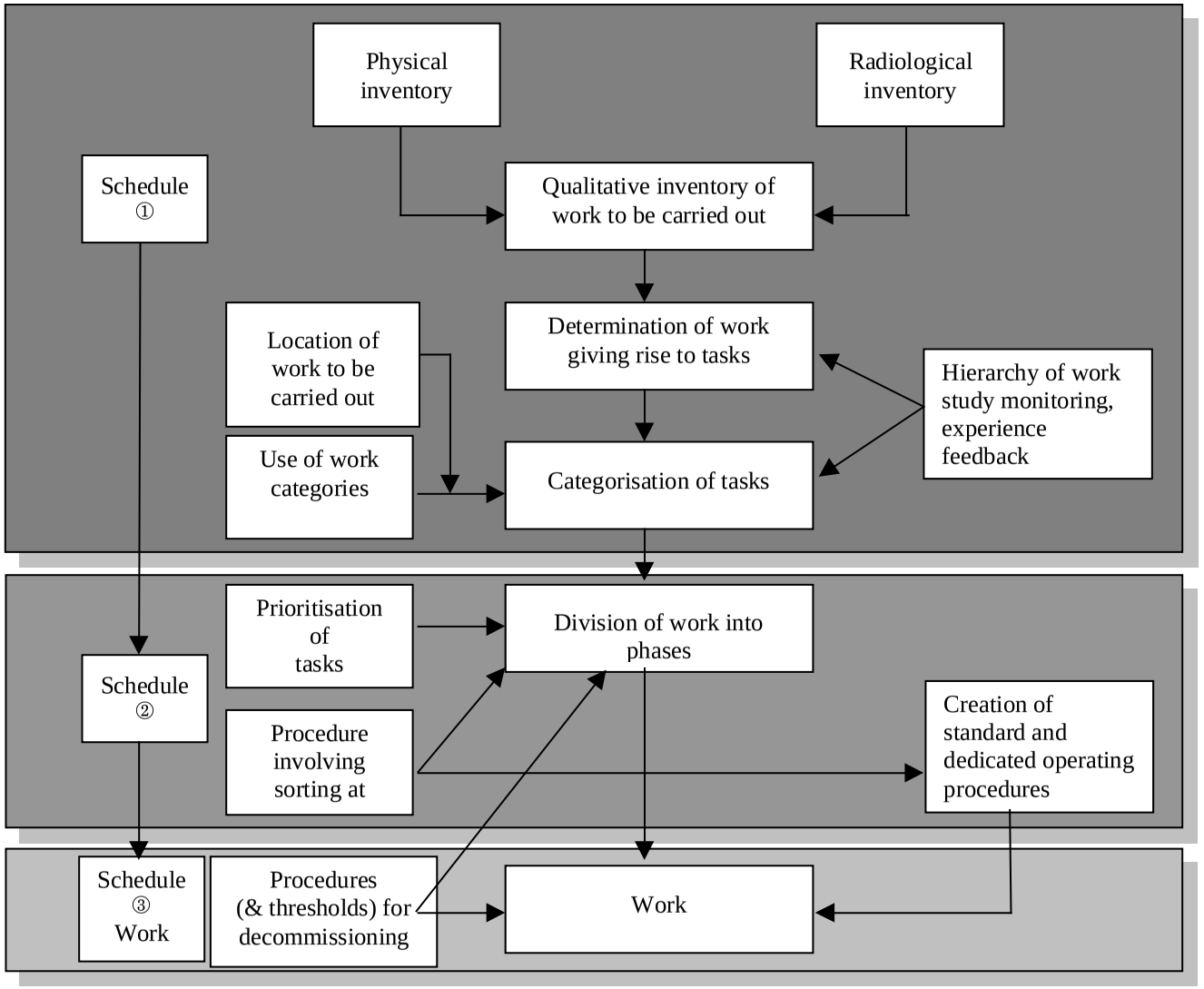
Thus, by dividing the work into phases, it is possible, even before work starts, to obtain worksite curves (exposure/time), (personnel/duration), (professional qualifications/time to be spent on site) for assessing the forecast savings in human resources and equipment.

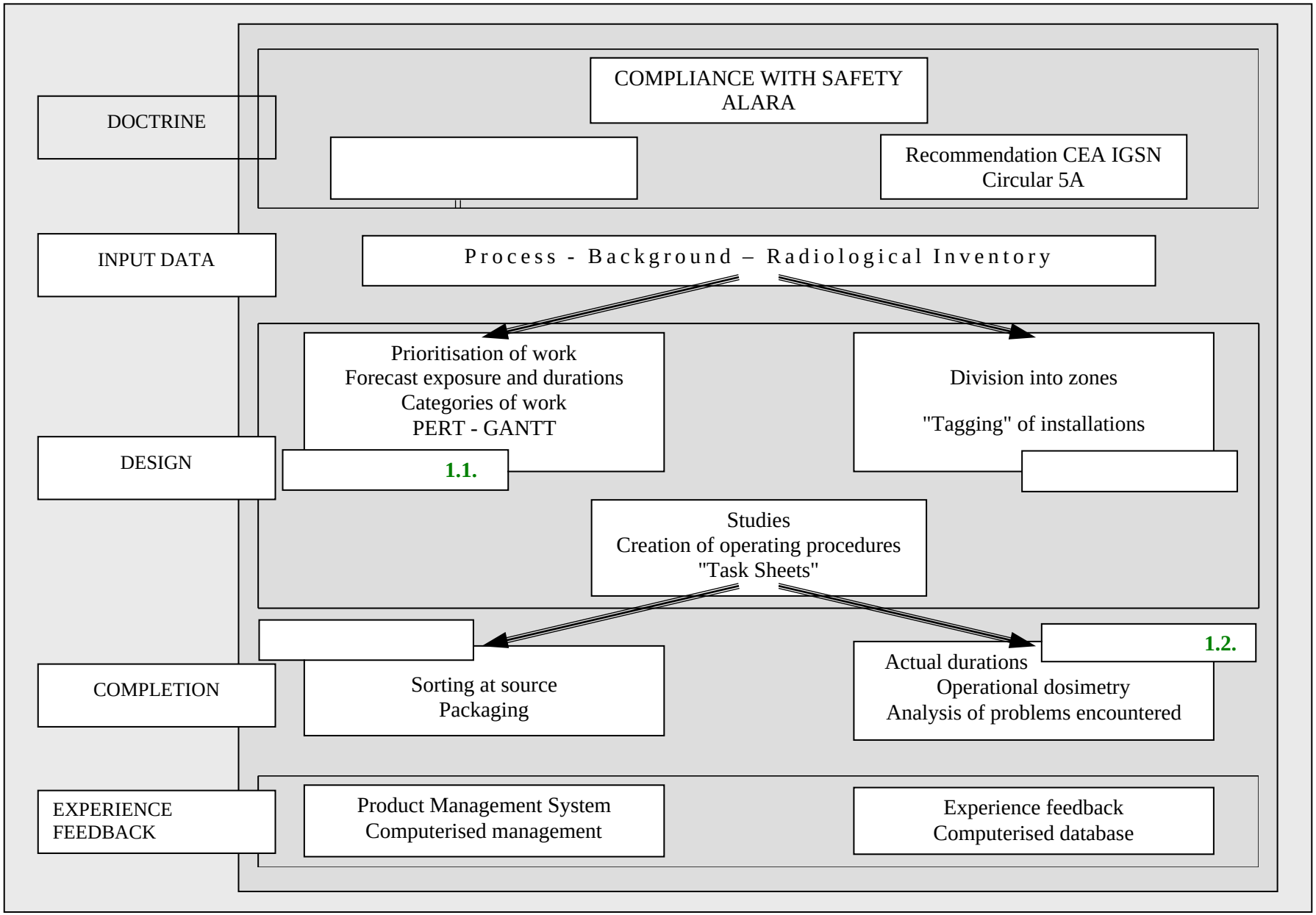
### Reports on how work is progressing

The physical and radiological inventories were used to devise tasks. Determination of the radiological status when each task is being carried out confirms the input data.

Finally, to bring a task to an end, the radiological status is determined to make it possible to move on to subsequent tasks. Monitoring the radiological changes on the worksite ensures that personnel are protected and waste generated in a satisfactory manner.

Determination and location of tasks – Study approach




DOCTRINE
COMPLIANCE WITH SAFETY
ALARA
Recommendation CEA IGSN
Circular 5A
INPUT DATA
Process - Background – Radiological Inventory
DESIGN
Prioritisation of work
Forecast exposure and durations
Categories of work
PERT - GANTT
1.1.
Division into zones
"Tagging" of installations
Studies
Creation of operating procedures
"Task Sheets"
COMPLETION
Sorting at source
Packaging
1.2.
Actual durations
Operational dosimetry
Analysis of problems encountered
EXPERIENCE
FEEDBACK
Product Management System
Computerised management
Experience feedback
Computerised database

| TYPE | INTERNAL EXPOSURE LIMITS IN RADIOLOGICAL PROTECTION ZONES | EXTERNAL EXPOSURE LIMITS IN RADIOLOGICAL PROTECTION ZONES | GENERIC DESCRIPTION OF WORK | ADDED H3 RISK | GENERIC DESCRIPTION OF PROTECTIVE MEASURES | SPR | SAFETY ANALYSIS |
|---|---|---|---|---|---|---|---|
| 1 | 80 => 4000 DAC | 2 mSv/h => 100 mSv/h | removal of hot spots by disassembly, cutting and machining of metal parts. | YES | remote handling, remote working, metal shields, work carried out quickly with ventilated clothing. | hold point on dedicated operating procedure and presence during work | analysis of nuclear risks and conventional risks with nuclear consequences, identification of failure modes, analysis of failure modes |
| | | | | NON | remote handling, remote working, metal shields, | | |
| | | | removal of hot spots or overall cleaning by removal of concrete. Dust produced. | YES | remote control, work carried out quickly with ventilated clothing, additional extraction/filtering | | |
| | | | | NO | ditto | | |
| 2 | 1 => 80 DAC | 25 µSv/h => 2 mSv/h | disassembly of mechanical assemblies whose dose rates are above the ambient dose rate. | YES | duration of work monitored, metal shields, | comments on dedicated operating procedure, surveillance | |
| | | | | NO | duration of work monitored, metal shields, | | |
| | | | local scraping of concrete, sludge retrieval, cleaning. | YES | ventilated clothing, additional extraction/filtering. | | |
| | | | | NO | ditto | | |
| 3 | 0.3 => 1 DAC | 7.5 µSv/h => 25 µSv/h | disassembly of large items of equipment, removal of ventilation ducts, electric cable etc. atmosphere < 5µSv/h | YES | mask for close work, permanent monitoring of aerosols.. | info. on standard operating procedure, overall surveillance | |
| | | | | NO | ditto | | |
| | | | cleaning of concrete < 1000 Bq/cm2 | YES | dust mask, monitoring of aerosols. | | |
| | | | | NO | ditto | | |
| 4 | < 0.3 and > 0.1 DAC | < 7.5 and > 2.5 µSv/h | cleaning of concrete < 100 Bq/cm2 | | white overalls, dust mask. | industrial safety, monitoring of waste generated | |