Beryllium safety surveillance during Be Beam/ target based experiments at Pelletron-LINAC Facility, Colaba

A. Chauhan[1]* and M. Kumar[1,2]
[1]*Industrial Hygiene and Safety Section, Health, Safety & Environment Group, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA*
[2]*Homi Bhabha National Institute, Mumbai - 400094, INDIA*

Introduction

Beryllium ($^{9}Be_4$) due to its remarkable strength, thermal and nuclear properties, find its applications in variety of fields *viz.* space, nuclear, electronics and various other industries. Its isotopes *viz.* ($^{7}Be_4$ & $^{10}Be_4$) produced by cosmic rays have been found in rain water and are used as radiotracers for various applications [1]. Various reports indicate that inhalation of Beryllium dust/powder is known to cause severe respiratory diseases like Acute Beryllium Disease (ABD) & Chronic Beryllium Disease (CBD). In addition, Be is also categorized as a Class 1A carcinogen by different agencies. All these hazardous effects associated with Beryllium compounds, powder, dust, fumes, mist, fine particles *etc.* limit its uses & utmost safety precautions are required to be taken while handling, manufacturing and performing experiments during which Be dust may become air borne and could contaminate the surrounding environment.

In view of all above, worldwide, Be safety surveillance is always performed while handling as well as performing any activity which can lead to airborne Be concentration and could lead to inhalation & contamination of items/ equipment *etc*. This also helps in estimating Be air concentration & surface contamination levels & ensuring the fact that nationally stipulated limits/levels are ensured [2-8]. These measurements also help in the prospective planning during Be handling & associated safety measures if required.

Be limits/levels-Indian Scenario

In India, the permissible level of exposure (PLE-8 hours time weighted average of air concentration) is 0.20 µg/m^3 & short term exposure limit (STEL-15 minutes time weighted average of air concentrations) is 2.0 µg/m^3 [8-9]. Further, Be surface contaminations levels should not exceed 10 ng/cm^2 in Be regulated areas and the items/equipment are considered to be free from Be contamination, if surface contamination level is ≤ 1.0 ng/cm^2. Similarly, waste water or any effluent generated is recommended to be safely disposed if Be content is ≤ 0.10 ppm (100 ppb) [2, 8-10].

Due to various interesting nuclear properties of Be like being the only element with no stable isotope with even no. of protons and even no. of neutrons also Be is one of the few elements which has a large scattering cross section for high-energy neutrons, about 6 barns for energies above approximately 10 keV in comparison to very small absorption cross section of about 7 mbarn. Because of these & other peculiar nuclear properties, Be has been a subject of investigations in different nuclear physics experiments either by studying Be ion beam interaction with various other elements or impinging Be ion beam on Be targets *etc.* [11]. Several such Be based experiments were conducted at BARC-TIFR 14 UD Pelletron Accelerator Facility, Colaba by Nuclear Physicists from BARC, TIFR & other institutes.

To prevent undue Be exposure and Be contamination free and safe working conditions, surveillance was ensured. In addition, general information about Be safety, related awareness and use of appropriate personnel protective equipment (PPE) and other precautions as and when required was provided to various users. This paper deals with the safety aspects of Beryllium in accelerator environment and surveillance related results obtained during various experiments carried out using Be ion beam/target are presented.

Material and Methods

During all nuclear physics experiments involving Be beam or Be target or both; comprehensive Be safety surveillance was ensured. As a safety caution, PPE's like high efficiency particulate air (HEPA) based respiratory masks were used during loading,

Electronic address: achauhan@barc.gov.in*

removing of Be based items/targets as well as during opening of vacuum chambers. Air pumps were continuously operated for collecting Be particulates if any on the filter papers. Background/base line data was also generated for the facility before start of experiments. In addition, Be surface contamination level of the ion source assembly was also ensured below stipulated levels during its installation as well as after completion of experiments. Samples of the water being used during experiments were also collected for further analysis.

Continuous air as well as short term air monitoring and surface swipe sampling during various experimental activities was carried out. After completion of the Be campaign, comprehensive surface swipe sampling of various locations of the facility including experimental chambers, other nearby locations *etc.* was performed. Regular analysis of all the air, swipe and waste water samples was performed chemically using UV based fluorometry technique [12-14].

Results:

Be analysis for all the air, swipe & water samples are given in the Table below:

Type of samples	No.	Range
Air (Average)	14	(<0.002-0.04) µg/m^3
Air (STEL)	21	(<0.002-0.206) µg/m^3
Surface swipes	62	<1.0 ng/cm^2
Water	9	(<0.01-0.03) ppm

Conclusions

All the values of Be air concentration as well as Be surface contamination levels during various experiments were much-much below the stipulated limits and majority of the measurements being either below detection level (BDL) or around background levels. The BE surveillance data generated may serve as a reference for future programmes while performing various experiments with Be ion beams and Be targets.

Acknowledgements

Authors are grateful to Shri J. A. Gore, Head, Pelletron Section, NPD and Prof. (Dr.) A. K. Gupta, Head, Nuclear Physics Division, Physics Group, BARC for various helps during the experiments. Authors are also thankful to Shri Alok Srivastava, Head, Industrial Hygiene and Safety Section, HS&EG, BARC for guidance and encouragement. Authors further thank Dr. Anil Shanbag, Health Physics Division, BARC and RSO of the facility for various discussions during planning and conduct of surveillance programme.

References

[1] Goel P S, Jha S, Lal D, Radhakrishna P and Rama, *Nuclear Physics*, 1956;1: 196-201.
[2] Eisenbud M, *Environ Res*., 1982; 27:79-88.
[3] Narayan S and Ramamurthy A, *Mineral Processing and Extractive Metallurgy Review*, 1995:14, 301-318.
[4] Thorat D D, Mahadevan T N, Ghosh D K and Narayan S, *Environmental Monitoring and Assessment*, 2001; **69:** 49–61.
[5] Sathiyamoorthy D, Mohanty T, Srinivas K, Selvaraj D & Thorat D D, *Fusion Science and Technology*, 2012; 61: 159-166.
[6] Jennan A. Phillips, *Workplace Health & Safety*, 2019; 67: 264.
[7] Occupational Exposure to Beryllium, 82 Fed. Reg. 2470-2757 (final rule Jan. 9, 2017) Retrieved from https://www.govinfo.gov/app/details/FR-2017-01-09/2016-30409.
[8] Bhat P N, Soundararajan S, Sharma D N, *J. Inst. Eng. India Ser.*, 2015; 96(2):151–160.
[9] Kumar M, Srivastava A. *Radiation Protection and Environment*. 2022; 45(3):107–120.
[10] Chauhan A, Kamble M K, Kumar M & Srivastava A.,*BARC Newsletter*, March-April, 2023.
[11] Gupta A K, Mehrotra N, Bhat P N, Soundararajan S, Shanbag A, Kale R M, Bhagwat P V, Choudhury R K and Kailas S, *Proc. of Indian Particle Accelerator Conference* (INPAC-2009), Indore, Feb.10 - 13, 2009.
[12] Bhat P N and Pillai K C, Water, Air and Soil Pollution, 1997; 94,297-306.
[13] Kumar M, Kamble M K, Prasad S & Srivastava A , *Proc. of DAE 2ndSymp. on Current Trends in Analytical Chem.* (CTAC-2021), 2, 58, 2021.
[14] Kumar M, Chauhan A, Kamble M K & Srivastava A; *Proc. of 8th Nat. Conf. on Advances in Radiat. Metrology (*AdMet-23), March 23-25, 15, 2023.