Belgoprocess

Individual protection equipment and ergonomics associated with dismantling operations in a hostile environment

1. Introduction

Belgium started its nuclear programme quite early. The first installations were constructed in the fifties, and the first PWR installed and operated in Europe, the BR3 power plant was situated in Belgium at the site of the Belgian Nuclear Research Centre (SCK·CEN). Presently, more than 55 % of the Belgian electricity production is provided by nuclear power plants.

After 30 years of nuclear experience, Belgium started decommissioning of nuclear facilities in the eighties with two main projects: the BR3-PWR plant and the Eurochemic reprocessing plant. The BR3-decommissioning project is carried out at the Belgian Nuclear Research Centre, while the decommissioning of the former Eurochemic reprocessing plant is managed and operated by Belgoprocess, which is also operating the centralised waste treatment facilities and the interim storage for Belgian radioactive waste.

2. Decommissioning of the Eurochemic Reprocessing Plant

Belgoprocess started the industrial decommissioning of the main process building of the former Eurochemic reprocessing plant in 1990, after completion of a pilot project. Two small storage buildings for final products from reprocessing were dismantled to verify the assumptions made in a previous paper study on decommissioning, to demonstrate and develop dismantling techniques and to train personnel. Both buildings were emptied and decontaminated to background levels. They were demolished and the remaining concrete debris was disposed of as industrial waste and green field conditions restored. The main conclusions of this pilot decommissioning project denoted that emphasis had to be put on:

- The automation of concrete decontamination, and
- The decontamination of metal components.

The main process building is a large rectangular construction of about 80 m long, 27 m wide and 30 m high. About 106 individual cell structures have to be dismantled, involving the removal and decontamination of equipment from each cell, the decontamination of the cell walls, ceilings and floors, the dismantling of the ventilation system. These activities are followed by a complete monitoring to allow for unconditional release of the remaining structures. As such, about 1,500 Mg of metal structures, and 12,500 m^3 of concrete with 55,000 m^2 of concrete surfaces have to be removed and/or to be decontaminated.

Most of the work involves hands-on operations under protective clothing tailored to each specific task. Tool automation and automatic positioning systems are successfully applied.

The specific Belgoprocess approach should be highlighted in which decommissioning activities are carried out on an industrial scale with special emphasis on cost minimisation, a commitment to results within an overall planning, and the use of technology on an industrial representative scale. This approach includes specific actions to reduce standby costs. It takes great care to limit radioactive waste management costs, keeping the generation of radioactive waste to a minimum, minimising the spread of radioactivity as much as possible by containing it to the furthest possible extent, and optimising the possibilities for recycling and reuse of valuable components from existing and potential waste streams. Extensive use of adequate decontamination techniques is made in order to allow dismantled components and materials to be unconditionally released, taking into account the limited availability of funding.

In a broader context, the recycling of materials is considered as a first order ecological priority, in which maximum reuse of materials is considered to limit the radioactive waste quantities to be disposed of, to reduce the technical and economic problems involved with radioactive waste management, to make economic use of primary material and to conserve natural resources of basic material for future generations.

The environmental impact of recycling options compared to the option of non recycling (mining or production of new material), dispose and replace, with the associated risks involved, is also considered, as well as the social and political impacts of recycling. It has to be admitted, however, that the general applicability of promising recycling techniques is largely influenced by the availability of internationally acceptable release levels for various practices.

Selected techniques make use of state of the art technology, providing own support to nuclearise commercially available technology, and must include specific requirements about safety, efficiency, waste minimisation, cost-effectiveness and feasibility of industrialisation.

The decommissioning activities have to deal with the specific radiological characteristics of the facilities. While the decommissioning of a nuclear power plant is mainly characterised by radiation risks due to the presence of in depth activation products, the alpha contamination of equipment and building surfaces in a reprocessing plant requires that adequate protective clothing is used to carry out the decommissioning work. Therefore, specific breathing and cooling air systems are provided to enable that the decommissioning tasks are carried out in acceptable working conditions.

3. Intervention clothing and other protection systems

Depending on the required decommissioning techniques and on the existing or expected spread of contamination on the work area, the operators use combinations of different kinds of protective clothing and equipment.

Figure 1. Protective clothing for decommissioning work in contaminated areas

As indicated in Figure 1, some of the basic protection means include:

- Underwear, socks, normal white overalls, cotton head protection, different kind of gloves, overshoes, boots;
- A plasticised paper overall, when working in low contaminated areas and when there is no risk for contamination by liquids;
- A plastic overall, plastic head protection, when working in highly contaminated areas or in case of risk for contamination by liquids;
- A flame-form (non-inflammable impregnated cotton) overall with flame-form head protection, when working with plasma-arc cutter or grinding disk in areas without contamination;
- An integral plastic suit, covering all the body and allowing the use of all other normal protective clothing, including filter mask, air line and safety helmet, when working in highly contaminated areas;
- A fission overall with fission head protection and heat resistant gloves, when working with plasma-arc cutter or grinding disk in highly contaminated areas;
- A ferranyl (chemical resistant) overall and ferranyl head protection, for use in acid environment;

- A full-face mask, a filter mask for use under integral plastic suits, air line with breathing and cooling air and emergency supply;
- Eye protection when using plasma-arc cutting;
- Ear protection, depending on the noise level;
- A safety helmet.

Adapted protective clothing and equipment may always be prescribed, depending on the specific working conditions.

4. Standardised intervention techniques and equipment

To arrive at a qualified and uniform system for intervention activities, the entire issue of working in ventilated or pressurised suits was described in a report that was submitted to the company's Health Physics and Safety Department. The report comprised a definition of a generally accepted intervention technique as well as a description of the available intervention equipment. Some technical issues remained unsolved, however, and it was decided to discuss these in detail in a working group. It was the aim to arrive at a qualified and uniform system to provide breathing and cooling air to the operators in their protective clothing when carrying out intervention activities in contaminated areas, especially with alpha contamination. Meanwhile the techniques and equipment defined and approved of were used.

Figure 2. Combined breathing and cooling air supply to operators in ventilated clothing

The group evaluated various existing systems for breathing protection. Based on the results of the discussions, a newly adapted system for a combined breathing and cooling air supply was tested. As indicated in Figure 2, it is connected to a full-face mask, similar to the type of face mask that was used before, but with two standard connections. The system is equipped with a low profile automatic, first breath activated, positive pressure demand valve, in addition to a safety device, allowing breathing through an absolute or a P3 filter when the normal air supply has dropped. A bypass on the positive pressure demand valve provides an additional air flow to refresh the operator's face if required and to remove excessive moisture. All supply systems were tested to evaluate if they could meet existing requirements for pressurised air systems and for free air systems in case of emergency.

The working group also investigated the required changes to the protective clothing system in order to enable the application of the new supply systems, aiming as much as possible at standardisation of the protective clothing system. Special attention has been paid to minimise weight and dimensions of the components and to improve the carrying comfort.

An in-line breathing air filter, fitting in an adequate aluminium housing, was successfully tested regarding pressure resistance and efficiency. A special mould was designed to enable serial production of the special synthetic connection system provided to ascertain a leak-tight penetration of the air line through the protective clothing system, and a special aluminium distribution block was developed to provide a controlled air distribution for both breathing and cooling air systems. It comprises a control valve, a non-return valve and additional connectors. The system was successfully tested in combination with the automatic breathing system, allowing breathing and cooling air flows to be delivered as required.

Finally, a new supply unit to provide filtered breathing air to the operators (with emergency supply and alarm systems) was constructed and successfully tested.

The whole system was tested under industrial circumstances by the decommissioning and decontamination operators. The results were very positive. No contamination was detected, neither on filters, nor on other components. Only some minor operator specific problems were reported with respect to the mask, the cooling or the automatic breathing device.

The proposals made to adapt the protective equipment were supported by a theoretical modelling of the entire system for breathing and cooling air supply to the operator.

5. Physical tests to evaluate the workload on the operators

In 1993, the work load on the operators during decommissioning activities with ventilated suits in contaminated areas was monitored in co-operation with a specialised institute. In a first phase, the physical condition of the operators under reference circumstances was measured by means of individual strenuous tests. In a second phase the physical load on the operators was measured under normal working conditions of plasma cutting and hydraulic hammering or scabbling.

During these measurements, the operators used the available protective equipment that had been adapted and applied since 1992. The tests were based on heart pulse rate and rectal temperature registrations as indicated in Figure 3. The data provided interesting information about the physical load on the human body during the intervention work.

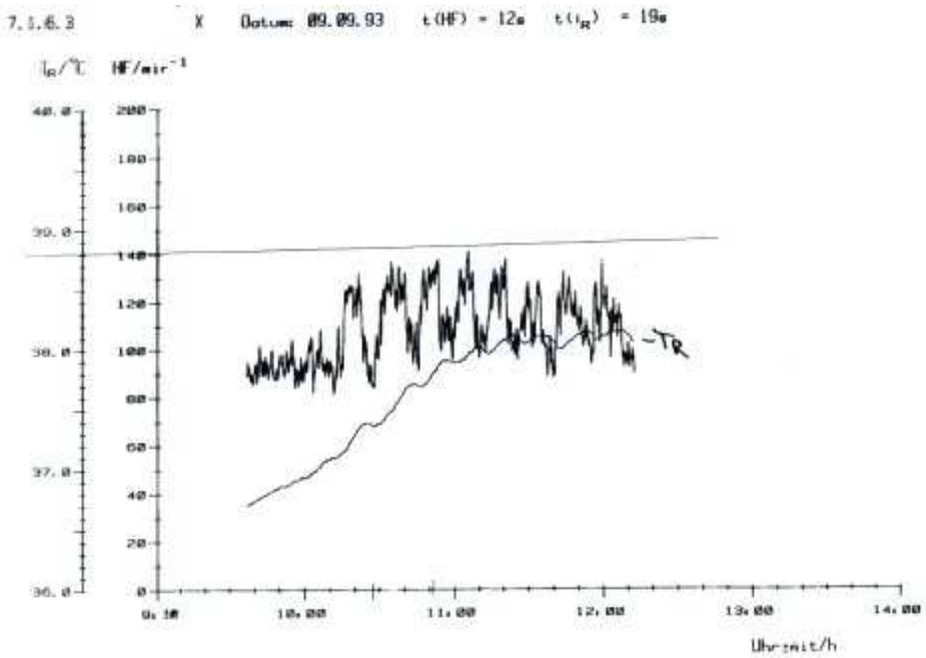

Figure 3. Heart pulse rate and rectal temperature registrations during decommissioning work using the earlier breathing and cooling air systems

The physical condition tests and the measurements of the work load on the operators under normal working conditions of plasma cutting and hydraulic hammering or scabbling, were repeated in 1995 before the newly developed protective equipment for intervention activities in contaminated areas, especially with alpha contamination, was generally used. The results of these tests were compared to the results of the tests, carried out in 1993, using the adapted breathing system that has been applied since 1992.

Although the physical condition of the operators had decreased by 7 % compared to the values of 1993, the results of the measurements when using the automatic breathing system combined with the overpressure mask, were 20 % more favourable with respect to the proposed heat stress limits. Increases in heart rate and rectal temperature proved to be less explicit as with the former system, and the recuperation of the operators during the lunch time break proved to be 100 %, as indicated in Figure 4. As such, the positive influence of the new combined breathing and cooling system was explicitly shown.

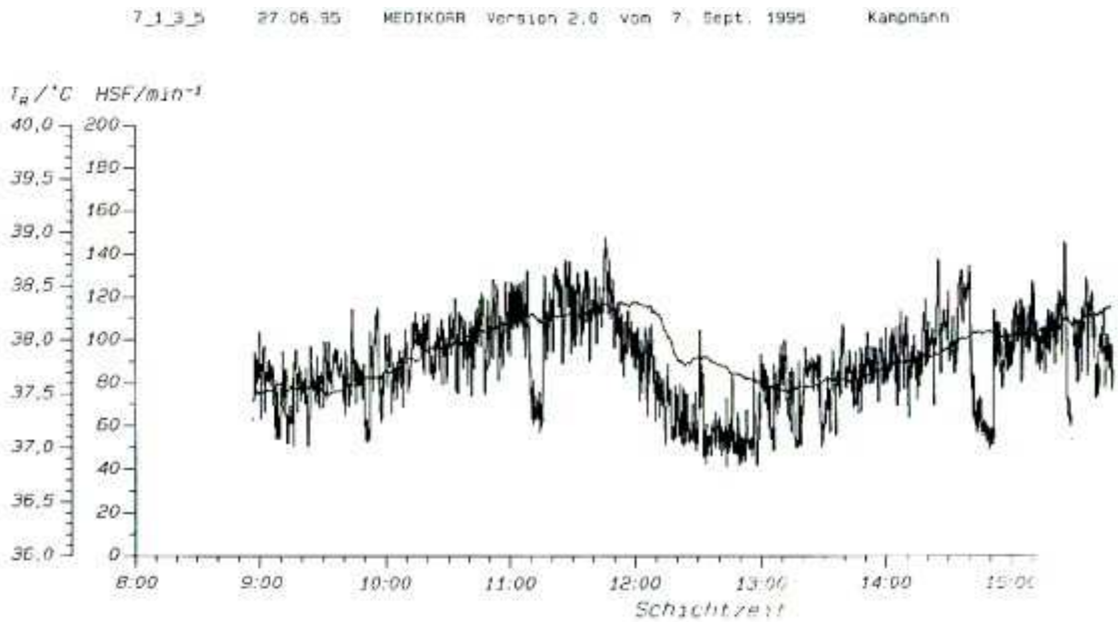

Figure 4. Heart pulse rate and rectal temperature registrations during decommissioning work using the newly developed breathing and cooling air systems

Based on these results, the legal aspects of the use of the new breathing and cooling system, combined with ventilated suits was discussed with representatives of the federal Administration of Labour Safety, including the author of the Royal Decree on the use of personal protection systems. In view of the developments, the tests carried out on the different parts of the system, and of the available descriptive files, no problems were seen in a general use of these personal protection systems on the Belgoprocess site or in Belgium. Further applications in the European Union or in other countries requires that the system is universally certified to obtain a dedicated 'EU'-mark. In addition, it must be shown that the system satisfies the specific regulations applied in every individual country.

6. Conclusions

When decommissioning nuclear facilities, one of the most important hazard concerns the potential for internal contamination through inhalation of radioactive particles. Combinations of different kinds of protective clothing and equipment are used to protect the operators.

To carry out intervention activities in controlled areas, especially with alpha-contamination, a qualified and uniform system to provide breathing and cooling air to the operators in their protective clothing was developed, tested, and applied. As much as possible standardisation of the protective clothing systems was aimed at. Special attention was paid to minimise weight and dimensions of the components and to improve carrying comfort.

In order to follow-up the efficiency of the protective equipment, physical condition tests and measurements of work load on the operators were executed under normal working conditions of plasma cutting and hydraulic hammering or scabbling. Increases in heart rate and rectal temperature proved to be less explicit as with the former system, and operators' recuperation during lunch time break proved to be 100 %. As such, the positive influence of the developed combined breathing and cooling system was explicitly shown.