IAEA
International Atomic Energy Agency

LESSON 2:

BASIC CONCEPTS OF WORKPLACE MONITORING – PART 2

Lesson 2: Basic Concepts - II

- Survey instruments
  - Selection
  - Calibration and Testing
- General Considerations for all Measurements
- Factors which will influence results
- Recording the Monitoring Results
- Check List to Pickup Proper Monitoring Equipment
- The Measurement Process
- Quality Assurance

CHOICE OF INSTRUMENTS

Selection of Instruments

There are 4 specialists who should be involved in instrument selection:

- The qualified expert.
- The person who is responsible for maintenance, repair and testing of the equipment.
- An administrator, to ensure that an appropriate contract is put in place with the supplier.
- A representative from the monitoring staff, with a wide practical experience of radiation protection measurements.

Choice of Instruments

1

Factors which affect the choice of radiation monitoring instruments for any particular application include:

- The types of radiation to be measured.
- Dose, dose equivalent rate or contamination measurements.
- Expected energy range of radiations present.
- Best available detection efficiency for radionuclide(s) of concern, based on fingerprint
- Required indication (units).
- Sensitivity and range of measurements required.

Choice of Instruments

2

- Whether an instrument can perform more than one function or if more than one instrument is required
- Indication goes high or off scale if over ranged.
- Possible interfering radiations present.
- The potential for the presence of very high dose rates or contamination levels.
- The speed with which an instrument responds.
- Logarithmic/linear analogue scales or digital displays and ease of use.
- Illuminated display and/or audible output.

Choice of Instruments

3

- Influence of ambient temperatures, humidity, radio-frequency radiation, magnetic fields, etc.
- Safety in explosive/flammable locations.
- Ease of decontamination
- Battery availability and life expectancy
- Size, weight and portability
- Ruggedness, reliability and serviceability
- Human factors, handle design, switches, etc.
- Training requirements for users

Choice of Instruments

4

- Access requirements, and ease of installation or maintenance for installed equipment.
- Installed or hand held equipment.
- Ability to network and remote readout.
- Availability of spare parts.
- Initial and ongoing maintenance cost.
- Access to a country supplier representative.
- Good technical support services.
- Warranties and delivery times.

TYPE TEST

Type Test

A workplace monitoring instrument is required to be type tested to demonstrate its suitability.

Type tests are intended to determine the characteristics of a particular type or model of an instrument under a series of irradiation and storage conditions.

It is generally carried out by manufacturer of instruments.

Type Test

Involves extensive testing to determine the radiological performance (e.g. response, linearity, energy dependence, angular dependence etc.) and the environmental, electrical and mechanical performance.

The knowledge of the instrument characteristics is the basis for the choice of a suitable instrument to be used in a specific radiation condition.

CALIBRATION AND TESTING

Calibration

Calibration is a process of comparing an instrument indication with the true value of the quantity of interest.

Workplace monitoring instruments used for external exposure should be calibrated in terms of the operational quantities $H^*(10)$ and $H'(0.07,\Omega)$.

Sources and dose rates employed should be traceable to a National Standards Laboratory.

For contamination monitors, a calibrated response should be provided to the user to convert the reading to surface activity.

Calibration

The quantities and units used in calibration should, wherever possible, conform to the current recommendations of the ICRU. IAEA Safety Report Series No. 16 gives clear guidance on the calibration procedures.

Calibration confirms the instrument is operating as expected by the types test and should be conducted prior to use, at a frequency typically required by regulation, e.g. annually, and after repair.

A sticker should be attached to the instrument to indicate its calibration validity and a calibration certificate should be retained

IEC Standards for Workplace Monitoring Instruments

IEC 60532:2010 – applicable to dose rate meters

IEC 60846-1:2009 – specify the design requirement and performance characteristics of dose rate meters

IEC 60846-2:2007 – applies to portable radiation monitors

IEC 61005:2003 - Specifies requirements for the performance characteristics of neutron ambient dose equivalent (rate) meters.

Testing

- The function test verifies that the instrument is still performing as expected
  - Test is conducted at regular, short intervals by the user, for example before each use
    - The frequency should be defined
  - Includes a set of simple on plant tests which looks for major problems
    - Includes physical inspection of the instrument, zero, battery, background and source checking
- Instruments which fail testing should be identified and removed from service

GENERAL CONSIDERATIONS FOR ALL MEASUREMENTS

General considerations for all measurements

- Instrument should be appropriate for the type, energy and intensity of radiation and for the quantity of interest.
- Check there is a valid calibration and test certificate.
- Perform the appropriate function checks on required ranges using appropriate sources
- Instrument should be appropriate for the type, energy and intensity of radiation and for the quantity of interest.

General considerations for all measurements

- Orient the instrument correctly

- Choose correct range – usually low
  - When entering known high dose rates, operator doses may be reduced by selecting a dose rate range that will reduce the overall time to make the measurement

- Be aware of time constants.
  - Allow correct time for instrument to respond do dose rate before moving to next measurement

General considerations for all measurements

If an audible output is provided, use it to give an instant indication, particularly of hotspots and narrow beams.

Consider whether alarms could be useful. If so, set to the appropriate levels.

Protect or allow user modification.

General considerations for all measurements

Believe the instrument reading. Do not assume it is an instrument problem.

If the indication is not what is expected, consider leaving the area. A lower indication than expected or a zero may be caused by instrument failure.

If the indication is significantly higher than expected, leave the area. This applies particularly if an instrument goes into overload.

General considerations for all measurements

For dose rate measurements, go no closer than 3 detector dimensions to the source (due to inverse square law requirement).

Be aware of narrow beams from shielded sources.

A detector will average through its sensitive volume and the indication from a large area detector may underestimate the dose rate in the beam.

Always seek to minimise personal dose/contamination.

General considerations for all measurements

- Consider whether the source may be pulsed.
  - Pulse counting equipment, such as a Geiger-Mueller (GM) based unit, generally under-reads when the count rate from the detector exceeds 30% of the pulse repetition frequency.
- Be aware of any environmental aspects - rapid changes of temperature, high humidity, high electromagnetic and electrostatic fields.
- Consider dynamic ranges.
- If not using instrument for a long time, remove batteries.

General considerations for all measurements

Be aware of any personal dangers in the area to be monitored.

- Be sure that the monitoring equipment is suitable when these are taken into account.
- For example, telescopic or long reach instruments can be dangerous if used in areas where there are exposed electrical conductors.
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General considerations for all measurements

Be aware of any potential problems with the area to be monitored which could cause damage to the equipment such as the presence of spikes which could penetrate detector windows, or contamination of contamination monitors.

Make sure you have a means to record results with you.

- Do not record zeros or background, record the reading.
- Record any relevant conditions (e.g. power level, dusty conditions) where this might affect results.

General considerations for all measurements

For installed equipment, the appropriate location will have to be chosen with care to reflect occupancy and the sources of dose rate or activity. Cabling and services will have to be provided.

For portable equipment, monitoring points may well have been identified. Be sure you know where they all are.

Factors which will influence the final results

1. Instrument reading
2. Background correction
3. Fingerprint and its application
4. Calibration factor, either obtained directly during the process of calibration or derived from that data combined with other information on nuclide, energy, etc.

Factors which will influence the final results

5. Source efficiency - rate of the emission of particles from the surface being monitored to the rate of generation of that particular particle (including geometry and self absorption)

6. For wipe counting, the removal factor and the area wiped.

7. Conversion to the quantity of interest, if necessary.

8. Other influence quantities (temperature, pressure).

RECORDING THE MONITORING RESULTS

Recording the monitoring results

The records should contain following details:

Where?

The location of the monitoring points, described clearly and unambiguously.

When?

When the monitoring took place.

Recording the monitoring results

The records should contain following details:

Who?

Who performed the measurements.

With What?

Which type of monitoring instrument was used, including serial number, the date of calibration of the equipment and confirmation that the equipment was in an adequate condition for use.

Recording the monitoring results

The records should contain following details:

How?

How that piece of equipment was employed; Any work procedure followed;

How much?

The actual measured value of the dose rate or contamination level, including the measurement quantity (do not record “background” or “zero”).

CHECKLIST TO CHOOSE A PROPER MONITORING INSTRUMENT

Checklist to choose a proper monitoring instrument

- Does it have a valid test certificate ?
- Does it look to be in working order ?
  - Is there, for example, obvious damage to cable or connectors ?
- Is the battery good enough to last out the work period? ?

Checklist to choose a proper monitoring instrument

- Is the background count rate believable ?
  - Does the count rate change when the cable between probe and rate meter is flexed ?
- Use the appropriate check source for functional test !
- What to do if the Instrument appears faulty ?
  - A user should know whom to approach to rectify the instrument, where it should be kept and how it should be labeled !

Checklist to choose a proper monitoring instrument

Where ?

Where each monitoring point or area is and how to identify it

Where ?

The frequency at which the monitoring should be carried out. This could be task based or time based.

THE MEASUREMENT PROCESS

The measurement process

This should cover:

- The reference direction
- How to check battery and select range
- Use of any audio output (clicker or alarm)
- For contamination monitoring, the correct distance between probe and surface and how to maintain it safely

The measurement process

- How to take the measurement, considering the time constant of the instrument and how long to average the indication for
  - This should also cover the interpretation of logarithmic scales.
  - How to use collection media and preserve it.
- Where and how to record the data.
- How to respond to any unusual values.

The measurement process

How to identify environmental conditions which might cause instrument problems ?

- High electromagnetic, electrostatic and magnetic fields can cause high count rates or the instrument may fail.
- Very bright lights can cause spurious count rates.
- Cold instruments into warm, damp environments can cause condensation, giving spurious high dose rates with ionisation chamber instruments.

The measurement process

Maintenance by the User

- This could include zero setting, battery changing, cleaning and checking.

Modifications

- Do not perform unauthorized modifications on instruments.
- If modifications are required, talk to the manufacturer.
- Re-calibrate any instrument following modification.

The measurement process

Precautions

1. Do not swing probes by the cable.
2. Avoid getting instruments damp.
3. Take care of instruments.
   - Transport to avoid damage.
   - Avoid damaging or contaminating.
4. Do not inhibit or adjust alarms unless authorized.

QUALITY ASSURANCE

Quality Assurance

Quality assurance, QA, is a process designed to give confidence in the quality of measurements and to promote feedback leading to an increase in the quality in the widest sense.

The nature and extent of the QA programme should be consistent with the number of workers potentially exposed and the level of that exposure.

All persons involved in the monitoring programme are responsible, to some degree, for implementing quality control (QC) procedures.

Overall responsibility should be given to an identified individual.

Management should motivate staff to detect, report and correct problems.

Record and control software versions.