Decontamination and Decommissioning Program of a Radiopharmaceuticals Production Facility – 17103

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ABSTRACT

On May 2012, Best Medical Belgium (BMB) S.A., a manufacturer of pharmaceutical products located on the nuclear site of Fleurus, was declared bankrupt. According to the Belgian law, ONDRAF/NIRAS (Belgian Radioactive Waste Management Agency) was entrusted with the clean-up and the decommissioning operations of the former BMB facilities, nowadays known as “ONDRAF/NIRAS Site Fleurus” (ONSF). In June 2015, ONSF launched a Decontamination and Decommissioning (D&D) program, for which Tractebel supports the definition of the clean-up and decommissioning strategies; the drafting of the Final Decommissioning Plan (FDP) & License Application for decommissioning; and the follow-up of the clean-up and upcoming D&D works on site.

Four nuclear buildings are part of the clean-up and D&D activities. One of them, Building 14 (B14), represents the most challenging task with the clean-up of highly contaminated areas and their further decommissioning up to greenfield. Beside its two cyclotrons successively used for the production of radioisotopes, this building features hot cells and glove boxes used for the purification of radioisotopes and the conditioning of the final pharmaceutical product.

The present paper aims at presenting the development of the D&D program in terms of modifications of existing facilities to allow carrying out the clean-up and D&D activities and the management of dismantled radioactive materials in a safe, efficient and cost-effective way as well as in terms of strategic options to be developed for the FDP.

To support the clean-up and D&D activities, several workshops have been designed in order to treat radioactive materials removed from the building rooms. Those workshops feature an input buffer storage area, a common output buffer storage area and installations for the treatment of radioactive materials and waste (handling devices, cutting means, decontamination means, free release measurements means, etc.). Some modifications to the existing auxiliary systems will be required in order to dispose of appropriate systems to operate those workshops in a safe way.

Activated concrete structures will constitute the most important part of radioactive materials that will arise from the decommissioning activities. To limit the total decommissioning costs, and especially the costs associated to radioactive waste management, two strategies have been developed in order to manage a part of activated concrete as candidate for free release with a certain decay period or as candidate for conventional landfill. Both strategies will have to be further detailed and discussed with the competent Authorities to ensure they can actually be implemented.

INTRODUCTION

In 2015, ONSF decided to launch a program for the clean-up and D&D of the former BMB facilities for which they are liable on the site of Fleurus. Consequently, dedicated studies were launched by ONSF, with engineering support of Tractebel.

Four nuclear buildings (B4, B7, B14 and B20) are part of the clean-up activities that are currently planned up to mid-2019. One of them, building B14, represents the most challenging task with the clean-up of some highly contaminated areas and its further decommissioning up to greenfield expected by 2022. Beside its two cyclotrons successively used for the production of radioisotopes, this building features hot cells and glove boxes used for the purification of the radioisotopes and the conditioning of the final pharmaceutical product.

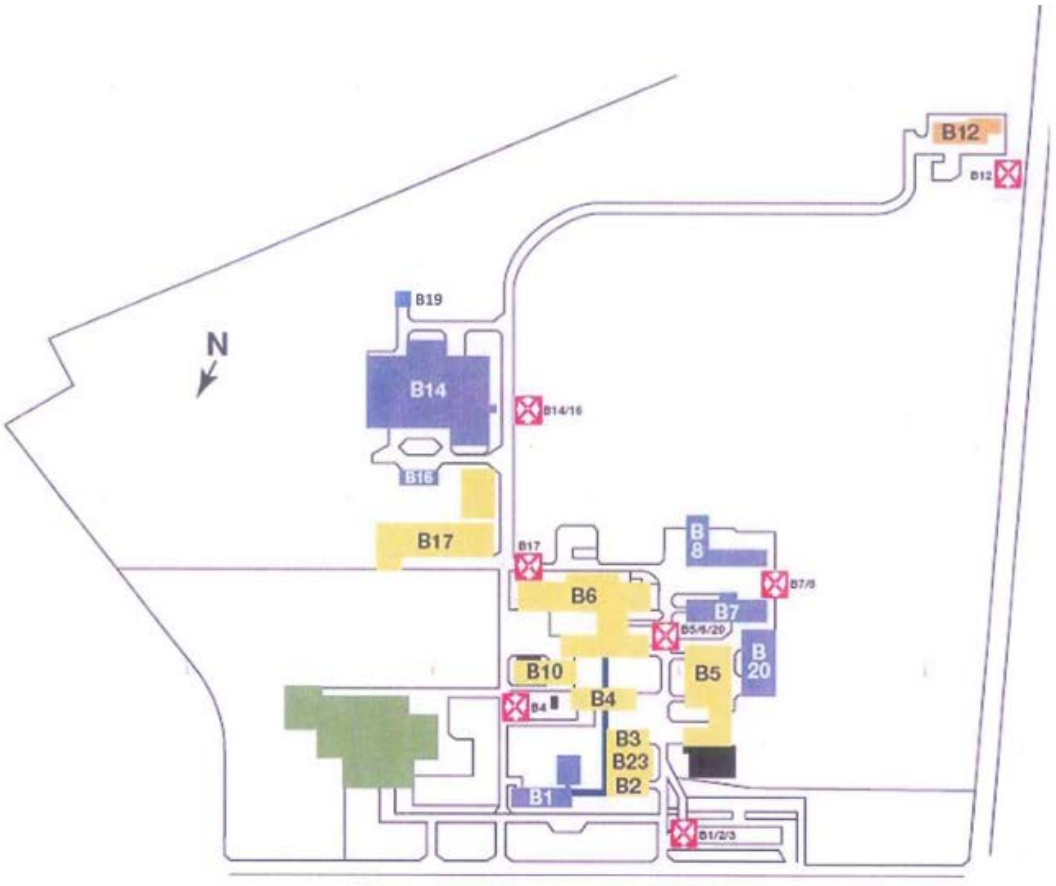

Fig. 1. Nuclear site of Fleurus

In order to prepare the clean-up and D&D studies and works, a physical and radiological inventory of the relevant installations, including toxic substances such as asbestos, has been drawn up by Tractebel in the early stages of the project. No less than 9000 tons of infrastructures and 1300 tons of equipment have been listed and will be part of the further clean-up and D&D program. Other activities initiated for

the clean-up program since the beginning of the project consist in the removal of very slightly contaminated and easily movable equipment.

Several workshops will be built within the existing B14 building in order to deal with radioactive materials arising from the clean-up and D&D activities. Tractebel has developed the workshops' design and functionalities in terms of sorting, cutting, decontamination, packaging and radiological measurements. For this purpose, the modifications to be implemented for the construction of such workshops have been studied (civil works, ventilation system, handling means, radiation protection devices …). Support for drafting the license application of the workshops has been provided as well.

Furthermore, Tractebel takes on the engineering studies for the drafting of the FDP that will be submitted to FANC/AFCN (Belgian Federal Agency for Nuclear Control) in order to get the License for decommissioning. Among others, the decommissioning of building B14 implies the dismantling of hot cells, cyclotrons and all other fixed equipment remaining after the clean-up phase, but also the management of contaminated and activated structures. Strategic options related to those activities will be developed and analyzed by Tractebel in the framework of the FDP in order to determine the optimum considering the technical, safety and economic aspects.

WORKSHOPS FOR THE MANAGEMENT OF RADIOACTIVE MATERIALS

Strategy

The clean-up and D&D activities for all controlled areas in the scope of the project will generate a large amount of potentially radioactive materials. In order to minimize the final amount of radioactive waste, different operations such as cutting, sorting, decontamination, measurements, etc., will have to be performed. When such operations are numerous and complex and when the working environment does not enable their safe and efficient achievement, those will be performed within dedicated workshops.

The benefits of implementing dedicated workshops to support the clean-up and D&D activities are the following:

- To better achieve the primary objective of the project in minimising the final amount of radioactive waste and so limiting the associated costs;
- To separate the clean-up and D&D activities of rooms from the treatment of removed materials;
- To enable a clear visibility of the schedule progress;
- To limit the impact and risks associated to the possible interactions of clean-up and D&D works with other nearby operations (including work of other companies operating on the same site);
- To perform the treatment of removed materials in optimal conditions (ergonomics, nuclear safety, conventional security, risk of cross contamination management, etc.).

In order to build the workshops, modifications of the existing B14 building will be implemented. The main strategy consists in designing the workshops with the necessary equipment and treatment capacity for the management of radioactive materials arising from the activities performed during the clean-up phase of the project. Some adaptations to those workshops could be further implemented during the decommissioning phase to best fit its specific requirements.

Three main workshops will be located inside the B14 building:

- "L1/L2" Workshop that will be dedicated to the treatment of radioactive materials which are activated or imply a high risk of contamination. Potentially contaminated materials will be processed in this workshop as well, in separated campaigns;
- "L3" Workshop that will be dedicated to the treatment of radioactive materials which are slightly activated or imply a low risk of contamination;
- "Low background radiation level" Workshop that will be dedicated to the surface free release measurements. Due to its function, the risk of contamination is practically non-existent.

Isotopic Vectors Management

The clean-up activities (and the further D&D activities) of the ONSF's facilities will have to deal with an important risk of cross contamination. Indeed, no less than 13 different isotopic vectors are observed for all the facilities. An isotopic vector is specific to a certain zone and consists in a list of all radionuclides which are potentially present in this zone. This has been defined in the framework of the present project to facilitate the radiological measurements of removed materials (awareness of which radionuclides have to be measured in function of the isotopic vector list).

Due to this variety, measures will have to be taken inside the workshops in order to avoid the cross contamination of radioactive materials arising from the clean-up and D&D activities of rooms having different isotopic vectors:

- One isotopic vector at one time is managed inside each workshop;
- At the end of a campaign dedicated to a specific isotopic vector, the workshop will be cleaned in order to be able to perform a campaign dedicated to another isotopic vector:
    - Workshop cleaning (rooms and equipment);
    - Blades of cutting equipment can be replaced if necessary;
    - Workshop contamination measurements (rooms and equipment).

General Overview of Radioactive Materials Management

The design of the workshops is based on a qualitative analysis considering the different types and amount of radioactive materials arising from the clean-up activities. The general way to manage those materials is illustrated in Fig. 2.

Radioactive materials will arise from the clean-up activities inside the rooms of all the concerned facilities (worksite). Those materials will undergo a radiological measurement before leaving the worksite. The result of this orientation measurement will contribute to the definition of the further processing of materials and the associated destination such as the “L1/L2” workshop, the “L3” workshop, the “low background radiation level” workshop, etc.

Materials candidate for unconditional free release have to undergo two successive and independent radiological measurements (surface or/and volume measurements). The type of free release measurement depends on the isotopes and material (geometry, dimensions and density) to be measured. This aims at demonstrating that the activity level is below the free release limits applicable in Belgium.

Radioactive waste is adequately packaged on-site to meet the Waste Acceptance Criteria (WAC) for non-conditioned waste defined by ONDRAF/NIRAS. After transportation of the non-conditioned waste, its conditioning will be performed in Dessel at the Belgoprocess site, a subsidiary of ONDRAF/NIRAS.

Not all radioactive materials will be processed in Dessel, melting of metallic materials for recycling will be considered as well and outsourced to external melting facilities.

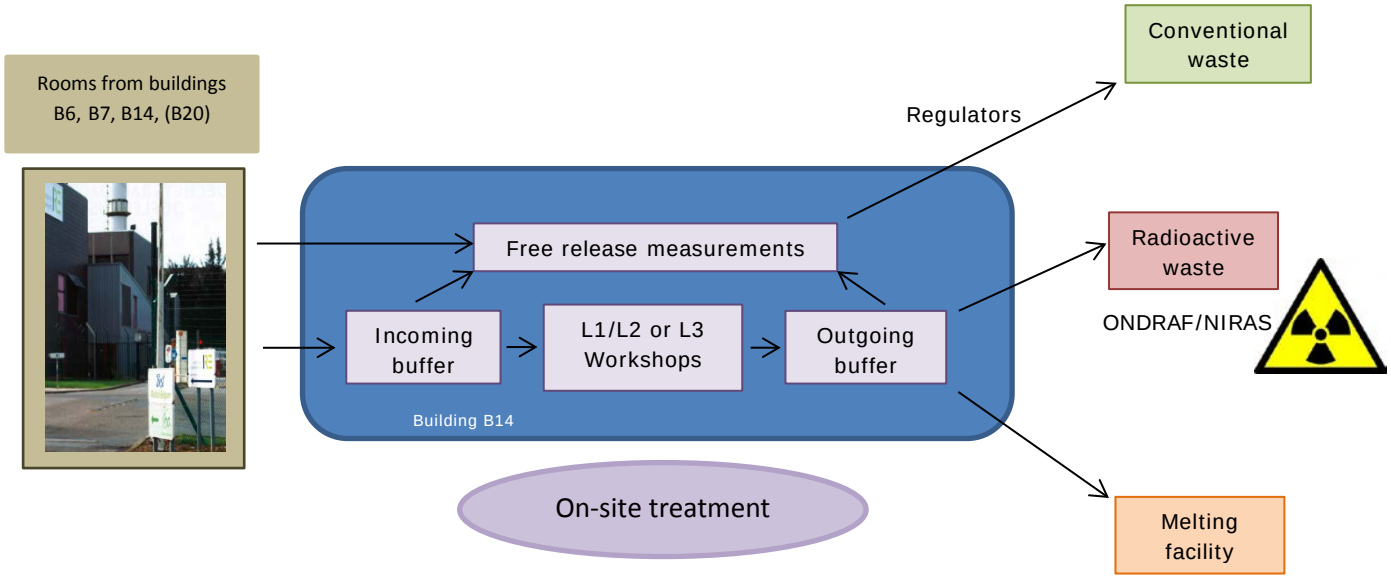

Fig. 2. Management of radioactive materials arising from the clean-up and D&D activities

Workshops Design

The workshops will be built inside the existing B14 building located on the Fleurus site. This building is also part of the scope of the clean-up and D&D activities.

The layout of the workshops is given in Fig. 3 with the associated radiological zoning that has been established to determine the protective measures necessary to ensure a safe working environment. The identified containment classes are, according to ISO 17873:2004 [1]:

- The “L1/L2” workshop is located in the red part (C3) which means an area in which some surface contamination could be present but it is normally free from airborne contamination. In some cases, resulting from an incident or accident situation, there will be a potential surface or airborne contamination at a level higher than in C2 area;
- The “L3” workshop is located in the yellow part (C2) which means an area that is substantially clean during normal operation. Only in exceptional circumstances, resulting from an incident or accident situation, a medium level surface or airborne contamination is acceptable;
- The “low background radiation level” workshop is located in the green part (C1) which means a clean area free from radioactive contamination, whether surface or airborne. Only in exceptional situations, a low level contamination is acceptable.

As illustrated in Fig. 3, the “L1/L2” and “L3” workshops have an input buffer storage area in order to store radioactive materials awaiting their future treatment. A

common output buffer storage area is designed for both workshops. Due to the radiological zoning of the “L1/L2” workshop, an airlock is foreseen for the entrance and the exit of operators and materials.

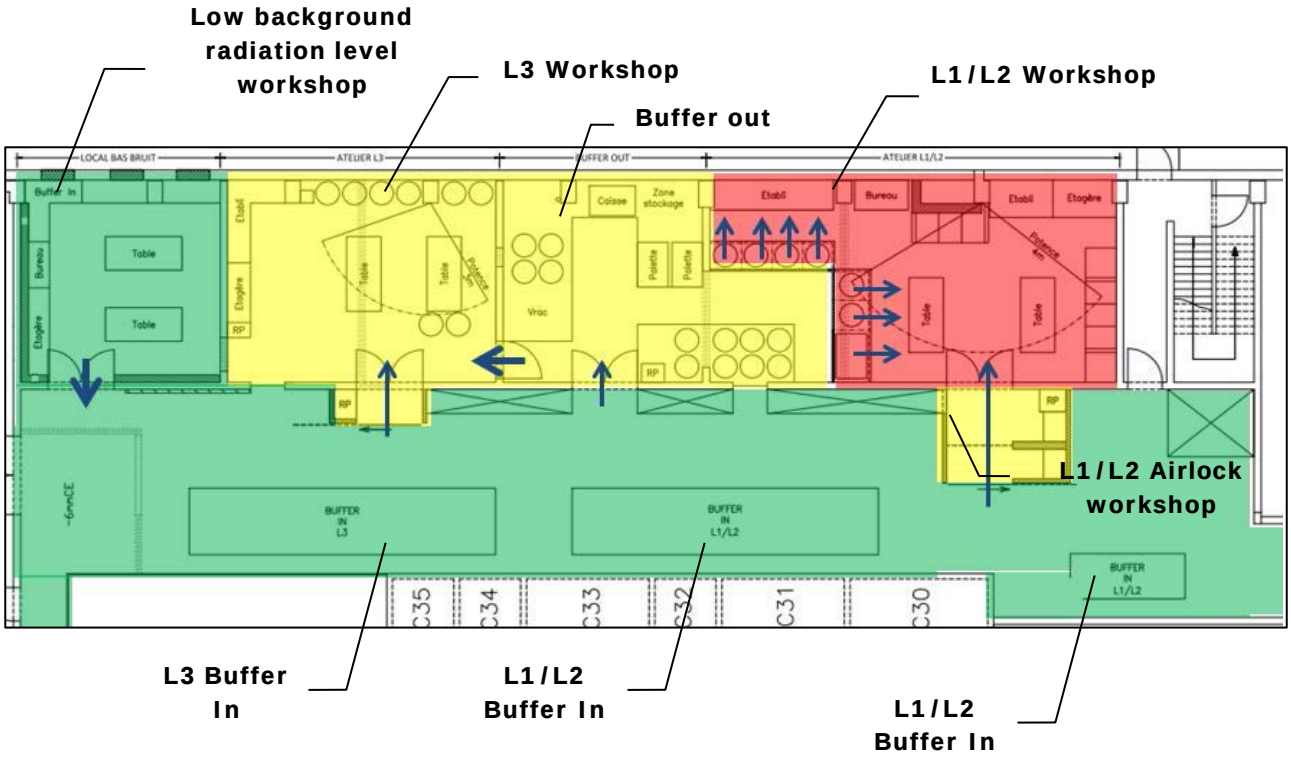

Fig. 3. Workshops to be built inside the B14 building - Functional rooms

The main functions of the workshops enable to ensure a safe and efficient treatment of radioactive materials or waste arising from the clean-up and D&D activities. Their definitions are the following:

- The “L1/L2” workshop will enable:
  - The buffer storage of radioactive material or waste awaiting their future treatment in the workshop;
  - The handling of radioactive materials or waste during their treatment in the workshop;
  - The radiological measurements in the workshop to define the next step of the process;
  - The dismantling and cutting of radioactive materials or waste;
  - The light decontamination of radioactive materials;
  - The sorting of radioactive materials or waste in function of their final destination and the following criteria:
    - Contamination and activation (separation of contaminated and activated parts from non-radioactive parts);
    - Physical properties (metal, glass, wood, etc.) and dimensions;

        - Radiological properties;
    - The packaging of radioactive materials or waste;
    - The recording of required data (traceability);
    - The evacuation of radioactive materials or waste up to the output buffer storage area;
- The “L3” workshop will enable:
    - The buffer storage of radioactive material awaiting their future treatment in the workshop;
    - The handling of radioactive materials during their treatment in the workshop;
    - The radiological measurements in the workshop to define the next step of the process;
    - The dismantling and cutting of radioactive materials;
    - The sorting of radioactive materials in function of their final destination and the following criteria:
        - Physical properties (metal, glass, wood, etc.) and dimensions;
        - Radiological properties;
    - The packaging of radioactive materials;
    - The recording of required data (traceability);
    - The evacuation of radioactive materials up to the output buffer storage area;
- The “low background radiation level” workshop will enable:
    - The buffer storage of materials awaiting their future treatment in the workshop;
    - The handling of materials during their treatment in the workshop;
    - The (surface) free release measurements of raw materials;
    - The recording of required data (traceability);
    - The evacuation of materials up to the output buffer storage area.

To be able to perform those functions, each workshop will be equipped with the appropriate handling devices, cutting means, light decontamination means, measurement devices, packaging means, etc.

Auxiliary Systems

Some auxiliary systems will have to be modified or installed in order to enable a safe and efficient work inside the workshops. Those are the following:

- The existing ventilation system will have to be adapted in order to generate the required pressure cascade inside the workshops. This will prevent the dispersion of contamination and ensure a dynamic confinement of the workshops;
- The existing fire system will have to be adapted inside the workshops (fire detection and suppression system);
- Radiation protection means will have to be installed in the workshops in order to comply with the ALARA principle (radioactive airborne contamination detection, dose rate measurement, airlock, etc.). The implemented measures will depend on the type of workshop;

- The electricity network will be adapted to best fit the new needs of the workshops (switches, lighting system, power plugs and sockets);
- Etc.

STRATEGIC OPTIONS FOR B14 BUILDING D&D

The preferred strategy that shall be applied for the D&D of building B14 is an immediate decommissioning of its installations and structures.

After the clean-up activities, the physical inventory of building B14 will be mainly composed of two cyclotrons (one CGR cyclotron and one IBA CYCLONE 30 cyclotron), hot cells, auxiliary systems (ventilation, handling, electricity, water distribution, compressed air distribution, heating, etc.), tanks used for the collection of liquid effluents, activated and contaminated structures but also the workshops put in place to support the clean-up and D&D activities.

As explained for the clean-up activities, dismantled materials will follow different treatments in function of their final destination (free release, melting or radioactive waste).

The strategy for the decommissioning phase of building B14 is developed within the framework of the FDP. Several issues influence the selection of the D&D strategy:

- The management of activated structures (concrete);
- The selection of primary waste packages for activated radioactive waste (concrete);
- The logistics for radioactive materials transportation inside building B14;
- The dismantling of both cyclotrons.

Among these issues, the possible strategies for the management of the activated concrete are presented in more detail below.

The Management of Activated Concrete Structures

Slightly activated concrete will constitute the most important part of radioactive materials that will arise from the decommissioning activities.

Activated concrete is localized in the surrounding areas of the shielded and targets rooms. Depending on the type of use and the final shutdown date of both cyclotrons, the level and the depth of activation are different. This is the reason why the environment of the IBA cyclotron constitutes the biggest part of the activated concrete and represents the most important decommissioning challenge.

Future radiological characterization will indicate the depth of activation in the walls, the ceiling and the roof of each room. In function of those results, activated concrete will be removed following different approaches:

- Small thicknesses will be removed at one time for small activated depths of concrete. If necessary, this process can be repeated several times to remove the entire activated depth;

- Concrete blocks will be removed at one time for large activated depths of concrete.

Several strategic options for the management of activated concrete structures have been analyzed. For this purpose, a cost-benefit analysis has been performed to compare, in function of decay time, the management of activated concrete as radioactive waste, as candidate for unconditional free release, or as candidate for conditional release. This study indicates that:

- The management of activated concrete as radioactive waste is economically not efficient;
- The management of activated concrete as candidate for unconditional free release after a certain decay period enables to significantly reduce the amount of radioactive waste and the associated costs. Following this strategy, building B14 will have to be subjected to limited monitoring during the required decay period;
- The management of activated concrete as candidate for conventional landfill, if approved by FANC/AFCN, could enable to reduce the amount of radioactive waste as well.

Finally, two scenarios that must still be developed and detailed are currently considered for the management of dismantled concrete mixing the consideration of free release, conventional landfill and radioactive waste:

- Scenario 1: a part of activated concrete will be stored at Belgoprocess site, during the decay period. It will be finally free released after that decay period. The rest of activated concrete, for which the decay period is judged too long, is managed as radioactive waste;
- Scenario 2: a part of activated concrete will be sent to conventional landfill if accepted by the Authorities. The rest of activated concrete, for which the level of activation is too important to be stored in a convention landfill, is managed as radioactive waste.

CONCLUSIONS

In partnership with ONSF, that is liable for the clean-up and D&D of the former BMB facilities located on the Fleurus site, Tractebel completed the feasibility and the design of the workshops to be built inside building B14 in order to support the management of radioactive materials and waste arising from the future clean-up and D&D activities.

These workshops feature an input buffer storage area, a common output buffer storage area and installations for the treatment of radioactive materials and waste (handling devices, cutting means, decontamination means, free release measurements means, etc.). Some modifications to the existing auxiliary systems will be required in order to dispose of appropriate systems to operate those workshops in a safe way.

Activated concrete structures will constitute the most important part of radioactive materials that will arise from the decommissioning activities. To limit the total

decommissioning costs, and especially the costs associated to radioactive waste management, two strategies have been developed in order to manage activated concrete either as candidate for free release with a certain decay period or as candidate for conditional release (storage in conventional landfill). Both strategies will have to be further detailed and discussed with the competent Authorities to ensure they can actually be implemented.

REFERENCE

1. «Nuclear Facilities — Criteria for the design and operation of ventilation systems for nuclear installations other than nuclear reactors», ISO 17873:2004, 2004.