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MONITORING SYSTEM FOR IMPROVING RADIATION SAFETY MANAGEMENT

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Abstract

Medi SMARTS (**M**edical **S**urvey **M**apping **A**utomatic **R**adiation **T**racing **S**ystem), a gamma radiation monitoring system, was installed in a nuclear medicine department. In this paper the evaluation of the system's ability to improve radiation safety management is presented. The system is based on a state of the art software that continuously collects on line radiation measurements for display, analysis and logging. Radiation is measured by GM tubes; the signal is transferred to a data processing unit and then via an RS-485 communication line to a computer. The system automatically identifies the detector type and its calibration factor, thus providing compatibility, maintainability and versatility when changing detectors.

Radiation levels are displayed on the nuclear medicine department map at six locations. The system has been operating continuously for more than one year, documenting abnormal events caused by routine operation or failure incidents. In cases where abnormal working conditions were encountered, an alarm message was sent automatically to the supervisor via his tele-pager.

An interesting issue observed during the system evaluation, was the inability to distinguish between high radiation levels caused by proper routine operation and those caused by safety failure incidents. The solution included examination of two parameters, radiation levels as well as their duration period. A careful analysis of the historical data, applying the appropriated combined parameters determined for each location, verified that such a system can identify abnormal events, provide alarms to warn in case of incidents and improve standard operating procedures.

System description

The Medi SMARTS system is based on three main components: Detector, Data Processing Unit (DPU) - the meter, and computer software. The system, installed in the nuclear medicine department, consists of six detectors placed in the following locations: Hot lab, injection room, waiting room, gamma camera room, stress test room and PET camera room, as shown in Figure 1. The system measures and collects radiation data continuously from all six locations. High sensitive GM detectors or Pancake detectors continuously monitor the radiation. Measurement results are transferred on-line, from the monitoring channel via an RS-485 communication network to a PC work station for on-line display and documentation.

The daily dose of about 600 mCi (Tc-99m) is prepared in the hot lab. The total dose is divided into smaller personal doses of about 20 to 30mCi (see Table 1). The doses are then transferred into the injection room and injected to patients. The patients are referred to the waiting room before being taken to the gamma camera room for imaging. The patient's doses for the PET camera are delivered by a pneumatic system, from the cyclotron area directly to the PET room.

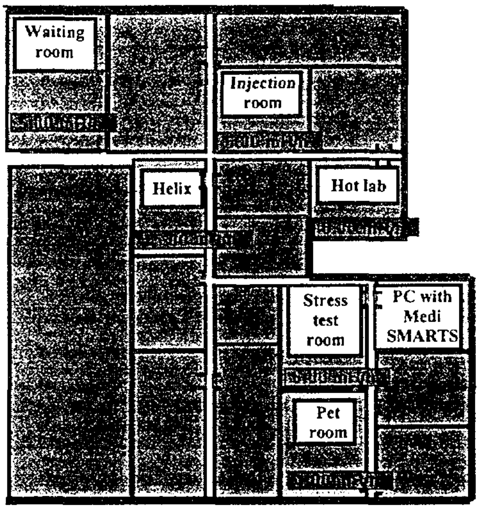


Figure 1. Hadassah Ein Karem Nuclear Medicine Department

Table 1. Radioisotopes Characteristics

Isotope	Abundance [%]	Half-life	Dose typical activity [mCi]	Energy [keV]
Ga-67	20 36	3.3 days	8	184 93
Tc-99m	89	6 hours	20 ÷30	140
Tl-201	92	73 hours	3	70
Xe-133	36	5 hours	5 ÷ 15	81
Se-75	60 85	3.3 days		136 280
I-131	81	8 days	5	364

Results

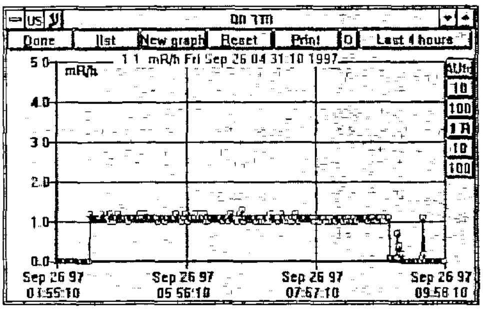
The system has been running continuously documenting radiation levels. During the department's routine operation, the radiation level exceeded background level in the following cases: In the hot lab, when the daily dose was taken from the generator into a shielded working station and when a personal dose activity (syringe) was taken to measurement. In the injection room during the injection time, until the patient was taken to the waiting room.

Although failure events can involve less activity than that of a syringe dose, the failure events can be separated from routine operations by careful analysis of time histories in each monitored area. Examples of these events and their surrounding time are shown in graphs 1 to 7. A summary of the abnormal events is given in Table 2.

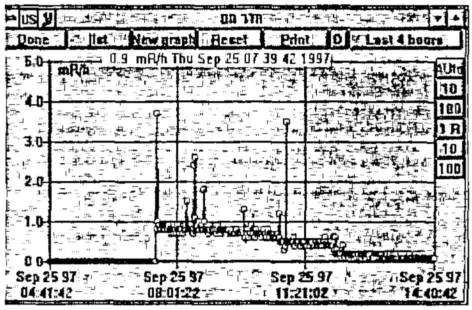
Useful alarm levels could be set to identify most of the anomalies by differentiating between long term and short term increases in radiation background, due to routine operations. Alarms can be displayed on the meter, are used to warn personnel, and may be logged in a history file for analyzing standard isotope handling procedures and for training personnel.

Table 2. Abnormal Events

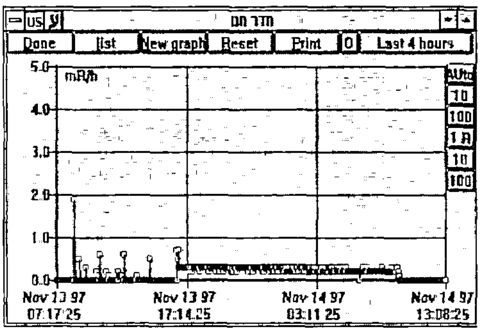
Location	Start	Stop	Event Description	Graph #
Hot lab	26.9.97 04:30	26.9.97 09:00	A new Tl source was supplied and left during the night out of the lab, near the door.	1
Hot lab	25.9.97 08:00	25.9.97 12:00	A source was left out of the shielded container. Its decay can be noticed while the high peaks represent routine activity in the lab.	2
Hot lab	13.10.97 17:00	14.10.97 12:00	Abnormal background in the lab A source was left out of its shielded container.	3
Hot lab	15.6.98 08:00	15.6.98 11:50	Contaminated saline was deposited in the regular trash can.	4
Injection room	12.2.98 16:20	12.2.98 17:10	Abnormal radiation level for about one hour. A syringe was left uncovered after injection.	5
Waiting room	6.1.98 17:20	6.1.98 17:25	An injected patient approached the secretary's desk for about five minutes	6
Stress test room	7.9.98 08:49	7.9.98 10:35	Abnormal background, decay of the intensity can be observed.	7



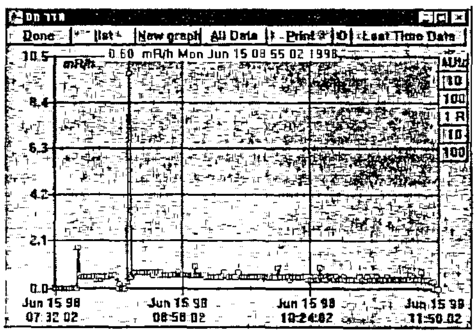
Graph 1. Hot lab



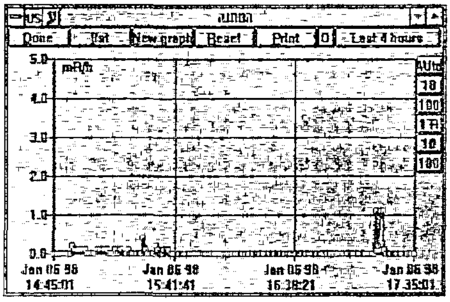
Graph 2. Hot lab



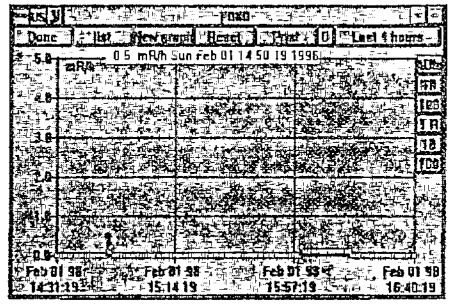
Graph 3. Hot lab



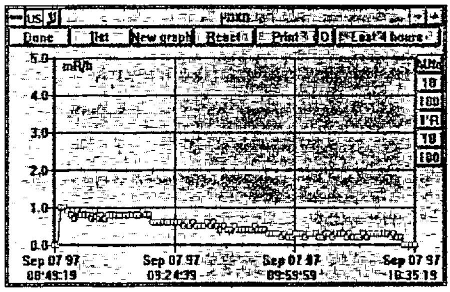
Graph 4. Hot lab



Graph 5. Injection room



Graph 6. Waiting room



Graph 7. Stress test room

Discussion

Distinguishing between high radiation levels caused by department routine proper operation and those caused by safety failure incidents was a main problem. The solution employed consisted of radiation levels examination as well as the duration period, see Table 3. A careful analysis of the historical data, applying the combined parameters, verified that such a system could identify abnormal events, provide alarms to warn in case of incidents, and improve standard operating procedures. Such a solution should decrease the number of false alarms and increase the personnel attention to alarms.

Table 3. Alarm thresholds for each one of the locations

Location	Immediate Alarm [mR/h]	Delay Alarm		Background Radiation levels measured at normal working conditions
		mR/h	minutes	
Waiting room	0.5	0.2	5	0 ÷ 0.2 mR/h
Stress test room	4	0.8	10	0 ÷ 0.1 mR/h
Hot lab	10	1	15	0 ÷ 0.2 mR/h with speaks of 1 mR/h for about 2 min duration during production
Injection room	2	0.3	10	0 ÷ 0.2 mR/h
Gamma camera room	0.3	0.1	7	0 ÷ 0.1 mR/h
PET camera room	7	1	20	0 – 0.1 mR/h with background of 0.2 mR/h for about 3 hours duration camera calibration.

Conclusion

The Medi SMARTS system proved itself to be a useful tool in hospital nuclear medicine departments for monitoring radiation safety procedures, training personnel, provide historical data for documentation and improving routine operations.

The ability to filter and determine a fault condition from the general abnormal conditions by using an event duration time limit, enables the department inspector to respond only to the fault condition and to educate the personnel to respond to DPU alarm messages.