The Development And Implementation Of A System To Accredit Ionising Radiation Instrumentation Specialists.

J McClure, Health Protection Agency, Centre for Chemical, Radiological and Environmental Hazards, Chilton, Didcot, Oxfordshire. OX11 0RQ

Abstract

The United Kingdom's National Physical Laboratory's Ionising Radiation Metrology Forum has developed a new certificate for an Ionising Radiation Instrumentation Specialist (IRIS) under the Radiation Protection Advisers 2000 aegis. This was not intended to supplant the recognised role of the qualified person. It was designed for those involved in ionising radiation instrumentation who wished to demonstrate an advanced level of expertise and competence. An IRIS is expected to demonstrate significant expertise in monitoring methods, instrument limitations, calibration requirements and facilities, setting up of instruments and the provision of advice to the employer and Radiation Protection Adviser (RPA). Following the model of the RPA accreditation process, assessment is via a portfolio covering both theory and practice.

Evidence is required of a basic underpinning knowledge across a wide range of topics such as:

- Basic atomic and nuclear physics
- Interaction of radiation with matter
- Practical radiation fields
- International guidance requirements
- Signal processing and display
- Power supplies
- Understanding the effect the environment can have for both for calibration and routine operation

In addition demonstration of a more detailed understanding is required in the following areas:

- Statutory requirements relating to the selection use, maintenance or testing of Radiation instrumentation
- UK guidance pertaining to instrument calibration
- Measurement quantities and units
- Principles of operation of detector systems
- Types of facility and their essential attributes including traceability to National standards
- Typical instrument problems
- Detection and measurement and best monitoring methods

Finally evidence must be provided that demonstrates the use of a detailed understanding of the following areas and the practical implementation of this understanding in day to day workplace situations.

1. Introduction

In 2006 the Society for Radiological Protection's Qualifications and Professional Standards Committee issued a call, via the Society for Radiological Protection's (SRP) newsletter, for people working in areas relating to Radiation Protection that would be interested in developing specialist certificates. In the early days of Radiation Protection Advisor (RPA) 2000 a specialist certificate had been awarded in the field of radiation instrumentation, but this had been suspended in order for RPA 2000 to commit maximum effort to accredit core RPA's before the ending of grandfather rights in 2005. This was discussed at a meeting of the Ionising Radiation Metrology Forum where a large number of members expressed an interest in applying for an instrumentation specialist certificate if one were available.

The SRP's Qualifications and Professional Standards Committee were happy to provide advice and support in the development of the specialist certificate, but made it clear that the technical content and assessment would be the responsibility of the specialist instrumentation community. It was decided that the certificate would be aimed at those involved in ionising radiation instrumentation who wished to demonstrate an advanced level of expertise and competence. An Ionising Radiation Instrumentation Specialist would be expected to demonstrate significant expertise in monitoring methods, instrument limitations, calibration requirements and facilities, setting up of instruments and the provision of advice to the employer and Radiation Protection Adviser (RPA). Following the model of the RPA accreditation process, assessment would be via a portfolio covering both theory and practice.

2. Role of the Ionising Radiation Instrumentation Specialist

Following further deliberation by the IRMF it was agreed that the accreditation would be applicable to someone whose knowledge exceeded that which would be required for a QP and was capable of a more advisory role on selection and use of equipment, rather than only being competent to determine whether it was working correctly or not. At this level an accredited individual would be able to provide definitive advice to RPA's in their role relating to guidance on instrumentation. In addition a Specialist certificate in ionising radiological instrumentation was considered to be a useful part of the career progression of someone who had been involved in instrument testing and had gained a real knowledge of the use of instruments in practice. This would give them something to aspire to, which would be good for their career development and would give extra confidence in those for whom they give advice.

Following these principles the role of an Ionising Radiological Instrumentation Specialist was defined as the following:

- Possessing an in-depth knowledge of how a wide range of instruments work and likely modes of failure.
- The ability to define an appropriate set of tests that will identify any shortcomings in the response of the selected instrument for its intended use.
- Understanding the limitations associated with different instruments and advising on the monitoring techniques that could be used to minimise the effect of these limitations
- The ability to interpret Type Test data to advise the RPA/employer on appropriate instrument selection
- Having the knowledge to advise on implications of instrument failure or inappropriate selection
- Understanding the levels of uncertainty associated with any measurement made considering many elements such as the uncertainty due to its calibration in a reference field, the uncertainty due to the instrument reading and the problems of making measurements in a practical field.

3. Required knowledge and experience

The same structure and definitions of the levels of understanding as detailed in the RPA 2000 accreditation process were applied with the exception of one new level of practical competence. The various levels of understanding and competence are defined as follows:

General Awareness. Knows that the topic exists and is aware of its significance to work activities in context. Also knows how and where to obtain help on the topic if needed.

Basic Understanding. Has a basic understanding of the topic with a level of detail that allows the IRIS to apply it to familiar work activities in context. If necessary, can research further knowledge using readily available sources and apply it in less familiar circumstances.

Detailed Understanding. Has a good understanding of the topic and the underlying principles and can apply the knowledge in appropriate contexts. Can apply the knowledge working from basic principles to deal with instrumentation and monitoring issues in new or unfamiliar areas and can identify issues arising from its application.

Practical Competence. Has a good understanding of the topic and the underlying principles and has applied the knowledge in appropriate contexts. Has applied the knowledge working from basic principles to deal with instrumentation and monitoring issues in new or unfamiliar areas and has identify issues arising from its application.

An initial set of required knowledge and competencies were proposed by the IRIS working group and six members of the IRMF from a wide range of backgrounds, such as hospitals, universities and calibration laboratories, submitted portfolios and were assessed against the proposed criteria. It soon became evident that the knowledge and competencies originally proposed were targeted to a narrow area of the radiation protection instrumentation community, primarily because the experience of the members of the IRIS working group had been gained in similar working backgrounds .The working group was therefore expanded and the required knowledge and competencies reviewed. Tables 1, 2 and 3 detail the final requirements for accreditation as an Ionising Radiation Instrumentation Specialist.

Table 1.Basic Underpinning Knowledge Syllabus for Ionising Radiation Instrumentation Specialists

Areas	**Level required**
Basic atomic and nuclear physics	**BU**
Interaction of radiation with matter	**BU**
Practical radiation fields: - Spectra emitted from various source types - Change in energy of scattered radiation - Change in energy of attenuated radiation - Generation of Bremsstrahlung radiation - P factor for contamination	**BU**
International guidance requirements: - ISO 4037 - Others relevant to work area	 **GA** **GA**
Signal processing and display	**BU**
Power supplies: - Batteries - Mains supplies - Internal instrument supplies generating high voltages	**BU**
Understanding the effect the environment can have for both calibration and routine operation - Temperature - Pressure - Humidity - Radon - EMC - Vibration and impact - Bright light - Magnetic fields - Pulsed fields	**BU**
Record keeping (certificates, sources etc)	**GA**
Quality control/ auditing	**GA**

Transport of radioactive materials	**GA**

Table 2.Detailed understanding Syllabus for Ionising Radiation Instrumentation Specialists

DU topic area	Elements of the competence required of an IRIS	Advisory and additional notes for the applicant
1. Statutory requirements: IRR99 regulation 19 or current regulation dealing with the selection use, maintenance or testing of Radiation instrumentation.	Fully conversant with IRR 99 reg 19 and the relevant parts of the ACOP and guidance.	Demonstrate an understanding of the roles and responsibilities of the employer, RPA and QP as detailed in IRR 99. Demonstrate an understanding of the regulations regarding the testing and calibration of ionising radiation instrumentation.
2. UK guidance: Relevant current NPL Good Practice guides eg. Good Practice Guide 29 - The Examination, Testing and Calibration of Installed Radiological Protection Instrumentation.	Demonstrate understanding of relevant Good Practice Guides and HSE guidance from the Ionising Radiation Protection Series.	Demonstrate an understanding of the contents of Good Practice Guides(GPG) relevant to your area of work and detail how the guidance is implemented. For example define a test plan that satisfies the requirements of a GPG. State which GPGs are relevant to your work area and why.
3. Quantities and Units: - Primary Physical quantities. - Limit quantities - Operational quantities. - Activity (per unit area, per unit volume, per unit mass).	Knowledge of: Fluence, air kerma, absorbed dose, ambient, directional, personal and effective dose equivalents. Activity, activity per unit area, activity per unit volume and activity per unit mass.	Demonstrate an understanding of all listed quantities and describe how they are derived. Also describe which quantity is the most appropriate for making a measurement for a variety of radiations and situations.

4. Principles of operation: - **Ion chambers.** - **Proportional counters.** - **GM detectors.** - **Scintillators.** - **Solid state detectors.**	Detailed Understanding of: 4.1 Ion chambers. 4.2 Proportional counters. 4.3 GM detectors. 4.4 Scintillators. 4.5 Solid state detectors.	• Ion chambers: - Current generating mechanism, including recombination, relationship between physical construction materials and the relevant measurement quantities. - Effect of volume of the chamber and the typical currents generated. Insulator requirements. - Why temperature and pressure affect the indication. - Why suitable for pulsed fields. • Proportional counters: - Basic physics of the device, including the electric field and why the output is proportional. - Why the different types are shaped as they are. - The effect of gas quality and the properties of different types. - The relationship between gain and the HV. - Consideration of gamma dose rate types. - Proportional counters in neutron detectors considering gas filling, mechanisms, gamma rejection, energy dependence and the use of moderators. • GM detectors: - Basic physics of the device, including the electric field how the discharge is spread including reference to fill gases, quencher and detector pressure. - Typical construction materials. - What happens at high count rates and why some GM's fail to danger. - Why an uncompensated GM has the observed photon dose rate response and how compensation filters work for both steel walled and end window types. • Scintillation detectors: - Method of operation e.g. how the light is generated. - What makes a scintillant more appropriate for a particular application? - Common scintillant materials. - How a photomultiplier works and the affect of a magnetic field. - What happens if the detector has a light leak.
		• Solid state detectors: - The concept of a diode and the depletion layer. - Magnitude of charge collection and comparison to gas filled detectors. - Use in spectrometry, swab counters, alpha in air monitors and personal dosemeters.

5. Detection and Measurement Monitoring methods.	A detailed understanding of : 5.1 The limitations associated with different instruments; and 5.2 The associated monitoring techniques that can be utilised in order to mitigate for any less desirable instrument characteristics.	Provide one or more items of written work to demonstrate a detailed understanding of the limitations concerned with making a measurement using ionising radiation instrumentation. Your evidence is likely to consider at least some of the following: • Determining the average indication and describing the technique used, including consideration of statistical independent readings, the response time of the instrument, its averaging time and the influence of detector sensitivity and the magnitude of the dose rate or level of contamination being measured. • Statistical dependence on the number of counts collected. • Speed of monitoring. • Limits of detection. • Maximum missable activity. • Minimum detectable activity. • Narrow beams or hot spots. • Averaging area, scattered radiations.

6. Calibration facilities: - **Traceability to National standards** **Types of facility# and their essential attributes:** - **Gamma dose rate** - **X-ray** - **Beta dose rate** - **Neutron dose rate** - **Surface contamination** **# A Detailed Understanding of at least one type of calibration facility is required. This should be described in detail.**	A thorough understanding of: 6.1 Traceability. 6.2 Levels of uncertainty associated with the establishment of the calibration reference field. 6.3 How this relates to the final instrument response figure derived. 6.4 Essential attributes of at least one type of calibration facility.	Provide one or more items of written work to demonstrate a detailed understanding of calibration facilities. Your evidence should include the following: • Understanding of how to demonstrate an unbroken chain of calibration to show traceability to National Standards. • Assessment of uncertainty budget relating calibration field uncertainty to National standards. This may include contributions from: - Transfer standard. - Room Scatter. - Set up distance. - Temperature. - Pressure. • Followed by assessment of uncertainty in final response figure calculated for instrument under test / use in the field for a number of different types of instruments. This may include contributions from: - True dose rate. - Monitor reading. - Background reading. - Parallax. - Beam non-uniformity. • State the type of calibration facility for which understanding is detailed. ie. Gamma, X-ray, contamination. Discuss the relevant essential attributes, for example: - Production of known field. - Collimation. - Scatter. - Build-up. - Positioning. - Uniformity.

7. Typical Instrument problems	The sound ability to: 7.1 Identify common modes of failure; and 7.2 Describe the effect that the failure has on the use of the instrument. 7.3 Define the required scope of test after repair.	Provide one or more items of written work to demonstrate a detailed understanding of typical instrument problems. Your evidence is likely to consider at least some of the following: • Light leaks. • Punctured detectors. • Aged or damaged scintillators. • Battery failure/contacts. • Cable damage. • Damaged meters and displays. • User maladjustment. Detail how the following repairs are likely to impact on an instrument's response and what are the minimum tests that should be performed in order to assess this. • Re-foiling of a scintillator. • Replacement of a GM detector. • Replacement of a PM tube. • Replacement of cables.

Table 3. Practical competencies for Ionising Radiation Instrumentation Specialists

Extended description of the Practical Competence area	Elements of the competence required of an IRIS	Advisory and additional notes for the applicant
1. Setting up instruments - Energy thresholds - HT - Dead time - Overload current - Averaging times - Alarms	Understanding the principles of setting up a range of instrument types.	***Provide one or more items of suitable evidence from your work to demonstrate competence. Competence is likely to be demonstrated if your evidence addresses a number of the following situations:*** (a) Setting of appropriate energy thresholds dependant on detector and proposed use. (b) Establishment of appropriate HT setting according to type of detector and proposed use. (c) Evaluation and application of detector dead time. (d) Setting appropriate overload current. (e) Setting appropriate integration time or time constant. (f) Setting appropriate alarm levels.

2. Advising the employer - Advise on instrument selection - Clear account of why an instrument has failed - Advise on the implications of failure if the instrument was used - Explanation of varying indications from different types of instrumentation	Comprehensive advice on appropriate instrument selection	***Provide one or more items of suitable evidence from your work to demonstrate competence. Competence is likely to be demonstrated if your evidence addresses the following situations:*** (a) Practical interpretation of type test data to demonstrate that the instrumentation is radiologically fit for purpose. (b) Consideration of non-radiological issues such as: - Maintenance costs and availability of spares (Batteries, foils etc). - Suitability for the environment (Robustness, EMC, weather etc). - Ergonomically suitable for the user (Clarity of display, Weight, single or dual handed etc). (c) An example(s) of the practical provision of such advice.

4. Benefits observed within the HPA following the introduction of the IRIS cetificate

The IRIS certificate was formally accepted by the RPA 2000 board in 2011 and seven assessors simultaneously appointed. The benefits of having a target to achieve specialist certification have been apparent across the instrumentation laboratories of the Health Protection Agency. We have already developed modules for each of the required knowledge areas at a range of levels and these modules are available to HPA staff at all three laboratory sites. This has enabled structured and consistent training of less experienced members of staff. It has also highlighted the need to ensure that, when the more challenging or unusual monitoring scenarios or instrument set-ups are required, experienced members of staff use these opportunities to train personnel. This ensures continued staff development and address the potential skills shortage that could occur if succession planning is not addressed within the industry over the coming years. Having a well defined set of expectations for an Ionising Radiation Instrumentation Specialist has also lead to the development within the HPA of a list of knowledge and experience requirements for the appointment of a person as a Qualified Person. This had been an ill defined area in the past as a result of there being no defined criteria for the appointment of a qualified person as defined in the Ionising Radiation Regulations.

5. Acknowledgements.

The author would like to acknowledge the valuable assistance of D.R. McClure, Health Protection Agency, D.J. Gallacher, Guy’s and St.Thomas NHS foundation trust, P. Deacon-Smith, Guy’s and St.Thomas NHS foundation trust, D.E. Delahunty, RRPPS university hospital Birmingham NHS trust, Dr R. Mooney, RPS Forster Green hospital, Belfast, S. Threadingham, DSTL Alverstoke, P.H. Burges, Nuvia Ltd, C. Lee, NPL and all members of the QPSC and RPA 2000 board.