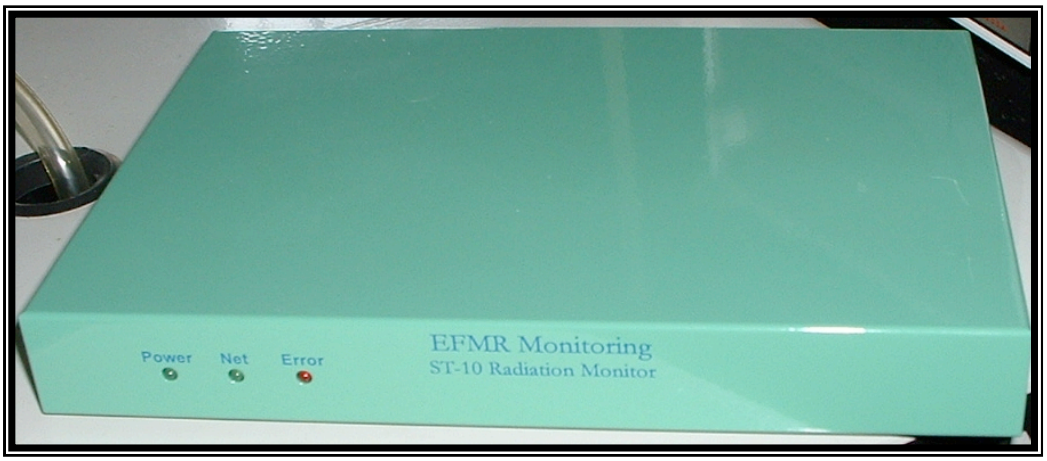
The EFMR

ST-10 Radiation Monitor



Operating Manual

Contents

Introduction

Purpose and Scope

The ST-10 radiation monitor is used by EFMR to collect radiation exposure rate information from the area encompassing and surrounding nuclear facilities. The EFMR mission statement is included below (paraphrased from the EFMR web site):

EFMR Mission Statement: To monitor radiation levels surrounding the Three Mile Island Nuclear Station and the Peach Bottom Atomic Power Stations so that deviations from normal background radiation levels are detected and reported expeditiously, thus allowing for a prompt response from our citizens network, especially in the event of another accident or any radiological release in the area. If abnormal levels are detected, EFMR can then report the data to proper authorities including the PA Department of Environmental Protection, the US Nuclear Regulatory Commission and other groups or interested individuals (as appropriate)…EFMR is a nonpartisan and nonprofit community based organization created, and operating upon the premise that all segments of the community are valuable, and must be included in efforts to educate the general public about radiation and nuclear power production. To this end, EFMR has successfully empowered non-governmental organizations, schools, and individuals to monitor for radiation in the environment.

ST-10 Functionality

The ST-10 radiation monitor was developed by Schnitz Technology exclusively for EFMR of 4100 Hillsdale Road, Harrisburg, PA, 17112 (Phone 717.541.1101). The unit is a stand-a-lone gamma radiation monitor designed to automatically collect and communicate surrounding gamma radiation levels and log the data collected to the internet. The ST-10 reports ambient gamma radiation levels continuously, twenty four hours a day, three hundred sixty-five days a year. The unit reports the data collected in a “counts-per-minute” format which can be converted to units of mR/h using the graph supplied in this manual (see page 14).

The ST-10 connects to the internet through a cable or DSL (Digital Subscriber Line) modem using a standard Ethernet connection. ST-10’s are deployed in homes, businesses, and other locations around nuclear facilities out to about twenty miles from the facility. Monitoring locations are selected from a list of volunteers solicited by EFMR. Volunteers agree to provide secure and stable locations where individual ST-10 units can passively monitor background radiation levels without significant environmental or physical disturbances.

Connections

Power Requirements

The ST-10 derives power from a supplied 12 volt power supply that connects to a standard 110 volt AC power outlet (see photo).

Ethernet & Serial Connections

As seen above, the ST-10 has three Ethernet connections on the rear of the unit, and one nine pin console connection (serial port) that may be used to monitor the data being collected locally during calibration efforts. The console can also be used to check the unit's operation without the internet during set-up and routine maintenance operations. Power, net activity and error lamps are provided on the front of the unit (see cover page photo). A system reset (seen above) is also available.

Network

The ST-10 connects to a router using an Ethernet connection. The router connects to the internet with a standard DSL or cable modem.

Operational Considerations

Units of Measure

The unit "counts per minute", is a term used by many technical groups to describe the number of observable events of a specific type collected in a one minute time interval. In the world of radiation measurement, the term relates to how many ionizing events are being detected or reported by a radiation detector per unit of time, in this case 1 minute. During the calibration process, the number of counts recorded in one minute increases as the amount of radiation is increased. For instance, a one minute count in a radiation field equal to 1 mR/h may yield thousands of counts per minute, while a radiation field of 10 mR/h may yield tens of thousands of counts per minute – a factor of ten increase in count rate. This cause and effect relationship allows one to use counts per minute to estimate mR/h from any observable count rate up to the level of the detectors ability to respond. All detectors fail to respond proportionately at some point depending on the amount of radiation they are receiving. This is a part of their normal response function. A typical calibration curve showing the ST-10's response function is shown on page 13 of this manual. The graph plots counts per minute against mR/h.

The unit "mR/h" is a radiological measurement term where the "m" stands for milli or 1/1,000 of a Roentgen (R). For dominant power plant radionuclides, a Roentgen is roughly equivalent to a REM (Rad Equivalent Man). The REM is a unit of dose used to relate a level of radiation damage to humans, and assign a risk of producing harmful radiation effects in living tissue. The US Environmental Protection Agency (EPA) reports that humans typically receive about 0.38 REM (380 mrem) per year from all natural background radiation sources combined.

Start-up

After selection of a location, a fully calibrated unit is placed in a home or business near an electrical outlet and computer/modem connection. The Ethernet cable is attached and the power supply is connected. A portable computer is then connected using the serial connector. The unit is added to the network and a check source is used to verify operation. Only radiation monitors with current (not expired) calibration stickers are placed into service.

If desired, a Thermo Luminescent Dosimeter (TLD) or Optically Stimulated Dosimeter (OSD) or equivalent, may be placed with an ST-10. TLD's or OSD's are added to provide an alternate verification methodology as deemed appropriate by EFMR. As an example, a dosimeter might be placed with a unit if significant fluctuations in count rate are observed over time at a specific location. The additional dosimeter information could then be used to verify the significance of the observed fluctuations.

Operation

Once installed, the ST-10 radiation monitor will constantly monitor the radiation environment at a host site or test area. To access the web based counting results perform the following:

1) Start any internet connected PC or MAC.
2) If you are running Mac OS X, download Sequel Pro at:
   http://www.sequelpro.com/download
   If you are running Windows, download HeidiSQL at:
   http://www.heidisql.com/download.php
3) Start the program and fill in the information boxes with the following:

NETWORK:	MYSQL (TCP/IP)
HOSTNAME:	db.efmr.org
USER*:	"enter your user name"
PASSWORD*:	"enter your password"
PORT:	3306
Database:	monitor

*User Name and Password are obtained from EFMR

4) Press the OPEN box at the base of the window.
5) Double click on the "reading" value on the left side of the listing, and select data from the option menu near the top of the page. The data is now shown as a list with the following format:

sensorvalue	timestamp	sensorid	nodeid	receiptid
16	2012-03-16 23:08:29	103	103	4345441

   The sensor value is the count per minute value (16) for the listed time stamp, and the "nodeid" value is the S/N of the detector.

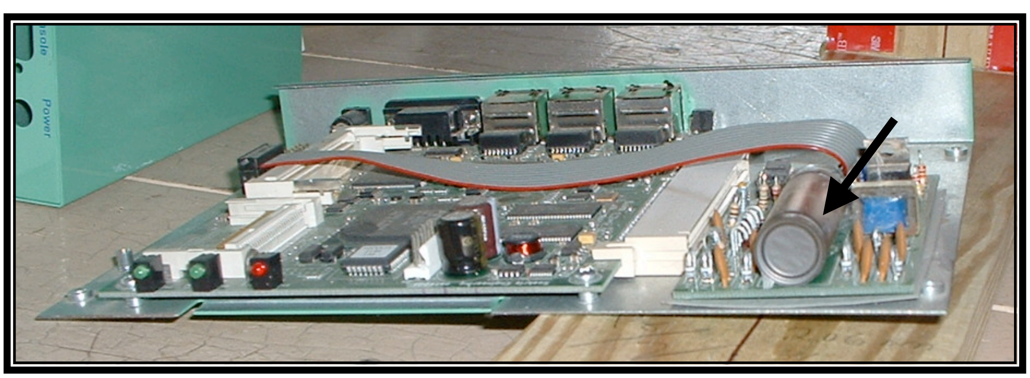
Placement

ST-10 unit placement is based on the availability of volunteer/host partner locations, and on actual wind directions around nuclear facilities. These are the key elements of strategic importance in accordance when selecting placement sites. As an example, the wind around Three Mile Island (TMI) may typically move from the south-east to the north-west. Therefore, it is wise to place more units in the north-west area to ensure that any radiological release has a good chance of being detected. However, EFMR is also concerned about other points of the compass around potential radiation sources. Therefore, EFMR considers placing some monitors at all compass points around nuclear facilities when these directions are available for monitoring using a volunteer/host participant location.

Availability of host partners is a key element when placing monitors in the vicinity of nuclear facilities. Host partners are sites provided by people or organizations who volunteer the use of their home, work area or other location. EFMR ultimately determines where a unit will be placed in accordance with need and unit availability, and is solely responsible for selecting each location.

Detector Characteristics

All ST-10 radiation monitors are equipped with the LND 71210 energy compensated GM detector. The detector is attached to a GM-10 interface board supplied by Black Cat Systems. The board contains the high voltage power supply and the timer counter circuit. The GM-10 board communicates with the computer and receives its power through a serial interface. The detector mounting assembly is shown in the following photo. The GM tube is on the far right. In the photo below the GM tube shown is a LND 712 which is not currently being used in ST-10 radiation monitors.

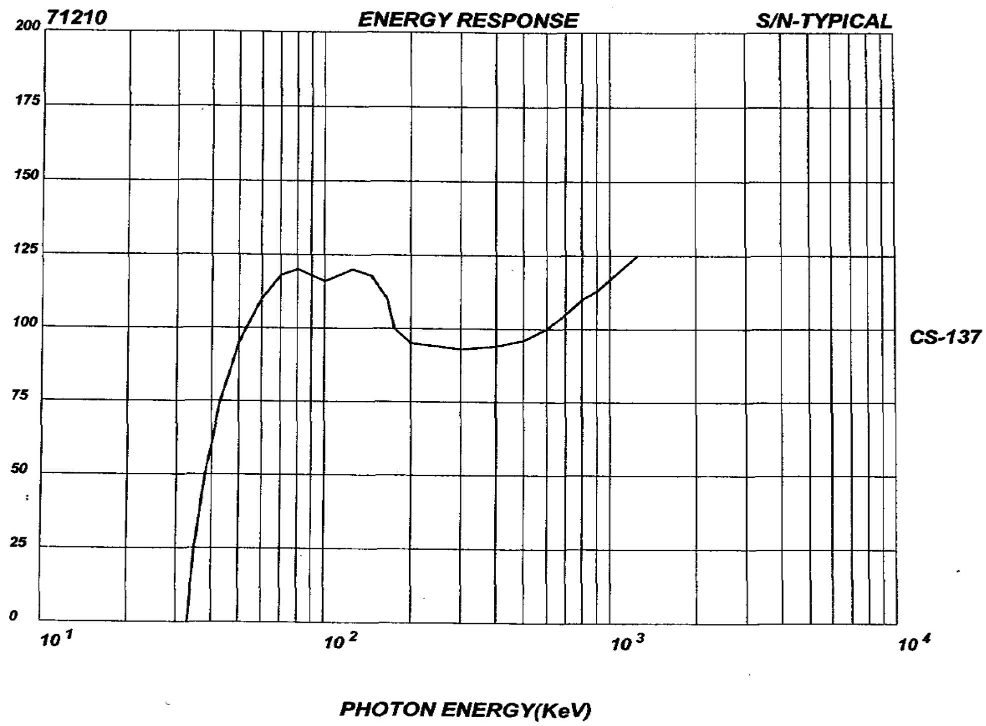


The LND 71210 GM radiation detector responds to x or gamma radiation, but does not respond to alpha or beta radiation. A typical gamma response for this detector is about 1,080 counts per minute per mR/h (Co-60). The full list of specifications for the LND 71210 detector is shown below (from LND web site).

71210 Energy Compensated Gm Detector

GENERAL SPECIFICATIONS	
Gas filling	Ne +Halogen
Cathode material	446 Stainless Steel
Maximum length (inch/mm)	1.82/46.2
Effective length (inch/mm)	1.5/38.1
Maximum diameter (inch/mm)	0.84/21.4
Connector	Pin
Operating temperature range °C	-40 to +75
ELECTRICAL SPECIFICATIONS	
Recommended anode resistor (meg ohm)	4.7
Maximum starting voltage (volts)	350
Recommended operating voltage (volts)	500
Operating voltage range (volts)	450 - 650
Maximum plateau slope (%/100 volts)	6
Minimum dead time (micro sec)	90
Gamma sensitivity Co60 (cps/mr/hr)	18
Tube capacitance (pf)	3
Maximum background shielded 50mm Pb + 3mm Al (cpm)	10
FILTER SPECIFICATIONS	
Material	Sn
Thickness (inch/mm)	0.08/2.0
WALL SPECIFICATIONS	
Areal density (mg/cm^2)	216
Thickness (inch/mm)	0.012/0.30

The LND 71210 energy compensated GM detectors energy response function is relatively flat from about 50 KeV to 1 MeV (see the following graph), making it a good selection for monitoring most nuclear power generated gamma-emitting radionuclides, typical of what might be released during an accident or from a facility planned release.



The detector is also relatively inexpensive and easily replaced if it fails. EFMR routinely checks all installed monitors and replaces any that are not functioning or are showing erratic counting characteristics. Monitors that have shown significant fluctuations outside of what might be considered normal variations in natural background response are inspected and may have the attached dosimeter (if available) read to verify radiation dose. Units that are shown to be problematic are replaced as deemed appropriate by EFMR.

Background Counting Rate

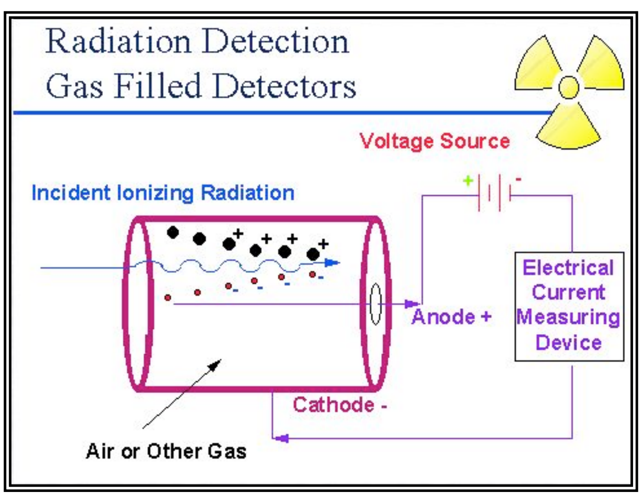
After installation at a host site the background count rate is continuously logged to the internet. Background may vary significantly from location to location and will rise and fall with natural occurring events such as sun spots, the time-of-year, precipitation, and the time-of-day, to name a few. This is routinely observed for all detection systems in most controlled environments, and is especially true for uncontrolled environments. Therefore it is normal to see a moderate rise and fall in background count rate over time. EFMR's trained personnel will review each locations count rate log to determine when a count rate is outside of what might be considered normal background variability.

General Information

Ionizing Radiation

Ionizing radiation of all types comes from many sources both man-made and naturally occurring. The sun, earth, and other galactic bodies produce significant volumes of radiation. The sun sends enormous quantities of visible light and other non-visible electromagnetic waves towards earth every second. Much of this energy is not detectable by typical radiation monitors. Only a narrow band of x and gamma radiation with sufficient energy to penetrate or interact with the 71210 GM tubes internal gas loading or outer wall is capable of triggering an event called a count. Counts resulting from natural occurring events are called background counts. The diagram below shows a typical gas filled radiation detectors operation.

A photon of energy (radiation) enters the detector ionizing the detectors fill gas. The ions formed migrate to the cathode or anode of the detector producing a current flow which is measured by a current measuring circuit. The amount of current produced is proportional to the amount of radiation that the detector sees. Because ions are produced the radiation is called ionizing radiation.

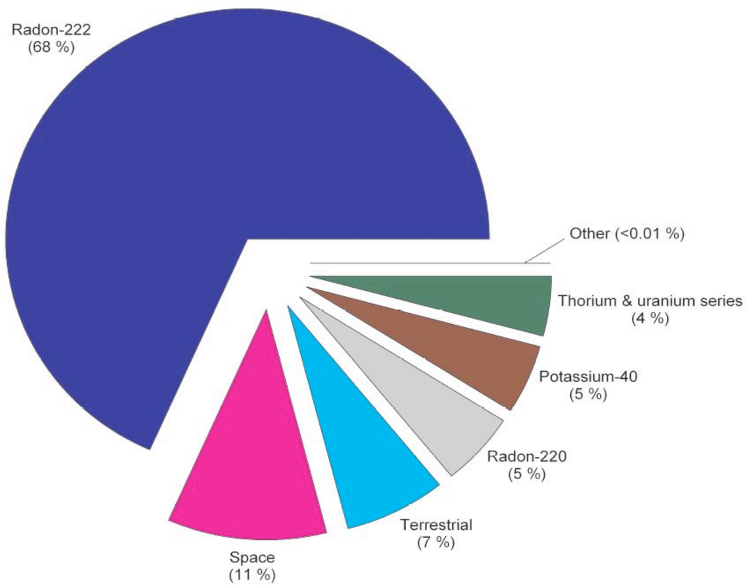


(From the Online Radiology Physics Courses - http://theonlinelearningcenter.com/catalog/default.aspx)

An ion is an atom or molecule in which the total number of electrons is not equal to the total number of protons, giving the atom a net positive or negative electrical charge. Ionizing radiation produces ions in living tissue as well as gases, and therefore can produce direct damage to cells or initiate the formation of free radicals. Free radicals are atoms or groups of atoms with an odd (unpaired) number of electrons. The damage produced directly and by free radicals is believed to be proportional to the amount of radiation received. The term dose is used to describe the amount of radiation any biological material has received over time.

Natural Background Radiation

Background radiation originates from several sources as reported by the US EPA in the following pie chart.



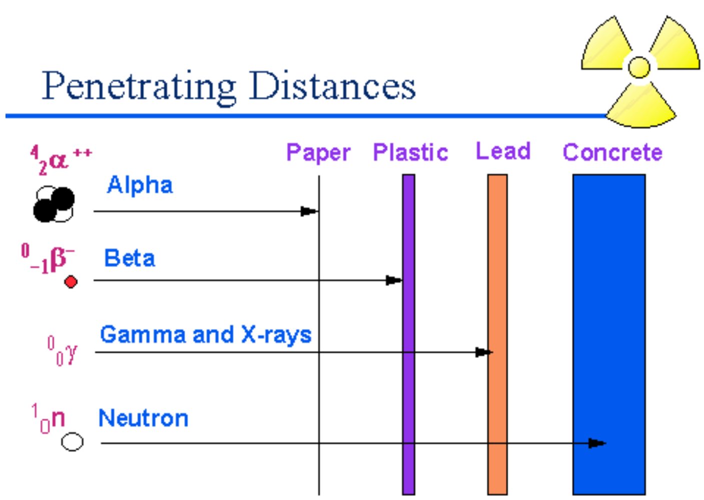
Natural background radiation originates from the earth and any material or living thing present on the earth. It is also a product of the cosmos. The total collective of all natural occurring radiation constitutes a cross section of the electromagnetic spectrum. As humans on earth we live and work in this sea of electromagnetic radiation. The ST-10's GM detector reacts primarily to the x or gamma radiation component found in this energy spectrum.

Background radiation in the United States delivers about 300 mrem per year to a typical individual. At higher elevations the dose would be somewhat above this value. In other areas the yearly background radiation dose might be slightly lower. As a crude estimate an ST-10 radiation monitor might be expected to yield a background count rate of about 40 cpm from a background of 300 mrem per year. However, some of this energy is outside the sensitive region of the ST-10's GM tube. A more common observable background count rate value for this detector is about 15 cpm with significant variation.

Radiation Types

There is a number of radiation types produced at nuclear facilities, but the predominant ones are alpha, beta, x and gamma radiation, and neutrons. An alpha radiation particle is the nucleus of the helium atom. It is composed of two neutrons and two protons. Because this is a relatively large particle it has trouble passing through even thin membranes. Therefore, it only takes a thin piece of paper to stop this type of radiation. Beta radiation is smaller particles (electrons), and it takes a thickness of about one centimeter of plastic to shield this type of radiation. The ST-10 is not sensitive to these two types of radiations. X and gamma radiation are packets of energy and can pass through a significant amount of dense material before being stopped. The ST-10 radiation monitor can detect these two types of radiations. Neutron radiation is a particle with no charge and therefore can penetrate significant thicknesses of all types of material. Water based compounds are mainly used to shield this type of radiation. Neutrons are found in the core of reactors and are not released during most accidents that happen at these facilities unless there is both core damage and complete loss of containment. While it is possible to see beta radiation released during an accident it is not common to see alpha or neutron radiation released under typical accident scenarios.

The diagram below depicts the penetrating power of the four types of radiation described above.

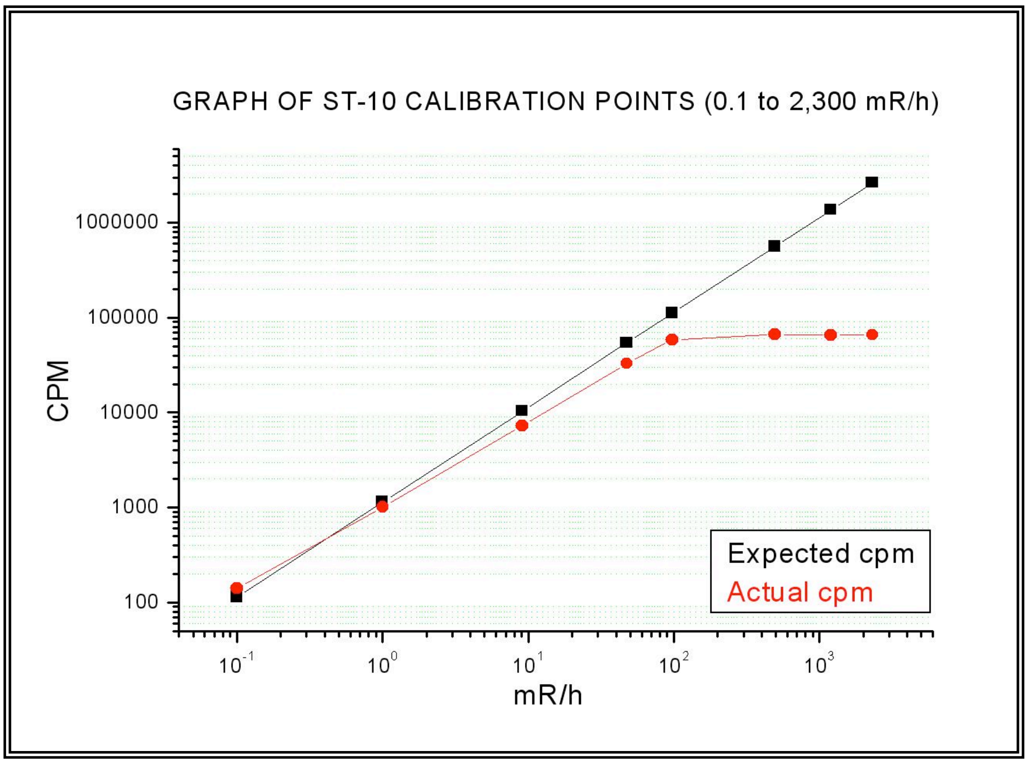


(From the Online Radiology Physics Courses - http://theonlinelearningcenter.com/catalog/default.aspx)

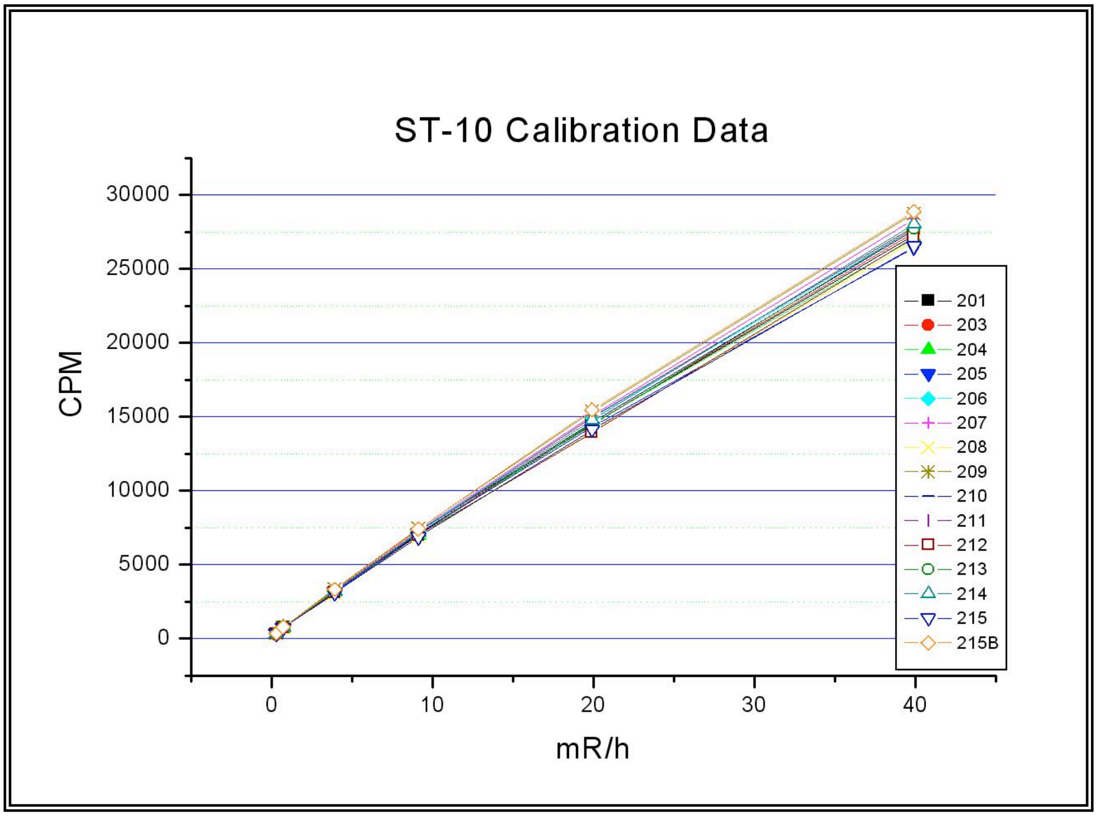
Routine Maintenance and Repair

Calibrations

All ST-10 radiation monitors are calibrated before being placed into operation at host/volunteer sites. After placement (at yearly intervals) the units are pulled from service and sent for re-calibration, or they are replaced with another ST-10 unit that has a current calibration sticker. Calibrations are performed by fully accredited calibration facilities chosen by EFMR. At these calibration facilities the units are exposed to known levels of Cs-137 generated radiation, from about 1 mR/h to about 40 mR/h. Calibration curves are then generated for each unit in terms of cpm per mR/h. The calibration curves below are for several ST-10 monitors. Their response is consistent and similar. The approximate exposure rate for any ST-10 can therefore be estimated from the graph below to ~90 mR/h.



Calibration results for a group of ST-10 radiation monitors are shown in the following graph. Here, fifteen different units are calibrated and the results are then graphed. While differences are expected between individual units, in general there is only about a 10% difference in count rate between the lowest responding and highest responding ST-10 monitors (see following graph). It is expected that additional units other than the ones shown below, will provide similar results.



Problem Identification

When any ST-10 unit has been identified as having a problem, EFMR will remove and/or replace the unit with another ST-10. This is done strictly at the discretion of EFMR who will determine when these units need to be replaced. As a first response, EFMR will call a host/volunteer and request a time when the unit can be serviced. Servicing will include a check to see if all cable and power supplies are attached properly. It may also include a source check to determine if the unit is responding properly to radiation. Units are usually removed from service for one of the following reasons:

1. No response
2. Erratic background readings well above what might be expected from typical statistical background fluctuations.
3. Host/volunteer request.
4. Physical damage requiring repair.

Emergency Response

While it is hoped that there is no need to respond to emergency situations regarding a nuclear facility, at times this is a necessity. EFMR will investigate all unusually elevated readings from any unit at any time when required by circumstances. EFMR maintains fully calibrated portable radiation monitors that can be used by EFMR personnel to evaluate an actual or perceived radiation related event. Typically this does not happen unless there is an ST-10 reading the equivalent of 30 mR/h in counts per minute (or about 21,000 cpm). However, EFMR reserves the right to evaluate any radiation related count rate for any reason at any time.

TLD Care

Thermal Luminescent Dosimeter’s (TLD’s) or Optically Stimulated Dosimeter’s (OSD’s), when deployed along with an ST-10, will be in a water resistant bag/container attached to the ST-10. These units are read out at the time of re-calibration or replacement of the ST-10 unit they are attached to, and at other times as determined by EFMR. Dosimeters should remain attached to the ST-10 while at the host/volunteer site. Dosimeters should not be exposed to direct sunlight for extended periods and should not be made wet. Avoid splashing cleaning fluids or water on the dosimeter cover bag. Do not remove the dosimeter from its protective cover. Lost or damaged dosimeters should be reported to EFMR as soon as possible.

Appendix - Technical Specifications and Parts Listing

Technical Printouts of ST-10 Parts

LND GM Tube 71210 Drawing and Electrical Specification