ON-LINE MONITORING SYSTEM FOR I-131 MANUFACTURING LABS

A. Osovizky[2], Y. Malamud[2], S. Turgeman[1], M. Weinstein[1], Y. Paran[2], and N. Tal[2]
[1]Nuclear Research Center-Negev, P.O.Box 9001, Beer-Sheva 84190, Israel
[2]ROTEM Industries Ltd., P.O.Box 9046, Beer-Sheva 84190, Israel

Abstract

An on-line monitoring and safety system has been installed in a lab for manufacturing I-131 capsules for nuclear medicine use. Production of up to 100mCi batches is performed in shielded glove boxes.
The safety system is based on a unique, "Medi SMARTS" system (**Medi**cal Survey **M**apping **A**utomatic **R**adiation **T**racing **S**ystem), that collects continuously the radiation measurements for processing, display, and storage for future retrieval. Radiation is measured by GM tubes, data is transferred to a data processing unit, and then via a RS-485 communication line to a computer. In addition to the operational advantages and radiation levels storage, the system is being evaluated for the purpose of identifying risky stages in the process.

Introduction

I-131 is commonly used in nuclear medicine departments for diagnosis and therapy of the thyroid. Two different types of I-131 capsules are manufactured in hot labs: Very low activity diagnostic capsules, and medium to high activity therapeutic capsules. Both types are prepared from a chemically stabilized NaI solution while the volume activity of the solution is gradually reduced by a non active solution to produce the requested activity dose for each capsule. Preparation of the therapeutic capsules is made within a glove box, shielded with 50 mm thick lead, and operated by mechanical manipulators. This is a necessary precaution due to the high activities processed from each batch and the I-131 high emitted energy. Each capsule's activity is measured by using a built in dose calibrator well. The capsule is transferred to another glove box to remeasure its activity, and then loaded into a plastic vial, and into a lead container. The lead container is labeled and removed from the shielded glove box into the packaging area, where it is prepared for customer delivery. The diagnostic capsules are prepared in much larger batches, where each batch uses uniform volume activity solution. A special automatic machine is used to apply an accurate dose of activity to each capsule. Thereafter, each capsule is dose - calibrated and packed in 10 units vials. Each vial is dose - calibrated again, labeled and packed in a lead container.
I-131 is a radioactive isotope with half life of eight days and γ radiation emission of 364 KeV[1]. Ionizing radiation areas are hazardous to workers. The On Line Monitoring System was installed in I-131 manufacturing hot labs in order to achieve the following safety goals:

1. Radiation monitoring in working areas to detect radiation zones caused as result of the normal production or abnormal operation.
2. Mapping the radiation in working areas to allocate and isolate high risk areas.
3. Personal dosimetry - on line estimation of the radiation dose for each worker.
4. A process-control detector for tracking the dose passage between glove boxes during the production.
5. Monitoring of air discharge from glove boxes through ventilation pipes for radiation control.

Medi SMARTS System

The Medi SMARTS System (**Medical Survey Mapping Automatic Radiation Tracing System**) is designed to measure and collect radiation data automatically and continuously from various medical sites where hazardous ionizing radiation may be found. Such sites include radiochemistry laboratories, nuclear medicine departments, PET and Cyclotron facilities.
Radiation is continuously monitored at each selected site, by dedicated detectors adapted to their specific task. Measurement results are continuously transferred from the communication channel via a RS-485 communication network to a P.C. working station. The Medi-SMARTS Software on PC is used for on-line display of the radiation measurement values on area maps. Alarm thresholds, malfunction warnings and local alarms are also displayed on the computer screen, while the radiation measured data is saved in a special database for further analysis.
The system flexible characteristics allow simple addition and removal of detectors and their communication adapters, in a very user friendly manner, whenever changes are required. The number of detectors connected to the control unit may vary from 1 to 300. The system is based on three basic components, (see Fig. 1): detector(s), data processing unit(s) and computer software with communication network.

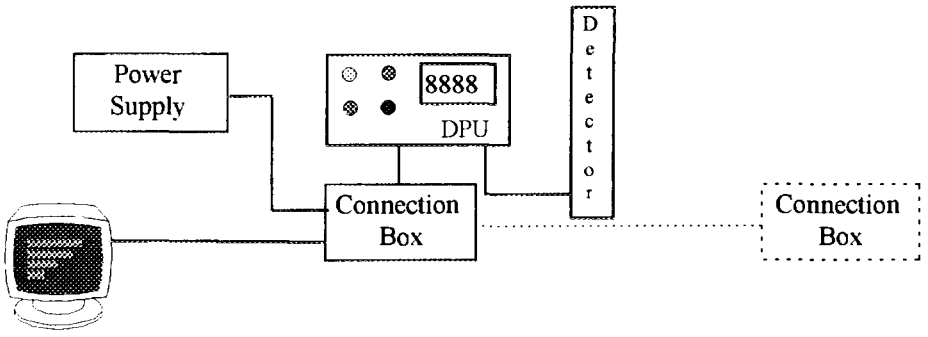


Fig. 1 - Medi SMARTS System Basic Components

Monitoring Channel

Each monitoring channel includes two parts:

1) Data Processing Unit (D.P.U) - Processes the detectors' signal and transmits the calculated radiation data via RS-485 communication network to the computer.
   The DPU includes and performs:
   a. Relay's output to indicate exceeding of radiation threshold levels and malfunction.
   b. Radiation measurement is displayed on a large, easy to read, digital LCD.
   c. Four LEDs for indication:
      LED 1 (Green) - Input supply voltage and 5V indication.
      LED 2 (Red) - Threshold (Thr) alarm.
      LED 3 (Yellow) - Short flashing for reception indication.
      Long flashing for transmission indication.
      LED 4 (Green) - The light turns off if fault alarm appears.
   d. Threshold and malfunction visual alarm on the display.
   e. Automatic identification of the detector type and the detector calibration factor.
   f. RS-232 Communication.
   g. RS- 485 communication.
   h. Displays on start up: detector type, DPU addresses, threshold levels.
   i. Automatic detection for detector malfunction.
   J. Calculation of the accumulated dose.

2) Detector - Three main types of detectors can be connected to the DPU: Ionization chambers [2] , Scintillators coupled with PMT [3] and Geiger Muller tubes[4] . Each one of these detectors has its own advantages for a specific monitoring task. Selecting the correct detector for a specific task is made according to the location (size, humidity), radiation field at the detection point (activity and energy), background noises, minimal detection level (MDL), reliability of the detection and detector life time. In order for the system to recognize the detector automatically, each detector has its own identifying frequency. This frequency is produced from a 555 oscillator [5] and is transferred to the adapter on one of the detector leads. Because of statistical variance between the detectors, each detector should be calibrated in order to achieve compatibility and versatility with all the monitoring channels. The calibration factor is saved in the detector and transferred to the DPU as new frequency. The ratio between the frequency sent by the detector and the predetermined frequency for the detector gives the calibration factor. Multiplying the rate of pulses by the calibration factor gives the calculated radiation field.

Medi-SMARTS Software and Communication Network

Medi-SMARTS software is Windows based (Windows 3.11, Windows NT, Windows 95). The RS-422 communication network operates in a half duplex mode (full duplex RS-485 mode is optional). Data is transferred to on line display via an RS-422 communication card installed in the PC, using the Medi-SMARTS software.

Software Highlights:

1. On line display of the DPU radiation measurements (Dose & Dose Rate or cps) on maps.
2. Automatic recovery after computer malfunction.
3. Survey maps.
4. Line graphs for trend analysis.
5. Bar graphs for dose rates display.
6. Fast retrieval of the last two weeks monitoring data.
7. Zoom possibility on selected time interval.
8. 800 last malfunctions optional display.
9. Adjusted loop cycle time.
10. Audio and visual alarms for exceeding of radiation threshold levels and malfunction.
11. Hierarchy of users authorization. Modifications are performed only by the person with the highest authorization permit controlled by passwords.
12. Network versions.

Method

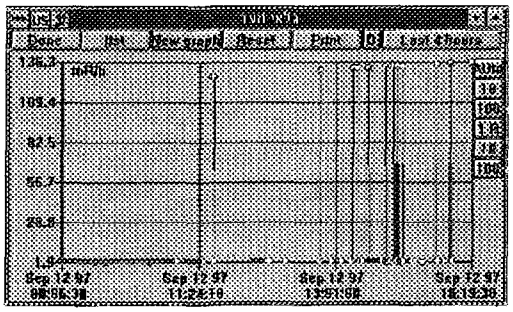
The radiation monitoring system installed in the I-131 manufacturing lab, has been built to cope with the five goals described in the introduction. Manufacture control and lab monitoring are performed by six detectors. Three detectors are located on the glove boxes, adjacent to personnel working positions. One detector is located on the lab walls for peripheral monitoring; one is used for process control for monitoring the material that flows between the two shielded glove boxes; and another is located on the air pipe to monitor the air release from the glove box.

The data processing unit display enables the operator to read the radiation levels continuously, and receive audible and visual alarms in case of threshold exceeding of the permitted level or in case of detector failure. Geiger Mueller detectors are used for the application. The detector specifications are: measuring rate 50μR/h - 1R/h, based on ZP1201 counting tube [4] with energy range of 50KeV ÷ 1.3KeV.

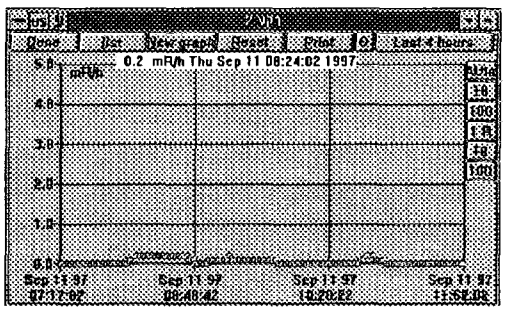
Results

The monitoring system installed in the manufacturing lab has been tested for advantages of the goals discussed in the introduction. The process control detector tracking the capsules passage between the glove boxes is shown in Graph 1, each peak representing a single dose passage. The ventilation monitoring measurements during production are shown in Graph 2. The monitoring measurements of the detector located on the glove box adjacent to personnel working position during production are shown in Graph 3 where each peak represents short exposure of a single capsule. The background detector located on the wall in front of the production box has been proved to provide an alarm in case of malfunction operation when the I-131 capsule has accidentally fallen outside as shown in Graph 4.

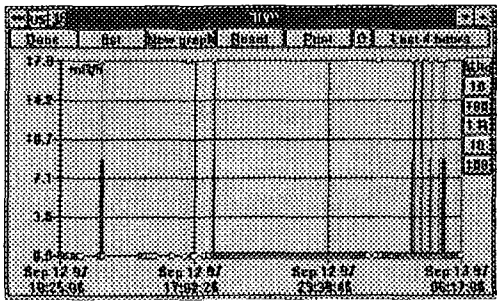
The system is still being evaluated for the purpose of identifying risky stages in the working areas. The results will be evaluated to find the correlation between the accumulated dose obtained from the detectors, and the radiation level obtained from the personal TLDs (Thermo Luminescent Dosimeter).



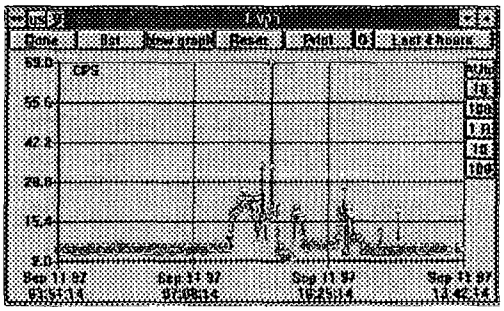
Graph 1



Graph 2



Graph 3



Graph 4

Summary

The system proved its ability to continuously store monitoring data, both from peripheral detectors and process control detectors. The system also provides immediate indication of process malfunctions, such as improper loading of capsules into containers during packaging. The DPU local visual indications have been very effective in identifying real-time radiation levels, enabling personnel to react to any operational event during the critical stages of production and packaging.

Further data for personal monitoring has yet to be collected and interpreted, to provide additional tools for personal safety.

References

[1] H. Kiefer, R. Maushart, Radiation protection measurement, Pergamon press 1972, pp. 330.

[2] N. Tal, et. al., **IC-10** data sheet, Rotem Industries Ltd.

[3]. N. Tal, et. al., **PM-10/11** data sheet, Rotem Industries Ltd.

[4]. N. Tal, et. al., **GM-40/41/42** data sheet, Rotem Industries Ltd.

[5]. National Semiconductor Corporation, Linear Application Databook (1993) pp. 8 ÷ 134.