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Current Status of Radioisotope Applications in Defence

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ABSTRACT

Reviews the current status of radioisotope applications in Defence – R&D Establishments, Defence Inspectorates, Ordnance Factories, Public Sector Undertakings under the Defence Ministry, Army, Navy and Air Force Establishments and Military Hospitals. It also lists the users of film badge service in Defence. Training programmes in radioisotope applications in Defence conducted by DRDO organisations have also been highlighted.

1. INTRODUCTION

Radioisotopes and ionizing radiations have provided a sensitive, versatile and elegant tool for varied applications. There are various applications of radioisotopes in Defence. The types of applications include X, gamma ray and neutron radiography, radioluminescent devices, nucleonic gauges, sealed and unsealed sources for miscellaneous applications, sealed sources for radiotherapy, unsealed sources for diagnostic, therapeutic and biomedical research applications, and Gamma Cells for research in biomedical sciences and radiation processing. In this paper status of these applications in Defence establishments is reported. Training courses in radiation safety and radioisotope applications which Defence personnel have undergone are summarized. Training programmes in the field conducted by the different Defence establishments for the benefit of civilian and military personnel are indicated. The collaborative efforts of DRDO and BARC in the organisation of a personnel monitoring service for radiation workers in Defence as well as a radioisotope dispensing service for clinical uses are indicated.

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The data for this paper has been collected from the records available with Isotope Group, BARC and the Division of Radiological Protection, BARC. Efforts have also been made to update the data and make them comprehensive by getting inputs from the user institutions in Defence upto the year 1985.

GAMMA RAY AND X-RAY RADIOGRAPHY CAMERAS

Industrial radiography is reasonably well utilized in defence for non-destructive testing and quality control using ^{192}Ir mainly, and to a smaller extent ^{60}Co, ^{137}Cs, and neutron sources.[1] However, considering that X and gamma radiography is a highly cost-effective technology and that only a comparatively small investment is required in setting up the facilities, there is ample scope for installing them in smaller units like EME Workshops. The data on the use of gamma ray and X-ray radiography facilities has been summarized in Table 1.

Table 1. Use of industrial radiography cameras and X-ray machines

Organisations	No. of institutes	No. of radiography cameras	No. of X-ray units	No. of recognised trained staff
DRDO	4	17	9	10
Defence Inspectorates	10	13	15	11
Ordnance Factories	9	21	18	6
Public Sector Undertakings in Defence	10	29	8	12
Total	33	80	50	39

There is a lack of adequate numbers of trained personnel at the levels of sites-in-charge who can decide on the optimal operational parameters for specific requirements and correctly interpret the radiographs (which requires a certain degree of experience) as well as of radiographers with formal certified training in correct operation of the units with proper attention to the radiation safety aspects. Long-term perspective training programmes are necessary with realistic forecasts of the growth of the facilities over the years, and also keeping in mind the frequent transfers of service personnel.

3. RADIOLUMINESCENT DEVICES

Radioluminescent devices are ideal for several applications in defence. They are self-luminous (requiring no batteries or other external source of power), light in weight, dependable and have long life. By suitable choice of the amount of radionuclide and nature of the phosphor material, one has a choice of colours and intensity levels. We have come a long way from the days when radium, a highly radiotoxic substance, was used as the source.[2] Devices using gaseous tritium light sources (GTLS) and ^{147}Pm sources are quite safe to handle and use. The requisite technology has been very well developed at BARC. A significant part of the Defence agencies (DRDO

Labs, Defence Inspectorate, Ordnance Factories and Public Sector Undertakings) needs are being met by BARC over the last two decades, although there still seems to be a certain amount of import of the devices by the Defence Services. With the commissioning of Dhruva reactor, one can hope that the future requirements of tritium would be met indigenously in a few years time. Instrument Research and Development Establishment (IRDE) Dehradun has done a considerable amount of work in developing illuminating devices for certain defence applications. Defence Laboratory, Jodhpur has made significant progress in this field for the last three years as part of its assignment of developing radioisotope applications of relevance to defence.

The current level of utilization of radioluminous devices by the different institutions in defence has been summarized in Table 2.

Table 2. Profile of radioluminous painted devices in defence institutions

Organisations	No. of establishments	Major users	Minor users
DRDO	5	2	3
Defence Inspectorates and Workshops	1	1	0
Ordnance Factories	12	6	6
Defence Public Sector Undertakings	2	0	2

4. NUCLEONIC GAUGES AND OTHER DEVICES USING RADIOISOTOPES

Nucleonic gauges are elegant devices for assessment of a variety of parameters during manufacture and for process control. Examples are thickness, density and level gauges, and gauges for determining moisture content[3] and density of soils at the surface and at depths. Radioisotopes are used in variety of products like smoke alarms, static charge meters and static charge eliminators. Four DRDO establishments, one Defence Inspectorate, two Ordnance Factories, repair depots and two Defence Public Sector Undertakings are using such nucleonic devices for varied purposes.

One is immediately struck by the totally inadequate utilization of the potentialities of these devices which are fairly simple, highly cost-effective and convenient to use. The phenomenal rise in the utilization of nucleonic gauges by industries in Japan and USA and consequent immense savings to the economy were well brought out during the last International Conference on Applications of Radioisotopes in Industrial Development (ICARID) Conference held in Bombay during March 1984. Given the urgent attention to this area would pay rich dividends to Defence production and inspection.

5. BIOMEDICAL APPLICATIONS

5.1 Radiology

This paper does not discuss radiological facilities available in the Defence services in detail. X-ray diagnostic units are commonly available in all military hospitals as

well as in many field hospitals. There is not as yet a CAT facility in any of the Command Hospitals of the Armed Forces Medical Services. Institute of Nuclear Medicine and Allied Sciences (INMAS) Delhi is planning to instal a CAT unit in the near future.

Radiation safety aspects in radiological departments of the armed forces are touched upon subsequently.

5.2 Radiotherapy

The Malignant Diseases Treatment Centre at Pune is the only facility in the DGAFMS set-up available for cancer management. Other four centres under DGAFMS have radiotherapy and brachytherapy facilities. In DRDO, INMAS is installing a radiotherapy facility.

In order to manage effectively cancer cases occurring in the armed forces personnel and their dependents, in-house radiotherapy facilities for defence needs have to be significantly increased.

5.3 Nuclear Medicine

In DRDO, INMAS stands today as a pioneering institution in nuclear medicine. Special mention may be made of the full spectrum of imaging modalities already installed or planned, involving both nuclear and non-nuclear techniques, like gamma camera, SPECT, PET (along with medical cyclotron), as well as CAT, thermography, ultrasound and NMR. Under the technical guidance of INMAS Nuclear Medicine Centres have been set up in six hospitals under the DGAFMS. These have the facilities of a medium-sized nuclear medicine department, carrying out conventional *in vivo* and *in vitro* diagnostic tests including radioimmunoassays and imaging with a rectilinear scanner and ^{99m}Tc labelled pharmaceuticals. Defence Institute of Physiology and Allied Sciences (DIPAS), Delhi Cantt has been conducting research in physiological problems using radioactive tracers both in animals and humans. Table 3 lists the nuclear medicine units in Defence.

Table 3. Nuclear medicine units in the armed forces

Organisation	Establishment	Remarks
		Has all modern facilities in nuclear medicine including gamma camera and SPECT. PET and medical cyclotron are being installed. Uses generator produced isotopes extensively. It also carries out radioiodine therapy for thyrotoxicosis on outpatients basis.
	DIPAS, Delhi	Carries out biomedical research with special reference to physiological studies using radiotracers both in animals and humans.
DGAFMS	6 units	All the hospitals have rectilinear scanners and use generator produced isotopes. They also have special wards for radioiodine therapy for thyroid cancer treatment. AH, Delhi has a gamma camera

The existing Nuclear Medicine Centres need strengthening by installation of gamma cameras which have become an indispensable part of any modern nuclear medicine setup. More nuclear medicine departments of modest size need also to be provided in the military hospitals, based on a judicious regionwise assessment of the requirement.

6. RADIATION PROCESSING

Radiation sterilization of medical products and radiation preservation of foods are two major biomedical applications of radiation processing.[4] BARC has set up the ISOMED plant at Trombay, which has been functional for nearly two decades. Several pharmaceutical concerns have utilized this facility and a variety of radiation sterilized medical products are available commercially. The Armed Forces Medical Services have been utilizing such products. BARC has done considerable R&D work on radiation preservation of food products. IAEA, WHO and FAO have unconditionally cleared food products which have been irradiated to doses upto one megarad. Government of India has also recently cleared in principle some of irradiated food products for human use. There is considerable scope for use of irradiated food products in forward areas. Two institutions in DRDO have gamma cells for research studies on radiation processing.

Radiation processing for development of newer products with improved characteristics like wood-polymer composites, radiation cured paints and cables etc. has great potential applications in the Defence field. Our task is to identify specific areas of immediate relevance and plan for a suitable design of a dedicated radiation processing unit.

7. RESEARCH AND MISCELLANEOUS USES

7.1 Sealed Sources and X-ray Units

Six establishments in DRDO, one each in Defence Public Sector and Services have sealed sources for NDT and research.

7.2 Unsealed Sources

Unsealed sources are used in Defence institutions of DRDO. Radiotracer methodologies which are powerful in elucidation of dynamic processes and reaction mechanisms, which in turn will lead to discovery of newer processes and optimisation of production processes, seem to be conspicuous by their total absence in the Defence field. Even well-established techniques like use of radiotracers in the study of wear, efficiency of lubricants, corrosion etc. do not seem to find place. This is an area where rich dividends can be reaped.

8. PERSONNEL ENGAGED IN RADIATION WORK

An idea of the total number of workers engaged in the handling of radiation sources obtained from data on the utilization of the film badge monitoring service of DRP, BARC has been summarized in Table 4.

Table 4. Monthly profile of film badge service in defence institutions

Establishments	No. of institutions	Number of users
	101	420
	14	218
	28	158
	8	165
	18	203
	169	1164

9. PERSONNEL FORMALLY TRAINED IN RADIATION METHODOLOGIES

Table 5 gives the number of Defence personnel that have undergone formal training courses in radiation safety and various aspects of radioisotope applications.

It is of interest to notice from Table 5 that DRDO is also conducting training programmes in radioisotope applications. Since 1961 INMAS has been conducting a

Table 5. Trained personnel in radioisotope methodologies (upto 1985)

Course (Year of commencement)	Duration	No. of trained defence persons
Diploma in radiological physics (1962) at BARC	1 yr	14
Industrial radiography and safety aspects IRG-I (Since 1978 at BARC and 1981 onwards at DLJ)	6 weeks	174
Industrial radiographers certification course-1 (Since 1978 at BARC and 1983 onwards at DLJ)	2 weeks	40
Safety aspects in the medical application of radiation (1961) at BARC	2 weeks	42
Safety aspects in the research application of ionising radiation (1980) at BARC	2 weeks	
Radiation safety in diagnostic X-ray technology (1981) at BARC	2 weeks	
Safety aspects in erection and maintenance of nucleonic level gauges (1977) at BARC	2 weeks	2
Safety aspects in handling radioluminiscent paints (1981) at BARC	2 weeks	5
Radiommunoassay and its clinical applications at BARC	4 weeks	
Total		294

one-year postgraduate diploma course in radiation medicine (DRM) in collaboration with Delhi University. Most of the trainees are AMC doctors. In addition INMAS organises as per requirement short-term orientation courses in nuclear medicine for AMC doctors, short-term courses for AMC technicians in radiation safety, radiopharmaceuticals, RIA etc. INMAS also conducts short-term orientation courses

in nuclear medicine at AFMC, Pune. Army Hospital, Delhi Cantt is also recognised centre for the DRM course under Delhi University.[5,6]

Defence Laboratory, Jodhpur (DLJ) conducts every year IRG-I course and Industrial Radiographer's Certification Course, intended specially for defence personnel (DRDO, Inspectorate, Training Institutions, Service Establishments). In 1980 DLJ also organised an in-house short-term training course in radioisotope methodologies for its scientists.

10. OTHER ACTIVITIES

INMAS has started a TLD Personnel Monitoring Service for defence institutions after obtaining the requisite permission from BARC. In a short time, all the personnel monitoring requirements of workers in defence establishments will be met by this service. BARC is also locating at INMAS a Regional Radiopharmaceutical Dispensing Cente to cater to the requirements of hospitals in and around Delhi for short-lived (^{99m}Tc) radiopharmaceuticals.

INMAS has conducted an in-depth survey of the radiation safety situation in a large number of diagnostic radiology departments under DGAFMS including military hospitals and base hospitals.[7] Based on the results of the survey, changes in work practices have been suggested where needed.

11. CONCLUSION

INMAS, Delhi has established advanced facilities in nuclear medicine. Defence Laboratory, Jodhpur has established the infrastructure and expertise to help defence organisations in other areas of radioisotope applications in defence. There is however considerable scope for a much wider application of radioisotopic methodologies in defence in various fields.

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REFERENCES

Reddy, A.R. & Rao, M.V.N., *Def. Sci. J.*, **32** (1982), 259.

2. ILO Manual of Radiation Protection Part V, Guide on protection against ionising radiation in the application of luminous compounds, Geneva, 1964.

Raghunath, V.M., Bhatnagar, P.K. & Meenakshisundaram, V., *Nucl. Inst. and Methods*, **206** (1983), 303.

4. Ashok Kumar, Chacharkar, M.P., et al., Proceedings of Radiochemistry and Radiation Chemistry Symposium, IIT, Kanpur, 1985, p. 377.
5. Rehani, M.M., *S. N .M. Newsletter,* **IX(2)** July 1985, 4.
6. Rehani, M.M., *S. N. M. Newsletter,* **X(1)** May 1986.
7. Jain, M.P. & Pratapa Rao, V.V.S., Final Report on AFMRP Project, 1086/79, 1979.