TECHNOLOGY FOCUS

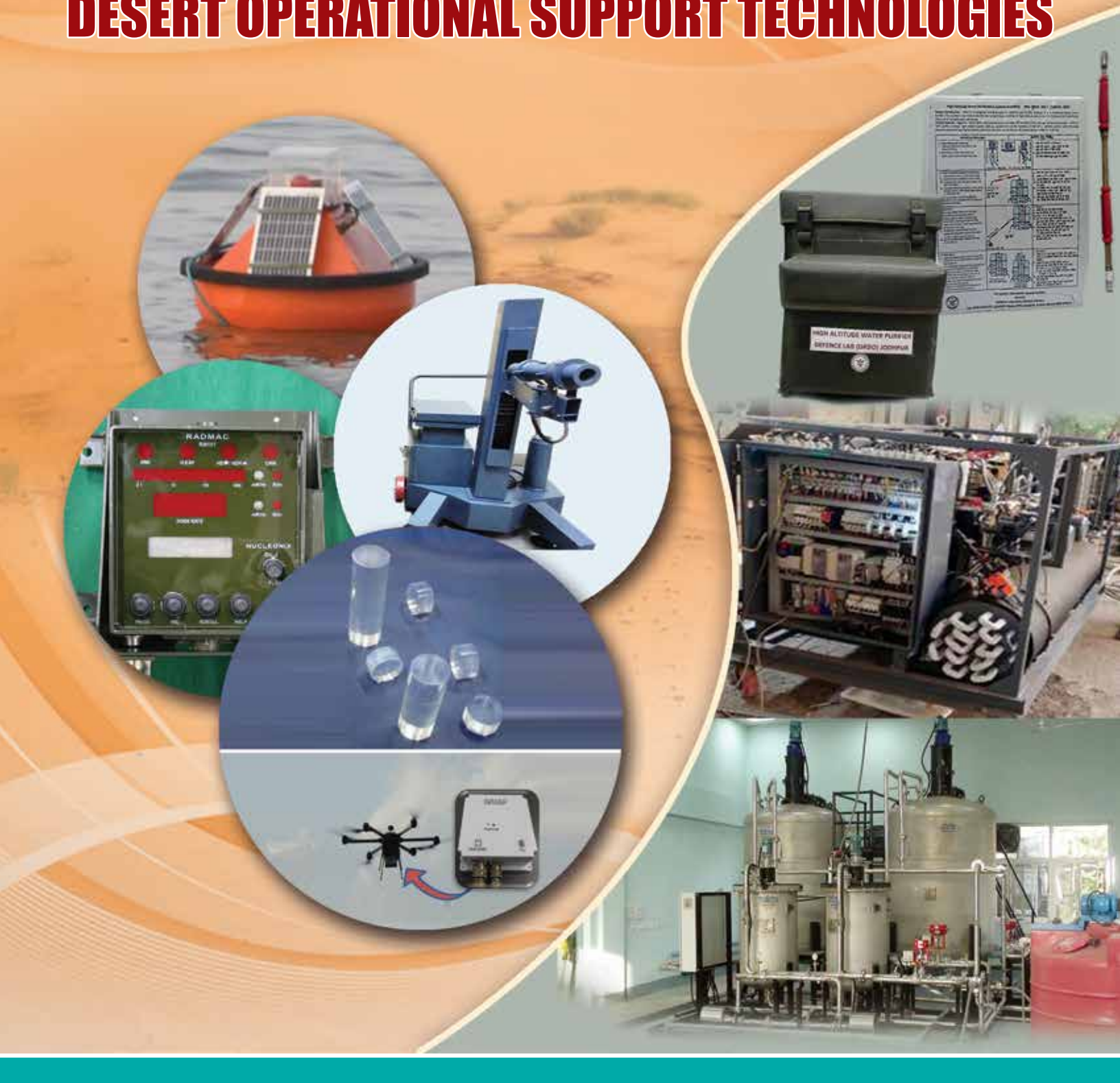
टैक्नोलॉजी फोकस

An In-house S&T Bulletin of DRDO

www.drdo.gov.in/technology-focus

Vol 32 | Issue 2 | March-April 2024 | ISSN No. 0971 - 4413

NUCLEAR RADIATION MANAGEMENT AND DESERT OPERATIONAL SUPPORT TECHNOLOGIES



Technology Focus focuses on the technological achievements in the organization covering the products, processes and technologies.

March-April 2024
Vol. 32 | Issue 2 | ISSN No. 0971-4413

Editor-in-Chief: Dr K Nageswara Rao
Assoc. Editor-in-Chief: Sudhanshu Bhushan
Editor: Dipti Arora
Prepress: Raj Kumar, Raman
Printing: Rajesh Kr Singh

Readers may send their suggestions to

The Editor, Technology Focus
DESIDOC, Metcalfe House
Delhi-110 054
Telephone: 011-23902403, 23902472
Fax: 011-23819151; 011-23813465
E-mail: director.desidoc@gov.in;
techfocus.desidoc@gov.in
https://www.drdo.gov.in/technology-focus

Laboratory Correspondents

Agra	:	Shri SM Jain, ADRDE
Ahmednagar	:	Col Atul Apte, Shri RA Shaikh, VRDE
Ambernath	:	Dr Ganesh S. Dhole, NMRL
Bengaluru	:	Shri Satpal Singh Tomar, ADE
	:	Smt MR Bhuvaneswari, CABS
	:	Smt Faheema AGJ, CAIR
	:	Shri R Kamalakannan, CEMILAC
	:	Dr Sanchita Sil & Dr Sudhir S Kamble, DEBEL
	:	Dr V Senthil, GTRE
	:	Dr Sushant Chhatre, MTRDC
Chandigarh	:	Dr Pal Dinesh Kumar, TBRL
	:	Dr Anuja Kumari, DGRE
Chennai	:	Shri K Anbazhagan, CVRDE
Dehradun	:	Shri Abhai Mishra, DEAL
	:	Dr SK Mishra, IRDE
Delhi	:	Shri Sumit Kumar, CFEES
	:	Dr Dipti Prasad, DIPAS
	:	Shri Santosh Kumar Choudhury, DIPR
	:	Shri Navin Soni, INMAS
	:	Dr Rupesh Kumar Chaubey, SSPL
Gwalior	:	Dr AK Goel, DRDE
Haldwani	:	Dr Atul Grover, DIBER
	:	Dr Ranjit Singh
Hyderabad	:	Shri ARC Murthy, DLRL
	:	Dr Manoj Kumar Jain, DMRL
Jodhpur	:	Shri DK Tripathi & Dr Yojana Janu, DL
Kanpur	:	Dr Mohit Katiyar, DMSRDE
Kochi	:	Smt Letha MM, NPOL
Leh	:	Dr Tsering Stobden, DIHAR
Mysuru	:	Dr M Palmurugan, DFRL
Pune	:	Dr Ganesh Shankar Dombe, HEMRL
	:	Shri AK Pandey, ARDE
	:	Dr Anoop Anand, R&DE(E)
Tezpur	:	Dr Sibnarayan Datta, DRL

From the Desk of Guest Editor

Defence Laboratory, Jodhpur located at the gateway to Great Thar Desert, is a multi-disciplinary R&D laboratory of DRDO under Naval Systems & Materials cluster. The laboratory is working on the strategically important areas of Stealth, Camouflage, Countermeasures, Desert Operational Support Technologies and Nuclear Radiation Management & Applications to cater the requirements of Tri-services and paramilitary forces.

In the area of stealth technologies, the laboratory has established expertise in Radar signature measurement and analysis, Diagnostic RCS imaging, Electromagnetic analysis, Infrared signature measurement & prediction, etc. Advanced materials and products have been realized towards signature management of legacy platforms. The laboratory is currently working on stealth solutions to futuristic platforms.

Camouflage, Concealment & Deception (CCD) is a major challenge in desert warfare. The systematic R&D activities undertaken by the laboratory resulted in establishment of camouflage infrastructure test facilities for signature acquisition of airborne and ground-based platforms in Microwave, Visual and Near Infra-Red (NIR) & IR spectrum. Special type of multispectral coatings, paints, stickers, and prototype adaptive camouflage add-ons have been developed to distort and suppress target signatures of strategic platforms and assets. Decoys for tanks & aircrafts and thermal Targets for missile testing have been realised and deployed.

To improve survivability of fighter aircrafts and warships against hostile RF seeking missiles, the laboratory has successfully developed microwave chaff. For chaff characterization, state-of-the-art test and evaluation facility, virtual reality-based chaff application and training center &pilot plant chaff production facility have been established. Three variants of Naval chaff & 118/I chaff cartridges for IAF have been realised and Transfer of Technology (ToT) given to industry partners for bulk production. Presently the laboratory is working on innovative Microwave Obscurant Chaff Technology to reduce the Radar Cross-section of the platforms.

In the area of nuclear radiation management ,several products viz Dosimeters, Roentgenometer, Gamma Flash Sensor, CBRN Hazard Prediction Software, Environment Survey Vehicle, Modernized NBC Protection System for BMP, NBC reconnaissance vehicle (Tracked), Mobile Reconnaissance Laboratory (Wheeled) have been developed and inducted into the Services. A mobile CBRN water purification system Mk-II has been developed to produce potable water in

chemical, biological, radiological , and nuclear contamination zones. The system has been extensively exploited by Indian Army and cleared for quantity production.

In the area of material technology, several advanced materials like Thermoelectric materials, Phase change materials, Artificial engineered materials, Ferro-magnetic materials, Magnetic alloys, Graphene, Exfoliated Graphene, Reduced Graphene Oxide, Nano-titanates, Gamma radiation sensors, etc. have been successfully developed for myriad applications.

The laboratory with an excellent pool of human resources, R&D infrastructure and facilities complimented with academia and industry collaboration, has shown an exponential growth over the years.

The laboratory has drawn-up a technological road-map, identified niche technologies and accordingly focusing on the developmental activities.

The previous issue (January–February 2024) of Technology Focus elaborated on the stealth, camouflage, and countermeasure technologies developed by the DLJ. The present issue is a continuation of the previous issue of Technology Focus and highlights the nuclear radiation measurement and desert operational support technologies developed by the DLJ.

Jai Hind ….

RV Hara Prasad

Outstanding Scientist & Director, DLJ

NUCLEAR RADIATION MANAGEMENT AND DESERT OPERATIONAL SUPPORT TECHNOLOGIES

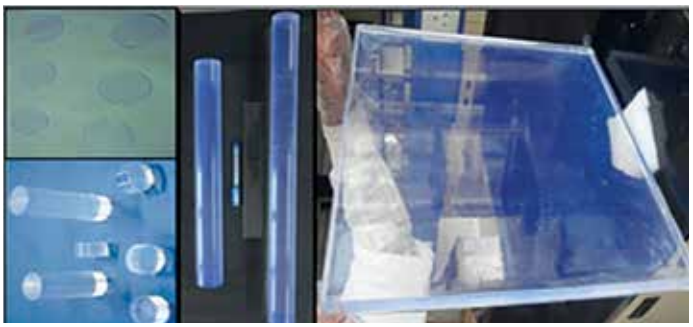
NUCLEAR RADIATION MEASUREMENT TECHNOLOGIES

Defence Laboratory, Jodhpur (DLJ) developed various instruments for detection and measurement of Gamma dose rate, portable dose rate meter for personal use, lightweight sensor for UAVs, Integrated Radiation Monitoring System (IRMS) for Alpha, Beta, and Gamma radiation measurements, etc. A class of instruments for use in different scenarios and platforms have been successfully realised.

Nuclear Radiation Sensors

Plastic Scintillators Sensors

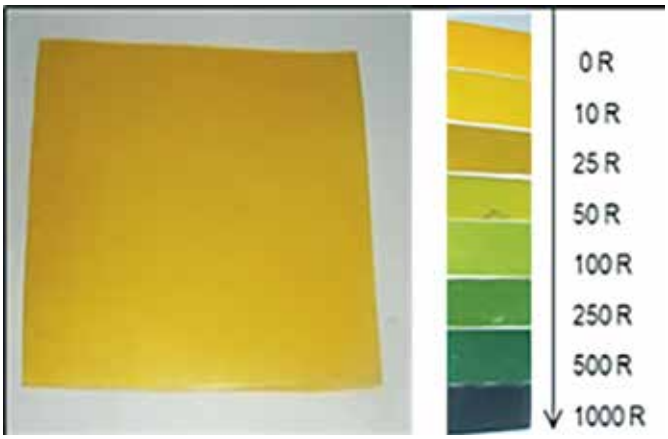
Indigenous technology has been successfully established for the development of large-size plastic scintillator sensors in the form of rods and sheets in collaboration with industry. Plastic scintillators are extensively used as large-area sensors for the detection and monitoring of Gamma and Beta radiations in radiation contamination monitoring and radiological emergency management applications.



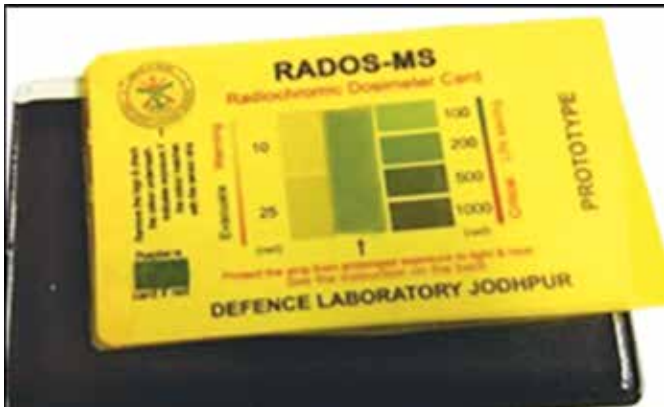
Plastic Scintillators Sheet and Rod

Radio Chromic Film for Gamma Dosimetry

Radio Chromic Films (RCF), consisting of diacetylene monomers uniformly dispersed in a polymer matrix, are sensitive to Gamma radiation and undergo a change in colour/colour intensity on exposure to increasing doses of Gamma radiation are independent of energy and dose rates and are tissue-equivalent sensor materials. Through the use of these films, RCF-based Gamma dosimeters are developed.



Radio Chromic Film



Radio Chromic Film-based Gamma Dosimeter

ZnO Nanorods-based Nanostructured and Composite Scintillators for the Detection of Alpha Radiation

ZnO:Ga-based nanorods have been grown on FTO glass using a low-temperature hydrothermal method, while the ZnO/PS composite scintillator consist of ZnO micro-particles uniformly distributed in polystyrene and casted in the form of a film. When Alpha radiation interacts with these scintillators,

they generate UV-Vis light, which is sensed by the Photomultiplier Tube (PMT), and pulse height spectra are recorded with the help of a multichannel analyzer. The scintillator has a promising response to Alpha radiation, and a detector is being developed.

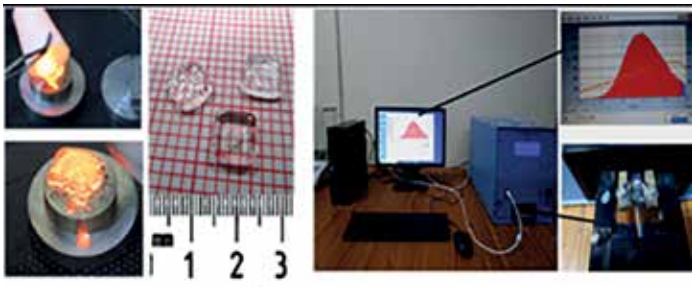
Perovskite Nanocomposite Scintillators for Alpha Radiation

Inorganic perovskite nanocrystals have excellent optoelectronic properties and have shown promise in radiation scintillation applications. An innovative radiation-induced preparation process has been developed for the fabrication of perovskite nanocomposite films. When exposed to Alpha radiation, the perovskite nanocomposite films exhibit scintillation in the visible region. The intensity of scintillation light is proportional to the activity of the Alpha radiation source.

Gamma Radiation Dosimetry using Thermo-Luminescent Lithium Borate Glass Chips

Lithium Borate (LBO) glass chips are fabricated using the melt quench method. Gamma radiation exposure causes the production of electron hole pairs that are trapped at the respective defect's centers. Thermal stimulation releases these trapped electrons and holes, and subsequent recombination releases visible light.

This light pulse is further converted into electrical pulses, and the intensity vs. temperature 'Glow Curve' represents the radiation dose.



Thermo-Luminescent Lithium Borate Glass Chips

MOSFET Gamma Sensor

The Metal Oxide Semiconductor Field Effect Transistor (MOSFET) sensor is a cumulative Gamma dose sensor that is suitable for INR and RNR dose measurement in nuclear emergency scenarios. The gamma exposure of these sensors results in a permanent shift of their threshold voltage, which is measured with the help of an electronic circuit.

Metal Oxide Semiconductor Field Effect Transistor

Nuclear Radiation Measurement Systems

Gamma Flash Sensor

The sensor has been designed for fitments into the tank and to detect the prompt gamma radiation pulse from a nuclear explosion. It provides the activation signal to the NBC protection system of the tank if it receives a very high gamma radiation intensity, which is expected from a nuclear explosion. The instrument has been successfully developed and inducted.

Gamma Flash Sensor

Roentgenometer

The roentgenometer measures the Gamma radiation dose rate from the fallout radiation levels during the post-explosion scenario. It has a

measurement unit with an analog display and a sensor module, which are mounted on the external surface of the tank. This equipment enables the commander to plan the operations and to avoid excessive doses for the soldier. The instrument has been successfully developed and inducted.

Roentgenometer

Portable Dose Rate Meter

A lightweight hand-held battery-operated instrument, for use by an individual, measures the Gamma radiation dose rate from fallout radiation and enables the individual to know the radiation levels in the contaminated zone. This instrument has an analog display, and soldiers can carry it during rescue operations. The instrument has been successfully developed and inducted.

Pocket Dosimeter

The pocket dosimeter measures the Gamma radiation total dose in addition to the Gamma dose rate in the contaminated zone. This instrument is microcontroller-based, small, lightweight, battery-operated, and has a digital display. The instrument has been successfully developed and inducted.

Pocket Dosimeter

RADMAC for Battle Tank

The Radiation Detection Measurement and Control (RADMAC) unit was designed and developed by combining the detection and measurement capabilities of a gamma flash sensor and a roentgenometer to automate the NBC protection system of the tank.

It has advanced features such as digital displays, a PC interface, total dose measurement, fallout activation signals, situation-dependent help, etc.

It was successfully trialed and evaluated along with other instruments developed as part of the modernization of the NBC protection system for battle tanks.

Radiation Detection Measurement and Control Unit

Remote Radiation Monitoring and Transmitting System

The Remote Radiation Monitoring and Transmitting System (RRMTS) consists of a field unit and a base station. It measures radiation at unattended remote locations. The RRMTS field unit has a detector probe for Gamma radiation measurement. This field unit transmits dose rate and energy spectrum data to the base station through an RF transceiver as and when required. It measures the Gamma radiation dose rate and identifies radioisotopes. The system has been inducted in the Services.

RRMTS (Field Unit)

RRMTS Base Station and Grid-wise Nodes Display

Radiation Contamination Monitoring Systems

Portal Monitoring System

A modular and easy-to-install Portal Monitoring System (PMS) is used for rapid screening of personnel with respect to radiation contamination during a nuclear or radiological emergency. The system can also be used to identify the unauthorised movement of radiation sources or special nuclear materials. The system utilises eight cylindrical plastic scintillator sensors. The detectors are mounted on the three limbs and entrance interconnectors.

The detector counts and alarm values are displayed on an LCD display. The system continuously acquires the counts, monitors the background radiation, and generates an alarm when the counts exceed the preset alarm values. Radiation data, along with the image of the contaminated person, is transferred to a remote base station through the Ethernet. The system complies with EMI/EMC, MIL STD, and environmental standards. It has been inducted into the services.

Contamination Monitoring System-Linen

Contamination Monitoring System-Linen (CMS-Linen) detects radioactive contamination in linen articles. The system is capable of performing rapid screening of linen for Gamma or Beta contamination at the time of an individual's routine work at a nuclear facility as well as after any nuclear emergency. The system utilises two plastic scintillator sensor sheets. The system complies with EMI/EMC, MIL STD, and environmental standards. It has been inducted into the Service.

Contamination Monitoring System- Terrain

Plastic scintillator-based Contamination Monitoring System-Terrain (CMS-Terrain) is a mobile, fast, and effective portable system for screening large areas to detect Gamma and Beta surface contamination in nuclear facilities, trans-shipment points of radioactive waste containers, during nuclear or radiological emergency scenarios, etc. The system uses two plastic scintillator sensor sheets. The system complies with EMI/EMC, MIL STD, and environmental standards. It has been supplied to the Services.

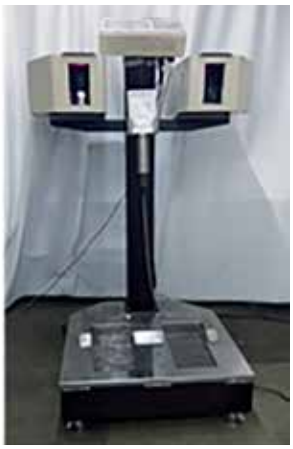
Hand Foot Contamination Monitoring System

The Hand Foot Contamination Monitoring System (HFCMS) is a portable system intended for

Portal Monitoring System

CMS-Linen

CMS-Terrain



Hand Foot Contamination Monitoring System

measuring radiation contamination in the hands and feet due to Beta and Gamma. The system is capable of performing screening of hands and feet during routine contamination monitoring at nuclear facilities and after a nuclear and radiological emergency scenario. It has been supplied to the Services.

Radiation Detection and Measurement System for Airborne Applications

The laboratory has developed Radiation Detection and Measurement (RADMAC-A) system that could be used in all helicopters being operated by the Services. This instrument presents radiation dose rate and total dose information on the Cockpit Visual Indicator (CVI) and alerts the helicopter crew regarding the Gamma radiation level around them. This enables the helicopter crew to make informed decisions during the flight. RADMAC-A can also be integrated with the helicopter's Integrated Architecture for Display System (IADS) for displaying radiation information on the cockpit display system. It has an airworthy, rugged design and complies with MIL standards.

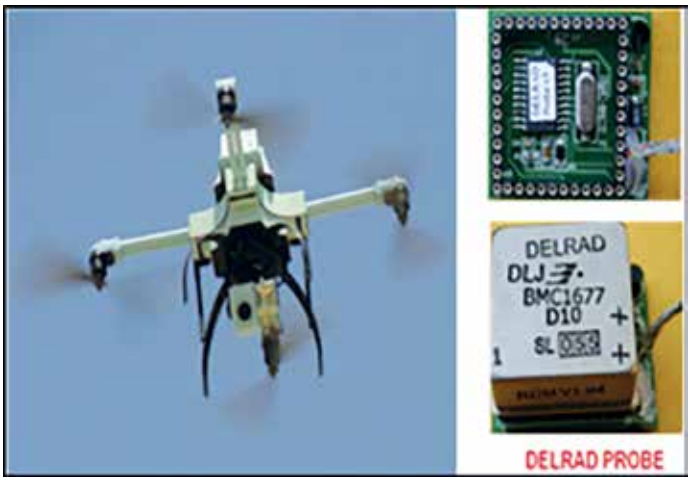
DELRAD Gamma Radiation Module

The Radiation Detector (DELRAD) is a semiconductor-based hybrid micro-circuit for the detection of Gamma radiation dose rates. This module operates at +5 V DC and can be interfaced to a microcontroller for dose rate measurement.

DELRAD weighs only 22 g and is suitable for integration into a UAV platform. This system was integrated into the UAV for aerial radiological surveillance of nuclear-contaminated areas.

RADMAC- Main and CVI Unit

CVI Installed on Cockpit of Helicopter



UAV and DELRAD Probe

Aerial Dosimetry System

The Aerial Dosimetry System (ADS) is a nuclear radiation monitoring instrument intended for use in UAVs, helicopters, and low-level flying aircraft for aerial surveys of contaminated zones. This system consists of an ADS unit and a Ground Control Station (GCS).

The ADS unit can measure Gamma radiation and identify radioisotopes. The unit can record the energy spectrum and transmit this data to GCS through an RF transceiver.

Aerial Dosimetry System Map Mode

Integrated Radiation Monitoring System

The Integrated Radiation Monitoring System (IRMS) is designed to measure the contamination due to Alpha, Beta, and Gamma radiation. It also has Gamma isotope identification capability.

The measuring unit automatically identifies the type of detector connected, adjusts the parameters, and presents the measurement results.

This instrument can operate directly from the mains power supply and from an inbuilt rechargeable battery in the field for 6 hours for a detailed study of contamination.

Integrated Radiation Monitoring System

Wide Area Radiological & Nuclear Surveillance System

A GPRS-enabled Gamma area monitor continuously monitors Gamma radiation levels in the surrounding environment and transmits the data in terms of dose rate along with navigation coordinates to a distantly located central server through a wireless GPRS link.

The continuous round-the-clock collection of data from an array of these sensors provides an early warning in case of any nuclear disaster or event for further planning.

Sea Area Ambient Radiological Surveillance System

A solar-powered floating Gamma radiation sensor, specifically developed for marine applications, detects Gamma radiation levels over the water surface as well as at specified depths under the water surface.

A network of a number of such floating sensors distributed in marine areas and connected through a wireless mobile data link to the centralized station provides live feeds of the radiation levels from different sensors, which are very useful for quick planning and decision-making by the concerned authorities.

Sea Area Ambient Radiological Surveillance System

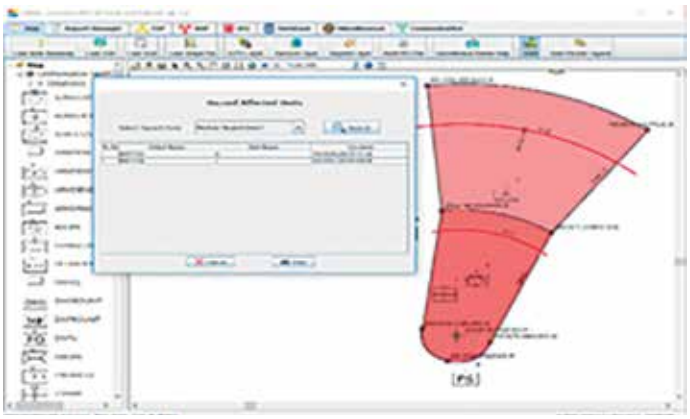
Radiation Direction System

A radiation direction system has been developed to indicate the direction of nuclear contamination due to any nuclear eventuality or accident, which in turn will help in finding the locations of the contaminated zones. This system is also useful for quickly finding the location of an orphan radiation source. This system can estimate the amount of radioactive intensity in terms of dose rate.

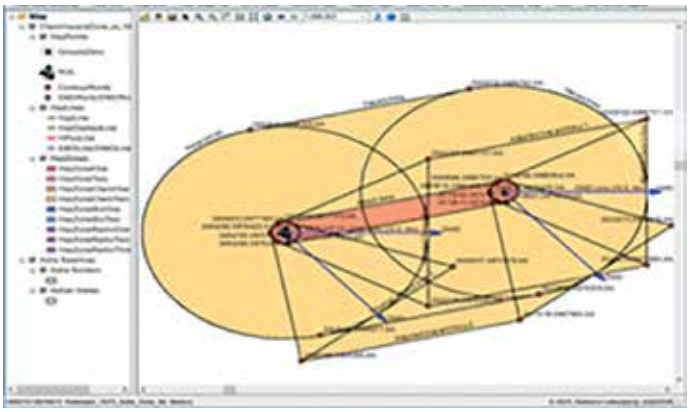
Radiation Direction System

CBRN Hazard Prediction Software

The CBRN hazard prediction software was developed to predict the dispersal pattern of nuclear and chemical hazard areas and to receive, process, and display sensor data from the CBRN Recce Vehicle for the Services.



Nuclear Hazard Prediction Software Output



Chemical Hazard Prediction Software Output

Radiation Imaging (CT) Facility

X-ray and Gamma-ray-based computed tomography facilities with resolutions of 1 µm and 0.2 mm, respectively, have been established for:

- High-resolution 2D radiographs
- Enhancing cross-sectional CT images using image processing techniques
- 3D visualization and surface extraction with image processing filters
- Dimensional measurement of critical materials, components, and parts

NABL Accredited Laboratory for Radiological Testing and Calibration Activity

DLJ has two facilities with NABL-accredited laboratories for radiological testing and calibration activity as per ISO/IEC 17025:2017. These facilities include Gamma radiation sources for Radiological Testing and Calibration (RT&C).

X-ray-based CT Facility

Gamma Radiation-based CT Facility

Positioning System of Medium Gamma Exposure Facility

DESERT OPERATIONAL SUPPORT TECHNOLOGIES

Water Purification and Extraction Technologies

Scarcity and poor quality of water are major concerns for desert operations by the troops. Purifying available water and checking its potability is an important logistical requirement. DLJ has been working on the development of current and futuristic desalination membranes, adsorption materials, special-purpose nanomaterials, filter modules, processes, and water purification systems of various capacities for individuals, sections of soldiers, units, and brigades. Also, work is underway for the extraction of water from vehicle exhaust and dry desert air to meet service requirements.

CBRN Water Purification System

A system for the purification of CBRN-contaminated water has been developed as per service requirements and evaluated in desert and high-altitude environments. It can provide 2500 L/hr of purified water in the CBRN agent and 6,000 L/hr of surface-available feed water.

CBRN Water Purification System (Mk II)

Technology for Purification of Contaminated Surface Available Water

High Altitude Water Purification System

A technology for the purification of contaminated (with turbidity, microbial, carbon dust, colour, and odour) surface-available water has been developed. A back pack unit manually (hand) operable to provide 12–15 L/hr of purified water has been deployed.

Flexi Life Saver Water Purifier

A bottle-type purifier has also been developed and evaluated by the army.

Emergency Sea Water Purification Kit

Technology for the purification of sea water has been developed that can provide 500 ml of potable water from sea water in 20–25 minutes without using electricity or any manual energy.

Contaminated Water simulation and Testing Facility

A contaminated water simulation facility is a unique facility capable of preparing and supplying various types of contaminated water. This facility is designed and established for continuously preparing large amounts of slurry and contaminated water and supplying water for the evaluation of different systems. The contaminated water testing facility also comprises instruments for trace contaminants detection in water, such as the ICP OES, FTIR, Surface Area Analyzer, UV-Vis Spectrophotometer, AAS, etc.

High Altitude Water Purification System

Flexi Life Saver Water Purifier

Emergency Sea Water Purification Kit

Contaminated Water Simulation Facility

Latent Heat Storage based Thermal Management Unit for High Energy Laser-based DEW System

Heat Management Technologies

Heat management is a major requirement for deserts. Both men and equipment deployed in the desert are affected by the extreme heat of the environment. DLJ is working on non-conventional heat management technologies such as Phase Change Material (PCM).

The technology of the Thermal Management System (TMS) is based on latent heat storage using in-house developed PCM, high-conductivity materials, and modules that have been used in high-energy laser systems.

Reusable PCM Heat Packs and Body Warming Articles

The laboratory has developed Meta Stable Super Cooled Liquid Phase Change Material (MSCLPCM) for PCM heat packs. These are triggering devices that will release heat on demand. PCM heat packs provide heating solutions at -10 °C ambient temperature.

PCM Heat Packs

PCM Cool Vest

The extreme heat of the Indian tropical climate adversely affects the performance and health of individuals. A PCM cool vest has been developed using DLJ-prepared PCM to protect people from the adverse effects of high heat exposure.

PCM-based Cool Vest

Test Facilities Established to Test Systems Exposed to Desert Environment

The military systems and other commercial systems need to be tested for different solar, temperature, and humidity conditions. A walk-in chamber has been installed and commissioned at the DLJ to cater to the test requirements of the developed product before field and user trials. The chamber can be operated 24 hours a day for testing of the systems under accelerated conditions.

Walk-in Solar Radiation Test Facility

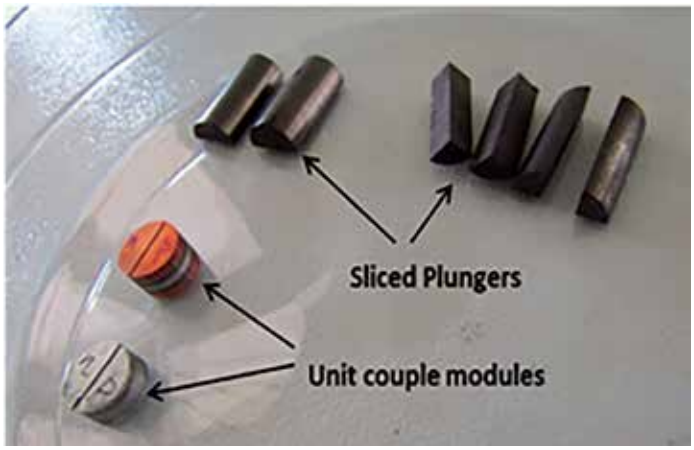
A blowing dust test facility provides simulated desert storm conditions for the test object planned to be deployed in a remote region of the Thar Desert. The facility provides blowing dust and settling dust tests at various temperature and humidity conditions.

Blowing Dust Test Facility

Thermoelectric Technologies

Thermoelectric-based materials technology offers the advantages of high reliability, silent operation, and long life for power generation from heat, solid-state cooling, infrared display, and imaging applications. In addition, it is a green technology. However, its use is limited due to the low efficiency of thermoelectric materials. DLJ had taken the initiative to address the challenge and succeeded in bringing materials in to technology.

High efficiency thermoelectric heterostructure nanomaterials have been developed in-house.



Enhanced Efficiency Thermoelectric Modules

Thermoelectric Research Centre

Thermoelectric Research Centre (TRC) has all essential processing and characterization facilities for thermoelectric material research. The process facilities include a vacuum pumping system with a quartz tube sealing setup, a spark plasma sintering system, etc. The characterization facilities include simultaneous see-beck coefficient and electrical resistivity measurement systems, high temperature hall measurement systems, etc.

High Temperature Hall Measurement Systems

Spark Plasma Sintering System

Chemical, Biological, Radiological, and Nuclear Water Purification System (CBRN-WPS) deployed at Lukung, Pengong, Lake, Leh-Laddakh

Editors are thankful to Dr Yojana Janu, Sc 'E', and Laboratory Correspondent of DLJ, Shri DK Tripathi, for preparing the write-up for this issue of *Technology Focus*.