Experience with Nuclear Inspector Training at JRC, Ispra
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Abstract
About 500 nuclear safeguards inspectors are working at the IAEA, EURATOM and as
national inspectors in Europe. Up to 50 of them are recruited every year and need training
for their new work, comprising all its aspects. A higher number of inspectors need
refreshment courses or introductions into new working fields. Moreover, new instruments
or techniques require special training, in class, laboratory or in field. This presentation is
based mainly on experience with laboratory courses on nuclear measurements for the
verification of nuclear material.

Introduction
More than 1050 trainees have followed nuclear inspector training courses at the Ispra site
of the Joint Research Centre of the EU within more than 20 years. These were mainly
laboratory courses and they are based on the infrastructure of the nuclear laboratory
PERLA, the non-nuclear laboratories TAME and Seals Lab. The training is embedded in
the R&D work of the JRC for nuclear safeguards and security and the direct support to
EURATOM, IAEA and EU member states, and the experienced staff doing this work is
also acting as trainers for nuclear and non-nuclear work.

A. Aim of nuclear safeguards inspector training
The main aim of training for new inspectors is to give insight into the safeguards system
as a whole, i.e. the historical, political and legal frame, the nuclear fuel cycle and nuclear
material. Inevitably they have to learn about the rules for inspectors, safety at work,
radiation protection, etc. They must understand nuclear safeguards as a system of many
elements such as
- owner declarations
- verification measurements
- bookkeeping
- statistical data evaluation
- item identity verification
- containment and surveillance
- site verification
- observation of any particularities in the inspection.
They have to become aware of the difference between direct verification methods for nuclear material, such as gamma and neutron radiation as direct proof for the presence of U or Pu and indirect methods as containment and surveillance. Moreover, the training courses have to provide background knowledge on the technical and management system of the whole nuclear fuel cycle.

In the courses on special techniques inspectors have to learn how to apply them and to understand what are their strengths and limitations, e.g. what can be “seen” and what is not visible for gamma or neutron radiation. They need to understand the connections of the specific technique of the running course with the other elements of the safeguards system. The training has to provide inspectors with the practical skills for the methods. They need to be convinced of their capability to decide after a measurement whether an object is in agreement with the owner's declaration or not.

B. Trainees

In respect to the training need we can distinguish three groups:

Newly recruited inspectors
For many different reasons, the newly recruited inspectors cover a broad spectrum of professions and professional experiences. It ranges from dentist to captain (former fishery inspector), from nuclear physicist to administration staff which has changed the position, and it comprises also civil engineers, nuclear engineers and natural scientists.

At the IAEA, the three months ICAS course series aims at giving all newcomers a common basic knowledge for the field of nuclear safeguards. EURATOM does not have this consequent approach.

Experienced inspectors
For this group of trainees, the courses are a possibility to get out of routine and to remind of the principle inspection aims. They may help renewing the motivation. Moreover it is a good occasion to discuss the everyday practice and to increase like this the efficiency and the quality of their work.

Inspectors who change the working field or the instrumentation
Inspectors with new duties should have the occasion to get a profound introduction into the new field. The same holds if new instruments are to be used, maybe in only one special application case.

C. Training types

The following course types are used in the established training schemes for safeguards inspectors:
- Systematic sequence of courses (e.g. IAEA: 14 week ICAS course for newcomers)
- One week laboratory courses on standard methods (e.g. JRC Ispra: Gamma
spectrometry for U and Pu, active and passive neutron measurements)
- In-field training (e.g. use of Čerenkov viewing devices for spent fuel)
- One day training modules in the laboratory at head quarter

There is no ideal course type. A variety of types is required. The course type depends on the kind and the amount of contents, the participants (newcomers or experienced inspectors), the available training location (class, laboratory, in-field), the training means (nuclear material, technical equipment) and the use of training tools (textbooks, presentations, visits).

D. Training course contents

The course contents are defined by the techniques the inspectors have to apply. But it should not be restricted to the mechanical execution of procedures. The aim must also be that the principles of a method are understood. Only on this basis the trainees can learn about the measurement uncertainties and the limitation of the methods which have always to be considered with the perspective of the main inspection task: to verify with a measurement result a declaration on nuclear material. The discussions have to make links to other safeguards means which help to overcome these limitations.

The course contents must adapt to the knowledge level of the trainees in nuclear physics and engineering. This requires a high grade of flexibility of the trainers. Occasionally it is necessary to restrict the contents to very basic elements, otherwise the trainees will not at all profit from a course. Sometimes there are also language problems.

E. General scheme of a course

The courses comprise typically the following elements:

a) Theoretical background, aiming to
- explain the inspection aim with a precise question, e.g.: “Can you confirm that the enrichment of this item is 3.6% as declared by the operator?”,
- explain the verification method and instruments,
- discuss the measurement results, the uncertainties and the answers “Yes” and “No” to the question,
- explain in which place of the nuclear fuel cycle such measurements are performed.

b) Do many practicals with the aim to
- get familiar with the equipment as used by inspectors in field,
- do the set-up of equipment before measurements (repeatedly),
- do many measurements in the wide range of examples.

c) Ask test questions every day.
d) Make a final test:
Practical test:
- verify a declaration,
- do a verification measurement, each inspector alone with one instrument,
- make an inspector decision: “The declaration is correct / not correct.”.
Theoretical test:
- make a multiple choice test concerning the contents of the course
Both practical and theoretical test will be evaluated in a discussion with the whole group.

F. Safeguards Training at JRC, Ispra

A variety of courses with technical character is offered at Ispra:

1. Preparatory course

2. Systematic basic NDA laboratory courses - PERLA:
   - U Enrichment Determination by Gamma Spectrometry
   - Pu Isotopic Composition Determination by Gamma Spectrometry
   - Active Neutron Interrogation
   - Passive Neutron Assay

3. Advanced / special laboratory courses - PERLA
   - Pu Physical Inventory Verification
   - Advanced Hands-on RADAR/CRISP/XSEAT

4. Measurement techniques for liquids - TAME
   - Mass/Volume Methodology
   - Solution Monitoring Evaluation Systems

5. 3D Laser-based Design Information Verification – 3D laboratory

6. JRC CANDU Sealing System (JCSS)

7. Special instrument courses
   - JRC Waste Drum Monitor
   - AWCC for FRM-II Fuel Element

8. On special request, e.g. for IAEA:
   - Advanced NDA for Experienced Inspectors
   - Pu Diversion Verification

The stress lies on methods for Non-Destructive Assay of nuclear material (NDA) and on containment and surveillance.
The Preparatory course, “NDA basic physics”, is held at the EURATOM headquarter at Luxembourg. It is foreseen mainly for new inspectors. The experience shows that it is necessary to repeat and exercise very basic elements, often there are also problems with calculations.

The four NDA laboratory courses in PERLA are of special importance for the inspectors. They demonstrate clearly the possibility for an inspector to verify with non-destructive methods the presence of nuclear material, its quality and its quantity. Most of the EURATOM inspectors have followed them at the beginning of their inspector service.

The advanced / special laboratory courses in PERLA combine different elements: the “Pu physical inventory verification course” comprises inspection planning, qualitative and quantitative measurements and statistical data evaluation. The “Advanced hands-on RADAR/CRISP/XSEAT course” combines automatic measurement stations, installation of informatics tools, unattended data collection, data evaluation and inspection report. The reaction of course participants proofed that these demanding courses are good for the motivation of experienced inspectors.

Special instrument courses are always changing and often held only one or two times.

As a whole, JRC Ispra offers about 14 sessions per year in total. The schedule and course descriptions are on the internet at http://npns.jrc.ec.europa.eu/web_inspector_v2/01-training_2012.php

JRC offers also Nuclear Security training, training on Destructive Assay methods (DA) and on statistics for safeguards.

G. What is important for training courses?

The experience with many courses allows to point on some elements which are important for successful training.

- Work in a laboratory in a "nuclear" environment. Some trainees enter nearly for the first time a controlled zone.
- Give trainees real nuclear material in the hand so that they get used to handle it practically without being afraid.
- There must be sufficiently many instruments. It is good if two beginners work together with one instrument, an already experienced trainee should have an instrument alone (he might also get additional tasks).
- Trainees profit from working time in the laboratory, it is
  - time to work slowly step by step, but without help,
  - time to look into documents or instructions,
  - time to make errors and to correct them,
  - time to repeat measurements and to make own tests,
  - time for intentionally wrong actions - to learn from mistakes,
  - time for discussion with the trainer (also on "minor" practical problems).
• The course contents must be carefully limited to a certain number of essential details which fit in the available time.
• One trainer is required for two instruments (max. 4 trainees), he needs to have time for discussions and the many laboratory problems.
• The trainers must have experience beyond the narrow field of the running course because there are always questions on other safeguards measurement methods. There are questions on hardware, software, electronics, detectors, measurement errors, the nuclear fuel cycle, diversion scenarios, nuclear weapons, radiation protection, etc.
• Small questionnaires every day, including very simple questions, allow discovering which part of the contents needs to be repeated.
• Training courses should make use of guidelines and user instructions.
• Make a final test: Verify alone a declaration and decide agreement / disagreement.

H. Training modules

The advantage of one week courses is that they cover a field systematically and in detail. The drawback is that the course may not meet exactly the interest of all participants; partially it is a waste of time and resources. An alternative may be to offer also short “training modules”. Such a module was performed in August 2011 and covered only one specific method for the U enrichment measurement. This subject fits in the time of one working day and can be performed with the resources which are available at the EURATOM headquarter at Luxembourg.

Training module on U enrichment measurement with MGAU

<table>
<thead>
<tr>
<th>Place:</th>
<th>DG ENERGY, Luxembourg, gamma laboratory</th>
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</thead>
<tbody>
<tr>
<td>Equipment:</td>
<td>two HRGe detectors plus spectrometer</td>
</tr>
<tr>
<td>Nuclear material:</td>
<td>CBNM LEU samples</td>
</tr>
<tr>
<td>Trainers:</td>
<td>one trainer from Ispra plus the laboratory head of DG ENER</td>
</tr>
<tr>
<td>Duration:</td>
<td>one day</td>
</tr>
<tr>
<td>Method:</td>
<td>MGAU</td>
</tr>
<tr>
<td>Trainees:</td>
<td>four inspectors</td>
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</tbody>
</table>

One day was sufficient to exercise the following tasks:
• Introduction to the one method
• Setup of the chains, also repeatedly,
• Individual discussions,
• Several measurements,
• Final test: Make an inspector’s decision.

The experience from this pilot course in this course format is quite positive.

I. Other training formats

Another potentially interesting and useful training format may be in-field training, e.g. concerning the enrichment measurement on UF₆ drums. These measurements require careful work in a technical environment with much background radiation. The key question is here: Do we find an operator to support and to host such training?

Alternatively, the on-the-job training could be used in a better way. Normally, the newcomer learns from the experienced colleague. Here it would be useful to have a personal contact between a trainee and an experienced trainer who would discuss the foreseen measurement with the trainee and the experienced colleague before they go in mission and to have an evaluation discussion afterwards.

E-learning and PC assistance for inspectors are occasionally considered. These means may be helpful before an inspection mission to repeat what was learned elsewhere. But this repetition may also be done using script from a training course and the guide lines for this inspection type and the user instructions for an instrument. There is also the question: How much working time will be required to develop such electronic training means? For how long will it remain valid? Would it not be better to make this working time directly available to the inspectors by offering them more time of the contact people in the instrument labs at the headquarter? Our experience from many courses is that the discussions with experienced laboratory staff would cover much better the practical problems of measurements, from cable defects over electronics problems to the right software version and instrument setup-data. This kind of support is more useful for inspectors. Moreover, it follows in a natural way the continuous changes with hardware and software and allows easily to include recent experience of other inspectors.

Summary

The work of inspectors in a nuclear installation is complicated due to many rules, restrictions and any kind of disturbances. It is often not easy to make precise technical work under these circumstances. For this reason inspectors need to learn and to repeat the necessary practical skills in practical training. Only with such exercises they can become confident in the results of their inspections.