

The molybdenum production facility and its relationship with NRG

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Abstract

Mallinckrodt Medical's (MM) Molybdenum Production Facility (MPF) is located in the Hot Cell Laboratories (HCL) of NRG. Following a tight schedule, molybdenum is produced on a regular basis by MM under the supervision of NRG. In this paper, successively a short description of the production process is given followed by an outline of the radiological impact to the surrounding. In a second part the organizational impact for the management of NRG in general and more specific the HCL is described. Attention is given to the consequences with respect to logistics, license, safety issues, monitoring, waste handling and operational support.

Keywords: *radio-isotopes, waste management*

Introduction

The Molybdenum Production Facility is operational in Petten since 1995. It was a joint undertaking by Mallinckrodt Medical, now a part of Tyco Healthcare and of ECN. The building cost (not taking the cell inventory into account) was about 10 million euro.

The facility consists of two independent lines of five hot cells, built around a joint transport hall. In August of this year, the 1000th batch of molybdenum was produced in the facility. Technetium, the daughter isotope of molybdenum, is used for medical diagnosis. Worldwide, about 30 million patients are given technetium injections per year. More than half of this technetium originates from Petten.

The chemical extraction process and the distribution of molybdenum to hospitals all over the world (but mainly to North America, Europe and Japan) are done by Mallinckrodt Medical, part of Tyco Healthcare. All other aspects of the undertaking (nuclear license, irradiation of targets, waste management, radiological monitoring, etc.) are the responsibility of NRG.

Production Process

Uranium targets, covered in aluminium, bought by NRG with Cerca in France, are irradiated up to 150 hours in the High Flux Reactor (HFR) in Petten. The BR2 reactor in Mol, Belgium serves as a back-up. After 20 hours of cooling time, the targets are transported to the MPF. The installation then already has been checked and cleared by NRG personnel.

There Mallinckrodt personnel are starting with a 14 hours production run. First, the targets are dissolved in NaOH in cell nr. 1. Because the dissolving of the aluminium generates a lot of hydrogen gas, this step is performed in a nitrogen atmosphere. The hydrogen is oxidised using hot CuO. The fission products enter the solution, while the uranium is collected onto a filter. The radioactive noble gases such as xenon and krypton are led to a delay line, where most of the isotopes can decay before being coming out of the chimney.

In cell nr. 2, the iodine-131 is taken out of the solution using silver, forming AgI. Immobilising the iodine greatly adds to the safety of the MPF.

In cell nr. 3, the molybdenum is purified further using MnO₂ and Ag-1 columns. The last purification step is performed in cell nr. 4, where the finished product is heated up and collected in a platinum beaker. The transport containers are loaded in cell nr. 5. After leak testing the containers are transported to the airport.

Radiological impact

The emissions from the MPF are dominated both in activity and in the resulting dose to the general public by radioactive noble gases. Through innovations and fine tuning of the process, these emissions have

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diminished quite drastically. The emissions as function of time are shown in Figure 1.

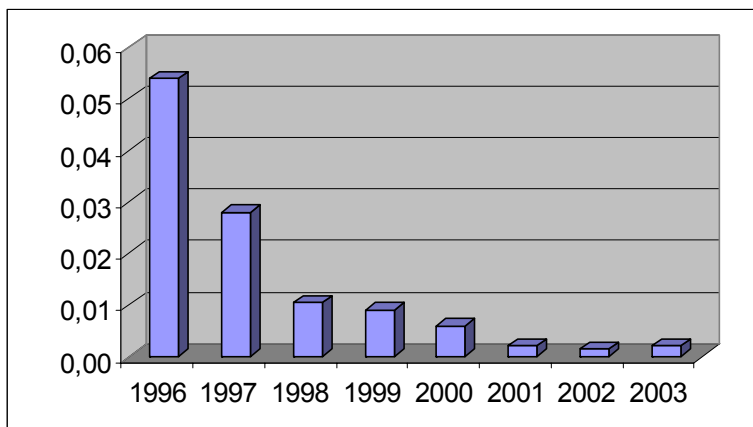


Fig. 1 Emission of noble gases in radiotoxicity equivalent units, per production

At present, about 170 productions take place in Petten every year, which means that less than 2 radiotoxicity units are being emitted per year. This should be compared to an annual permitted limit of 60 units, equivalent to a maximum dose to a member of the general public of 0,35 μ Sv per year.

In Table 1, the annual dosis of the workers in the MPF is shown. Although the extraordinary activities which are handled in the MPF (several PBq), the dose received by the workers is quite low. The mean dose is almost two orders of magnitude lower than the legal limit of 20 mSv per year. The handling of the transport containers is the dominant factor in the dose received; during production of the molybdenum the dose received by workers is much lower.

Year	Number	Max. dose (mSv)	Collective dose (mSv)	Mean dose (mSv)
2000	22	0,40	3,64	0,16
2001	22	1,15	5,42	0,25
2002	21	1,19	8,61	0,41
2003	22	0,50	6,41	0,29

Table 1 Number of workers in the MPF and their annual dose

Waste management

At each stage of the production process, radioactive waste is being produced. There are three types of different waste, each of them requiring a different route:

1. Solid Waste. In each cell, there are various items (tissues, chemical columns, connectors, tubes, etc.) which have to be renewed from time to time. They are put into a stainless steel "syntax drum" and transported to the NRG part of the HCL. The Low Level Waste (LLW, dose rate < 20 mSv/h on the surface of the drum) is transported to COVRA, the site in the Netherlands where radioactive waste is being kept. Intermediate Level Waste (ILW) is stored in a pipe storage at the HCL for up to three years, after which the drums have decayed to LLW and may be stored at COVRA much more cheaply than ILW.

Because the syntax drums are not compatible with the standard COVRA waste drums, the waste is being re-packed (compacted) at the HCL in order to reduce waste costs even more. NRG personnel do both the handling and the re-packing of the waste.

2. Liquid Waste. There are various types of liquid waste being produced, each having their own chemical composition and specific activity. The most active is the type 1 liquid, being completely dominated by ¹³⁷Cs, about 9 GBq / l. The liquid is stored in large tanks (300 – 1000 litres) in the

cellar of the MPF. When they are filled up and have cooled down for some years, they are being pumped into standard COVRA 44 litre containers and transported to the COVRA facility. There, the liquid is pumped into a 5000 litre vessel. When the tank is filled, the liquid waste is mixed with cement and stored at the COVRA site as LLW.

3. Uranium Containing Waste. With every production, some ²³⁵U (highly enriched) is collected onto a filter. After the production, this uranium is transferred onto a collect filter. After a cooling period of about one month in the cell, two such collect filters are being transported to the NRG part of the hot cell laboratory (HCL), where they are being stored under water in the HCL pool. After two years of cooling, the filters are being transported to the Waste Storage Facility (WSF), NRG's dry pipe storage facility. Like all High Level Waste in the Netherlands, the filters have to be transported to COVRA's newly built HABOG facility, where they will be kept for at least 130 years, after which they will be transported to a final disposal site.

Per production, the amount of liquid waste generated in 2003 was less than half the amount generated in 1996. This has been accomplished by fine tuning the chemical process and by solidifying part of the activity. The amount of liquid waste per production has changed significantly over time, due to a continuous effort to reduce this expensive type of waste. This decrease is shown in Fig. 2.

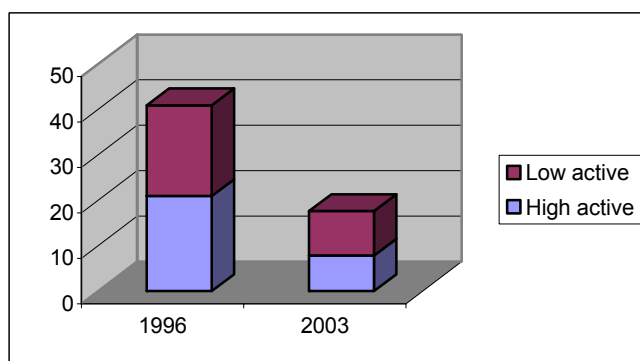


Fig. 2 Liquid waste (litres per production)

The volume of the solid waste (filters, chemical equipment, etc.) does not depend on the activity, which is being handled. Fig. 3 shows the number of drums of solid and liquid waste transported to COVRA over the years. Although the production of molybdenum shows a steep increase, the solid waste stream remains constant (due to fine tuning of the process and by packing the waste drums more efficiently), while the liquid waste stream is decreasing.

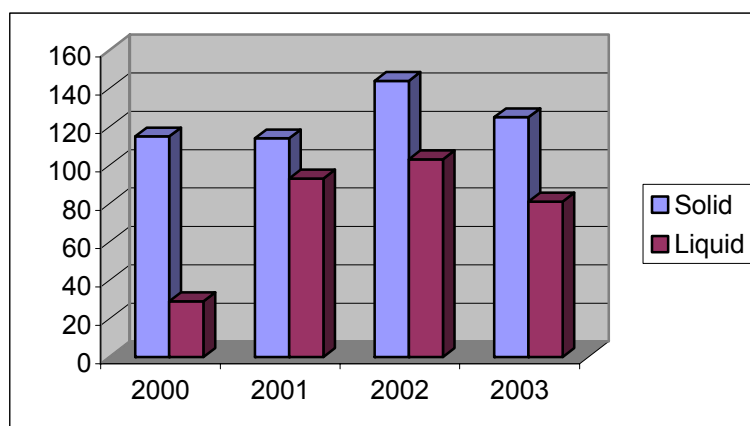


Fig. 3 Number of waste drums transported to COVRA

Organizational impact

NRG are performing quite some services to the MPF. Most of the work is done by the hot lab staff:

- Around the clock technical service
- Waste management (see previous chapter)
- Safety check before start of the production
- Radiation safety services
- Integral management of the facility
- Introduction of new safety related equipment, like filters

Other departments within NRG also perform the following services:

- Irradiation and transport of targets
- Radiological monitoring
- Maintaining and changing the nuclear license
- Safety assessments
- Decommissioning studies
- Decontamination and recycling of part of the molybdenum containers as used in hospitals

Conclusion

These are just some keywords to show the mutual dependency between NRG and Mallinckrodt. Even though molybdenum has been made in Petten for almost 10 years now, and we have just celebrated our 1000th production run, one can say that there still is a continuing drive for innovation in the MPF. Several waste reduction programmes have been carried out, and new process steps like the iodine separation and added filter capacity have been introduced within the last few years. The demand for molybdenum is still increasing, which will inspire Mallinckrodt and NRG to be even more innovative.