RADIATION SAFETY WHILE WORKING WITH PLUTONIUM

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ABSTRACT

Results are presented of the development and the application of technical measures for protection of personnel and population while working with plutonium. These measures permitted significant improvements in the radiation situation, decreasing 20-fold reduction in personnel radiation doses at work sites involved with plutonium metal.

INTRODUCTION

Plutonium-239 is one of the high toxicity radionuclides (Foreman, 1963). Thus to work with plutonium, it is necessary isolate the technological processes from personnel and the environment, and also to provide special measures for safety and radiation control. Measures and protective facilities for personnel and population at the work with plutonium in VNIIEF are examined in this paper.

Plutonium is an alpha-decay-radionuclide with accompanied characteristic X-radiation (16.6 keV). Additional neutron and gamma-radiation appears due to admixtures of plutonium-240 and americium-241. Plutonium presents the main hazard for personnel and population as the source of internal irradiation of the organism by inhalation and ingestion. According to current regulations the maximum permissible concentration for personnel is $1.9*10^{-14}$Ci/L for insoluble plutonium compounds and $9*10^{-16}$ Ci/L for soluble compounds. While working with plutonium metal, the possibility cannot be excluded for a self-sustaining chain reaction of fission (SCR) which is accompanied by momentary gamma and neutron radiation and by formation of beta-gamma radioactive fission products. The SCR event is classified as nuclear accident.

RADIATION SAFETY MEASURES

The basic measure to provide safety while working with plutonium is the containment of technological operations in sealed glove boxes. Vacuum boxes have been developed at VNIIEF (Figure 1) with a cleanup system for plutonium aerosols in internal cavities, providing reduction of plutonium concentration by 20-30 times after 1 hour in a box volume of 2 m^3 (Kasatkin, 1973) (Figure 2). Protection coefficients of these boxes is 10^4 for plutonium aerosols and 30 to 80 for penetrating radiation. It has been shown during investigations that the determinative factor of personnel impact at the work in glove boxes is hand irradiation.

For surface protection from plutonium contamination, special polymer covers (PC) have been developed to provide protection coefficients from 40 to 3500, with a maximum value of 7000. These PCs are used for dry decontamination of contaminated surfaces with a decontamination coefficient ranging from 10 to 500. this is in 10 times higher than decontamination by liquid solutions. Also, the volume of radioactive wastes formed during decontamination is decreased by 40 times (Perova, 1994).

Criticality (nuclear) safety is provided by: using special thermostable containers, regulation of plutonium quantity in the work place (box), safe box geometry, various communications and technological rigging.

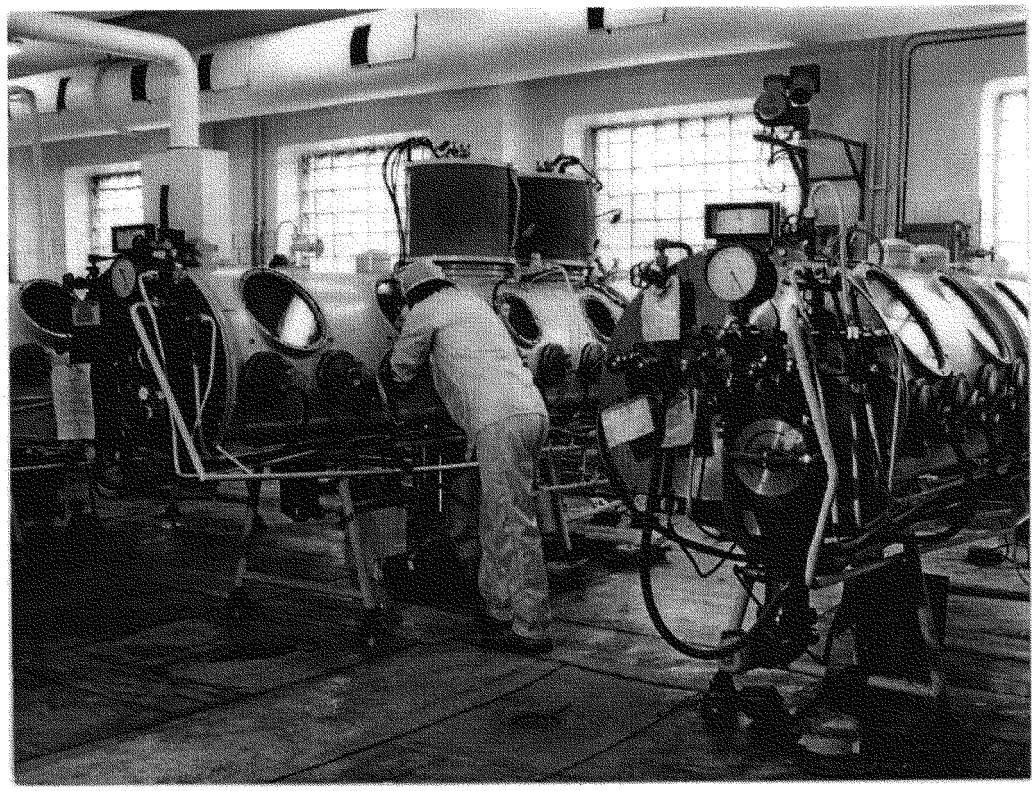

Figure 1 Vacuum boxes for handling plutonium

RADIATION CONTROL SYSTEM (RC)

Radiation impact factors on personnel and population define the requirements for methods and instruments of radiation control. The technology of plutonium work defines requirements for organization and technical equipment of radiation control (RC) services at the specific sites.

VNIIEF RC system has three basic blocks: individual dosimeter control, operative control by portable instruments and accident-preventive automatic control. Individual control includes:

- integral gamma-radiation dosimeter of whole body (thermo-luminescent type IKS-A) and hands (Figure 3);
- accident neutron and gamma-radiation dosimeter (semi-conductive type DOPING);
- control of plutonium content in organism through secretions (urine, feces) and with the help of human radiation spectrometer;
- control of plutonium entry in organism through swabs from hose cavities and through respirators activity;
- individual dosimetry by biological methods of frequency of chromosomal aberration.

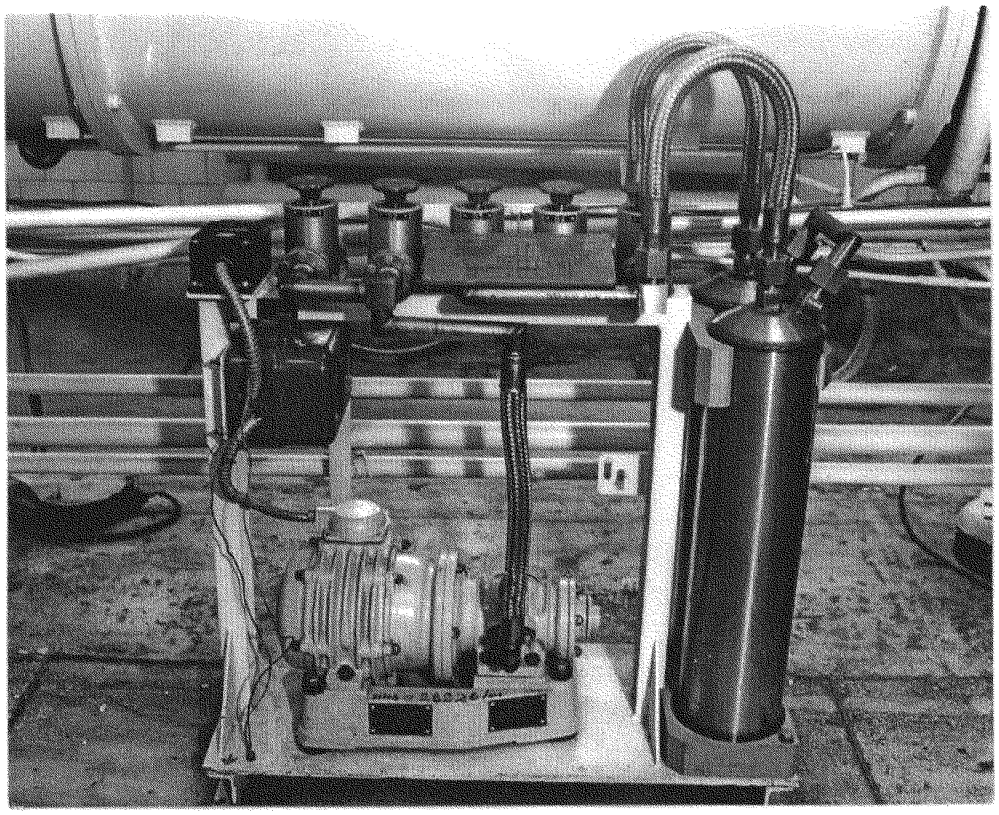

Figure 2 The cleanup system of box gas medium from plutonium

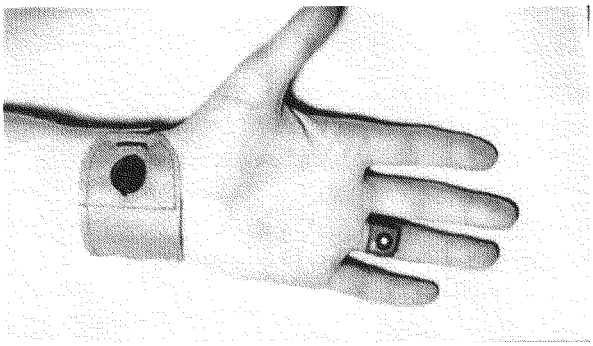

Figure 3 Dosimeters (ring and bracelet) for hand irradiation control

Operative control includes:

- exposure dose power of gamma-radiation, neutron flow and other particles;
- pollution of work surfaces, special clothes and skin;
- plutonium content in the air of work zone and in technological equipment;
- radioactive wastes sending on storage.

Accident-preventive automatic system includes (Figure 4):

- continuous control of plutonium content in air of work rooms and in ventilation exhaust systems;
- exposure dose power of gamma-radiation;
- dose of neutron and gamma-radiation at SCR rise with the help of zone dosimeters.

Figure 4 The desk of acciddent-preventive control system

CONCLUSION

Practical application of technical facilities providing radiation safety at the work with plutonium has allowed decreases of plutonium aerosols concentration in the air of work rooms and in atmosphere exhausts by approximately 100 times from 1975 to 1995. For this period, contamination of surfaces, equipment and special clothes decreased approximately 50 times, and personnel doses by 20 times. At the present time radiation dose rate to personnel and population are at the level of 0.01-0.10 of the maximum permissible concentration.

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KEY WORDS

Plutonium, Plutonium handling technology, Radiation Protection, Individual Dosimetry, Accident Preventive System.