

**National Network for Early Detection of Nuclear Emergency:
Indian Environmental Radiation Monitoring Network (IERMON)**

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Abstract

The paper describes India's initiative for early detection of nuclear emergency. The Indian Environmental Radiation Monitoring Network (IERMON) was established across the country by Bhabha Atomic Research Centre, Mumbai for online detection of nuclear emergency. The network is being expanded and upgraded in order to meet the different objectives of the monitoring network. The various scenarios of nuclear emergency, the criteria for selection of monitoring stations and the requirements of online monitoring systems are explained in the paper. The need for indigenous efforts for development and production of monitoring systems is highlighted. The paper also gives brief descriptions of some of the systems deployed in the network. Indigenously developed solar powered radiation monitoring system with GSM based data communication is described in detail.

Wireless sensor networks play an important role in emergency detection. The paper describes the proposed local area wireless sensor networks, integrated with IERMON, for detection and tracking of dirty bombs.

The last part of the paper explains the configuration and functions of IERMON Central Station. The Central Station is automated with redundant systems for detection and reporting of nuclear emergency. The Central Station is linked to the emergency response centres and control rooms through various communication links for online and real time access of data.

Keywords— IERMON, Environmental Radiation, Online Monitoring, Nuclear Emergency, Solar Power, Permanent Monitoring Stations, GSM Data Communication, Wireless Sensor Network, Network Central Station, Emergency Detection

A Container based Nuclear Radioactivity Analysis Laboratory

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Abstract

It is well known that after any nuclear eventuality, tremendous amount of radioactivity released in the environment and deposited on the ground as well as on water bodies. The preventative action will be carried out by disaster management team at the affected area specially decontamination, relocation and measurement of radioactivity level in food stuff. To carry out these requirements, it is altogether necessary to analysis of radioactivity in various environmental matrices for identification of radionuclides, level of contamination/ concentration and provides these inputs to disaster management team for next course of action.

In common practices, the contaminated samples are transferred to stationary nuclear analysis laboratory which are equipped with different nuclear instruments. These laboratories are very few where such facilities are available and may be far from incident. During transportation of contaminated samples any accident can take place and again new eventuality resulted.

Considering these problems, Defence Laboratory, Jodhpur has designed and developed Nuclear Contamination Analysis Station (NUCAS) in a container which can be transported to desired locations by air, road, train and ship. This laboratory is equipped with various instruments so that it can provide complete analysis results in field conditions with minimum time. This laboratory is state of art in field condition because it has Gen set for power, air condition with NBC filtration system, personnel decontamination facility.

NBC Disaster Management Services: Efforts & Preparedness at BEL
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Since '9/11' events the spectre of NBC threat has been daunting afresh worldwide. As NBC deterrence policy i.e. no first use of Nuclear or any WMD device is our principal ethos, an extra preparedness efforts required to tackle CBRN Disaster. In India vis-à-vis R&D efforts from DRDO, DAE, BEL has taken its in-house program towards NBC preparedness. The areas are:

- a) RPL Dosimeter as Nuclear Detector
- b) CBRN Shielded Al-Shelter
- c) Containerized Mobile Water Purification Plant for Uses at CBRN affected sites

Radio Photo Luminescent (RPL) Dosimeter: It is a BEL-DRDO designed wristwatch type product having two major Components: RPL Glass & Pin diode for sensing Gamma & Neutron Radiation respectively in the range 01-1000 Rad. As its sensing mechanism is RP Chemical reaction induced Optical Luminescence based, this equipment, unlike other electronic GM tube sensor would be resistant to EMP effect of Gamma and operational in real N-scenario. Key problems: glass melting, processing, radiation testing involved towards supplying 25,000 Nos. of RPL Dosimeter to Defense forces will be highlighted.

PUF Insulated Al- Shelter: Installation of state-of-the art Hot-press Bonding system -- a TOT process from M/S Cross Mobile, Germany-- used for manufacturing Al- PUF- Panels for shelter, has enabled BEL the largest supplier of Al- Shelter, Capacity 600 nos /month in India. Production challenges of BEL Engineers like designing, selection of accessories, rugged installation and testing trial at Army bases for various items e.g. Generators, AC, NBC ventilation system, Explosive /Chemical Agent Detectors etc towards supply of Al-PUF-Shelters especially for CBRN uses will be addressed.

Mobile Water Purification System for usages in CBRN Environments: In any disaster environment Potable water is one of prime requirements for army and disaster Management forces. Present paper will also address design parameters and Army field trial data of BEL designed Mobile Containerized Reverse Osmosis based Water plant, Product water flow capacity 3000 liter /hr for purifying brackish water, dissolved solid content, inclusive of CBRN contaminants, up to 5000 mg/liter.

POST RADIOLOGICAL & NUCLEAR EMERGENCY PREPAREDNESS AND GAPS

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ABSTRACT

Any untoward happening in the peaceful application of radioisotopes in industry, nuclear power production, medical field, agriculture use satellite crash or in transportation of radioactive materials in India may affect concerned occupational workers and limited population. The effect in India due to such scenario in neighbouring countries can also be anticipated. Further to deal with terrorist created Radiological Dispersal Device (RDD) explosion, Nuclear explosion on India or in neighbouring countries, of late Guidelines have been issued for managing Nuclear and Radiological Emergencies by National Disaster Management Authority (NDMA). RDD & improvised nuclear device (IND) explosion will differ in terms of magnitude of thermal, blast, nuclear effects. There is an international nuclear event scale of 1 to 7 for grading the nuclear / radiological event and identifying it as anomaly, incident, accident for action by Department of Atomic Energy which is self sufficient to deal with such eventualities. It may require support from Ministry of Home Affairs and Ministry of Defence in particular and Govt. of India in general in terms of mitigation, logistic, strengthening of border control, provision of mobile radiation detection, protection, decontamination.

This paper highlights initiative & availability of early warning & post radiological and nuclear emergency/disaster preparedness in terms of detection, protection; training as a first responder; early warning and action direction with Command Control Centre; provision of nuclear shelters; decontamination; radiation injury treatment; working tele-communication links; relief and response capabilities with police/fire services/civil defence & paramilitary forces / defence services; radioactive waste disposal.

Nuclear and Radiological Emergencies: Requirement of State of the Art Systems and Methodologies for Impact Assessment and Response

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Extended Abstract

Prevention and Preparedness for response to Nuclear and Radiological emergencies involves identification of various accident and emergency scenario which can lead to radiological consequences to public. While large number of nuclear facilities including nuclear power plants are in operation world over, the usage of radioisotopes are also increasing for the benefit of mankind. The nuclear accident at Chernobyl and radiological accident at Goiania led to serious concerns related to the contamination in public domain and made the world community to understand and prepare for responding to a situation where the persons who believe radiologically affected can be extremely large in proportion to the extremely small number who are actually may be affected.

All nuclear facilities are designed and operated to ensure the safety of the occupational workers, members of the public and the environment. Though the nuclear power reactors are having very large quantity of radioactivity inside the reactor core (hundreds of Mega curies), the release of radioactivity to the environment during normal operation is low and exposure to the member of the public is negligible compared to the natural radiation exposure. Due to engineering safety features incorporated into the design along with 'defence in depth' philosophy adopted, probability of a major nuclear accident having potential for release of significant quantity of radioactivity into the environment is extremely small. Even in the hypothetical major nuclear accident scenario which requires multiple failure of reactor systems, the fission products inside the reactor fuel have to get through many barriers including the reactor containments, if it has to get released into the environment. Still emergency preparedness is very much essential for all nuclear facilities to reduce the consequences, if at all any major release occurs from these.

The radiological impact following any nuclear accident depends on many factors including quantity and quality of radioactivity released, meteorological conditions during the release, topography around the site, elevation of release etc. In case of major releases to the environment, prompt and effective implementation of countermeasures can reduce the radiological consequences to the public. Hence, development of preparedness for response to such emergencies are very essential even for these 'very low probable emergency situations'. The early detection of accidental releases, quick assessment and prediction of radiological impact, capability of implementing effective countermeasures etc are components of nuclear emergency response.

Following the TMI accident in 1979, Chernobyl accident in 1986 and few radiological accidents like Goiania, many countries have intensified their efforts in nuclear and radiological emergency planning, preparedness and management. For an effective response to any major nuclear emergency, an Emergency Response Centre (ERC) having the facilities of i) Environmental dose rate monitoring system using both mobile and fixed units ii) On-line meteorological data station iii)

on-line computation and prediction of isodose curves in real time and iv) monitoring methodologies for various routes etc are essential. Vehicles equipped with different type of monitoring systems with on-line data transfer facility to the ERC can function as Radiological Impact Assessment Laboratory (M-RIAL) and can help in quick decision making even during a radiological emergency far away from the ERC. 18 DAE - Emergency Response Centres (DAE-ERC) spread over the country are developed and kept in readiness to strengthen DAE's Preparedness for 'Quick Response to nuclear / radiological emergencies' in the public domain. These DAE-ERCs have radiation safety experts and various types of monitoring systems at their centre for quick assessment of radiological status. The ERCs will also provide appropriate advise to the administration required for the relief and rescue measures in the presence of any radiation field/contamination in public domain either due to any accident or by deliberate acts. The DAE-ERCs also will be helping the CPMFs / Defence Forces in building up the "First Responders/Quick Response teams" of their organizations being developed for the response to any nuclear/radiological emergencies as well as guidance on the usage of radiation monitors.

A number of highly sensitive monitoring systems and methodologies have been developed for use at installations handling and storing sources and for use in public domain to detect illegal movement of radioactive sources and to locate, identify and search lost sources. Some of the important systems developed in BARC for prevention and response to nuclear and radiological emergencies are:

1. Aerial Gamma Spectrometry system (AGSS) for aerial radiation monitoring
2. Compact Aerial Radiation Monitoring System (CARMS) for remote Aerial Monitoring using Unmanned Aerial Vehicles (UAVs)
3. Portal Monitor and Limb Monitor
4. Vehicle monitor (for inspecting goods/scrap carried by vehicles)
5. Installed Environmental radiation monitoring systems with data transfer facilities to Emergency Response Centres (IERMON)

In addition, Indian Real Time Decision Support System (IRODOS) with combination of detection system around nuclear power plant and software for online impact assessment is developed as preparedness tool for responding to any major Nuclear Power Plant accident leading to release of radioactivity to environment.

AGSS and CARMS (designed for Unmanned Aerial Vehicles (UAV) based aerial surveys) are to be deployed on a mobile platform like airplane or helicopter, train or car / van, boat etc to perform quick environmental monitoring. Many aerial survey exercises and mobile radiation monitoring surveys/exercises are carried out to demonstrate the capability of these systems for searching of orphan sources and qualitative and quantitative estimation of radioactive contamination over large area on ground. Portal, Limb and Vehicle monitors are being deployed as stationary but redeployable monitors to detect unauthorised movement of radioactive material either by persons or in vehicles in public domain as well from nuclear facilities.

GIS based Emergency Response System is extremely useful for planning the countermeasures effectively, to reduce the exposure to the Emergency Response Teams (ERTs) and members of public and for training the ERTs and Decision makers / administrators on Emergency response. This system provides "Minimum Exposure Route" for evacuation operation both in terms of distance to travel and total dose received by the individuals. With the information on population density/distribution of the affected site, the number of people affected, the type of

shelters required, and the requirement of vehicles and other logistics for transportation (evacuation) or rallying points can be worked out.

While prevention of smuggling and illicit trafficking of nuclear and radioactive material are to be achieved by the installation of large number of sensitive state of the art detection system at various strategic location in the country, Challenges of nuclear and radiological terrorism, though not used in the world till today, cannot be ruled out. Hence development of First responders / Quick Response teams, medical preparedness for medical management of radiation injuries/contamination and public awareness programme on protective measures during radiation emergencies, etc are to be taken up at national level to reduce the consequences against the malicious usage of nuclear/radioactive material against the society.

Role of Medical First Responders in the Management of Nuclear/Radiological Emergencies (NREs)

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The increasing probability of occurrence of any Nuclear /Radiological and Emergency(NRE) is directly related to the enhanced usage of radioisotopes in medicine, agriculture, industry and especially the use of nuclear power as an important energy source. The enhanced threats of terrorism can be visualized in review of the spate of recent attacks on civilians. Such threats have indeed compounded the overall radiation risk to the community. There are a new adequate preventive strategies in place to prevent any theft or misuse of radioactive material and blocking of state-sponsored terror activities. The second line of defence is to be prepared for such emergencies. Such preparedness is crucial to involve multiple emergency functionaries at a single platform to respond effectively and promptly. The most important issue is medical preparedness and it includes training and equipping of Quick Response Medical Teams (QRMTs) or Medical First Responders (MFRs). Such teams should be task-oriented, well equipped, properly trained, ever-ready, self sustaining, with time tested SOPs. It is important to test their abilities during mock exercises such that they are able to prevent the occurrence of deterministic effects of radiation among the large sector of affected community. The prime objectives of these teams are reconnaissance, decontamination, medical management and safety measures. They are also responsible for the health of rescue service providers who are entering into the radiation–contamination zones. MFRs need to equip themselves with suitable protective gears, including those that are able to provide adequate protection against cross-contamination while doing resuscitation, triage and decontamination. DRDO has developed numerous technologies/products for rescue service providers and MFRs e.g. protective water-proof suits, suitable for indigenous climatic conditions, are available for QRMTs and a decontamination kit called ‘SHUDHIKA’ to remove the radioactive contamination from skin is already in use by Indian security forces. The various items of SHUDHIKA have been assembled and developed as per the guidelines of Atomic Energy Regulatory Board (AERB). The holistic management strategy requires identification of vulnerable areas, prioritizing the efforts towards the development of adequate medical logistics support, protection, detection, decorporation gears/agents followed by capacity development in selected zones in a project mode manner and expansion of these areas into the development plans as a long term approach. MFRs are likely to play a major role in case of NREs and it is our continuing endeavour to provide them with state-of-the art products/technologies so that they can remain safe during operational missions.

Leveraging Human Resource for Effective Management of CBRN Emergencies

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Human capital is the most crucial factor for a well-built disaster management (DM) system. Today, there is an appalling shortage of highly skilled and trained human resource (HR), which can play a proactive role prior to, during and after a disaster. Training suitable human resource can play a major role in modulating the pre-disaster (viz., disaster prevention, mitigation and preparedness) and post-disaster phases (viz., disaster relief, rehabilitation and reconstruction). Training is known to change the face of a disaster. Since HR is crucial to the activities in the disaster management cycle, it is necessary to pay adequate emphasis to this important resource while planning and executing DM programmes. Towards this end, the National Disaster Management Authority (NDMA) has been set up and a lot of endeavours have focussed in this direction via the promulgation of national guidelines. Some strategies that need urgent attention include: preparation of a comprehensive prevention, preparedness and mitigation plan in consonance with HR capabilities. At the top level the key stake holders include IAS, IPS, IFS, PCS and other Government functionaries. However, DM cannot be the job of the Govt. alone, since the set up is often paralyzed due to unexpected proportions of disaster. Time is the crux and the first response often comes from those in the vicinity and, therefore, DM should be integrated at the grassroots level in all curricula so that loss of precious lives can be minimized. Training of HR for DM is essentially required in the areas encompassing emergency rescue, fire fighting skills, artificial resuscitation, calling for help in emergency, networking of national and international resources/facilities, Army and paramilitary forces, civil authorities, medical personnel, doctors, nurses, paramedics, emergency medical technicians, drivers of ambulances, QRMTs, organizations dealing with emergencies and contingency planning, individuals, effective communication skills between different rescue agencies, and media, academia, industry, students and children, volunteers, NGOs, supply management, forecasting disasters, proper coordination and synergy between agencies, simulation of disasters etc. Training is needed both on and off the job. Training of trainers also needs attention. If DM is integrated into the system, there would be no need for additional planning. Since DM is becoming technology-intensive, and new kinds of disasters e.g., in the CBRN category are emerging the role of HR management has become even more important. If HR is thoroughly leveraged a full-blown disaster can be averted. Since CBRN disasters have an element of surprise, DRDO is playing a responsible role especially by empowering Indian Army, Indian Navy and Indian Air Force for effective CBRN emergency management.

Emergency Preparedness in Indian Nuclear Power Plants

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Abstract

Nuclear Power Plants (NPPs) adopt fundamental safety design principle of defence-in-depth, which is centered around multiple levels of protection, including successive physical barriers, preventing release of radioactivity into the environment. In implementing defence in depth, emphasis is on prevention of incidents/accidents with mitigation measures in public domain in-place as abundant caution outlining the preparedness for hypothetical eventuality.

All NPPs have an exclusion zone (EZ) surrounding the power plant. As per track record, the doses from operating NPPs at EZ are a fraction of prescribed dose limits during normal operation. The calculated doses during design basis accident are well within the acceptable doses at EZ. Some of the postulated incidents and events are outlined to be handled by NPP authorities and operating personnel invoking off-normal and emergency operating procedures, plant and site emergency plans and some by local and district authorities. The practice of verification of actual implementation of these preparedness plans in NPPs and effectiveness of implementation is checked as per defined periodicity at NPP level as well as local and district administration level. In addition there are communication exercises to ensure that all communication means are in place at the time of emergency. Such emergency plans are essential elements of regulatory clearances to NPPs granted by Atomic Energy Regulatory Board (AERB).

The Department of Atomic Energy (DAE) is the nodal agency in respect to manmade radiological emergencies in public domain. For this purpose a Crisis Management Group (CMG) is established in DAE, which coordinates with local authority in the affected area and National Crisis Management Committee (NCMC).

The paper covers emergency operating procedures and emergency plans- regulatory requirements, periodic checking, salient findings of exercises, emergency management hierarchy towards assurance of public safety during radiological emergency from NPPs and also makes a mention of safety design features of NPPs,

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Role of Regulator in Control of Nuclear and Radiological Emergencies

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Abstract

The nuclear facilities adopt a high level of defence-in-depth concept in its design, observe high level of quality control in construction and are operated within the safe operational limits and conditions (OL&C). The probability of occurrence of any major event is lower than 10^{-6} . In order to monitor degradation of components during operation, nuclear facilities follow a well established surveillance programme. However, despite the inherent and engineered safety features in the design and the measures taken during its operation, there are still possibilities of occurrence of an accident (event) resulting in to radioactive releases, which can affect the plant, personnel, property, general public and environment. Although prime responsibility for safety rests with the facility, role of the regulator is to ensure that the nuclear facilities comply with the applicable codes and standards and always conduct in a responsible manner. The International Nuclear Event Scale (INES) designed by the International Atomic Energy Agency (IAEA) is used for rating of the severity of nuclear events and for prompt communication, which is being followed by around 150 member states. However, the events rated below the INES, which are called Low Level Events and Near Misses (LLEs & NMs) and are the key indicators or precursors of events. Depending on the extent and severity of an accident, the emergency situations can be classified as emergency standby, personnel emergency, plant emergency, site emergency, off-site emergency and transboundary emergency.

The safety and regulatory review of the facilities in India are carried out by Atomic Energy Regulatory Board (AERB). However, the facilities under Bhabha Atomic Research Centre (BARC) which include medium and large size research reactors, reprocessing plants, research labs, irradiators, accelerators, high strength radioisotope handling facilities etc. are under the purview of a separate regulatory body. These facilities are designed and maintained to meet the expected site emergencies and are less likely to encounter any off-site emergency.

Regulators, while practising high level of expertise, maintain their regulatory independence. There are procedures for avoiding, mitigating and managing emergencies by fail-safe design, use of high quality components, regulatory inspections, periodic quality checks, emergency exercises etc. Interaction with other facilities and healthy interaction within the facility go a long way in addressing safety.

In this presentation an attempt will be made to discuss these issues.