URENCO Conference on GCEP Safeguards, held in December 2009

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Abstract. URENCO held a conference in Chester, UK from 30 November to 3 December 2009. A total of 77 delegates from 13 countries attended, including operators from eight centrifuge enrichment plants, inspectors from three international safeguards agencies, governments from six countries, scientists from six research organisations and academics from three universities. The aim of the conference was to discuss and influence the future of safeguards in gas centrifuge enrichment plants. All of the key players in this field were present. There were many excellent presentations by distinguished speakers, and there was a high quality of debate during the several working group sessions on the following five themes:

- How to detect production of high enriched uranium
- How to detect undeclared low enriched uranium
- How to detect diversion of declared uranium
- How to strike the right balance between equipment and inspector presence
- How to control access to information and train inspectors

This paper presents the main conclusions of the conference, including: issues where there was agreement across all working groups; issues where there were divided views, and further debate is needed; promising ideas where further work is needed; some safeguards techniques where there was little enthusiasm, and some areas where concerns were expressed.

1. Introduction

URENCO held a conference in Chester, UK from 30 November to 3 December 2009.The aim of the conference was *to discuss and influence the future of safeguards in gas centrifuge enrichment plants* (GCEP's).

Attendance was by invitation only, and URENCO succeeded in getting a balanced representation of all the different interests in the area of GCEP safeguards, with 77 delegates from 13 countries:

- 23 staff from centrifuge enrichment plants (in Brazil, China, France, Germany, Japan, Netherlands, UK and USA)
- 13 staff from international safeguards agencies (ABACC, Euratom and IAEA),
- 20 representing governments (Australia, France, Germany, Netherlands, UK, USA)
- 14 research scientists (from JRC, LANL, NNL, ORNL, PNNL and SRNL)
- 3 university academics (from Glasgow, Princeton and Virginia)
- 3 people from other organisations.

2. Format of the conference

The conference lasted three full days, and included:

- An opening plenary session with four presentations by distinguished speakers, to set the scene.

- Five sessions: one for each of the following themes:
  - How to detect production of high enriched uranium (HEU)
  - How to detect undeclared low enriched uranium (LEU)
  - How to detect diversion of declared uranium
  - How to strike the right balance between equipment and inspector presence
  - How to control access to information and train inspectors.

Each of the five sessions had the same format:
  - Three presentations
  - Discussion in four working groups
  - Feedback by the chairmen of the working groups.

- A summary of conference findings (amplified in sections 3 to 7, below).

- A visit to the URENCO enrichment plant at the nearby Capenhurst site.

The opening presentations and the working group feedback summaries were video-recorded by a URENCO internal TV crew.

The format worked well, in that:
- The presentations were by invited speakers and were of a uniformly high standard. These focussed mainly on policy issues.
- Over half of the time of the conference was spent in workshop discussions where there was a wide range of participation and a high quality of debate.

3. Agreed points

There was general agreement by all working groups on the following points:

- Rigorous *nuclear material accounts* (NMA) systems managed by plant operators and soundly verified by inspectorates are of fundamental importance. The annual *material unaccounted for* (MUF) is determined at the annual *physical inventory verification* (PIV). These activities underpin the whole safeguards regime.

- Swipe sampling is invaluable, but not foolproof. Swipe sampling can detect minute particles of uranic compounds which result from miniscule amounts of UF6 gas emanating from a GCEP in normal operation. Therefore swipe sampling can potentially detect the secret production of HEU and is therefore a good deterrent. However, the interpretation of analysis results is difficult, since false-positive results can potentially result from spurious particle transfer.

- There needs to be an industry standard cylinder identification (ID) system for UF6 cylinders. There should be a global standard for unique ID numbering, a systematic and permanent way of marking the ID on the cylinders, and automated methods of reading cylinder ID's. This is of fundamental importance for the tracking of cylinders and therefore for the accounting of uranium contained within them.

- We must learn from field trials before new techniques are implemented. Many new techniques are currently being proposed for safeguarding of GCEP's, and it is clear that full-scale field trials must be carried out on GCEP's with participation by international safeguards inspectorates, before any of these techniques can be implemented.

- The physical presence of inspectors on nuclear sites is invaluable. Many ideas are being discussed for installing safeguards monitoring equipment in GCEP's - for example to make better use of inspectorates' resources – but there will always be benefits in people inspecting nuclear sites. These include the direct human interaction between operators and inspectorates to avoid misinterpretations, and the ability of intelligent inspectors to spot potential indicators of misuse of a GCEP.

- It is crucial that centrifuge enrichment technology is maintained as a state secret. In the wrong hands, such technology could be misused, to make weapons-grade enriched uranium. Therefore the safeguards verification of GCEP's must respect national security regulations and the need-to-know principle. This does present a dichotomy: how to balance the need for secrecy of centrifuge technology with the safeguards need for curiosity of inspectors.

- There is a continuing need for thorough training of safeguards inspectors. This is particularly important since many experienced inspectors will retire in the next few years and new inspectors will be recruited. Inspectorates see training courses at GCEP sites as being particularly useful.

4. Divided views

There were divided views on the following points:

- Should inspections for flow verification be scheduled or randomised? Currently, safeguards verification of nuclear material flow at a GCEP takes place at regularly scheduled inspections. These are well planned, and so it is possible to verify all of the annual flow of nuclear material. Some delegates thought that such verification should take place at random, unannounced inspections: the deterrence effect would then permit a reduction in the number of inspections and would therefore help reduce inspection costs. However, there are philosophical differences of view on whether the partial coverage by unannounced inspections is worth as much as the full coverage by scheduled inspections. Views were also expressed that flow verification by unannounced inspections would be messy, with much wasted time on site.

- What is the right balance between inspectors and equipment? Currently, safeguards verification of GCEP's is mainly carried out by inspectors who can provide thought and interpretation. On the other hand, the installation of more monitoring equipment would relieve the burden of repetitive tasks and provide objective results. However, many saw dangers in monitoring equipment.

- Is detailed process monitoring desirable? Currently, safeguards verification of GCEP's is carried out by monitoring the flow of nuclear material to and from site, and between the storage area and the process plant. Monitoring of the enrichment process itself (i.e. the flows into and out of the cascades) would more thoroughly detect misuse. However, it could lead to an increased complexity and cost, and has the potential for compromising sensitive information on centrifuge technology with regard to both proliferation and commercial aspects.

- Should data be transmitted off-site? If data from safeguards monitoring equipment were automatically sent off-site (for example to IAEA headquarters in Vienna), this could reduce inspection costs (by reducing inspector travel). However, many thought it is not wise to allow potentially sensitive data to be seen by people who might not be known to the state in which the GCEP is located.

- Will more equipment reduce total costs? Some claimed that costs for safeguards verification would be reduced by partially replacing inspectors by monitoring equipment. Others doubted that that would be so: they thought that equipment developers always underestimate the lifetime cost of equipment – particularly when such equipment is still in the early phase of development.

- Should inspectors be trained on-the-job? Some felt that it was beneficial for experienced inspectors to mentor new inspectors during on-site inspections. Others wished training to take place mainly during specialised training courses: both in-house and at GCEP sites.

All of the above questions warrant further debate.

5. Promising ideas

The following promising ideas arose during the working group discussions:

- Multinational GCEP's have a non-proliferation benefit. Over the last three years, there have been many varied proposals for multilateral nuclear assurance (MNA) schemes, which aim to ensure reliable supplies of nuclear fuel whilst avoiding the spread of sensitive fuel plants (including GCEP's) to many more countries. Some of these MNA proposals are for the wider use of GCEP's controlled multinationally.

- *Black-box* GCEP's have a non-proliferation benefit. The *black-box concept* is that the operator of a GCEP does not have access to centrifuge technology, so that he cannot build centrifuges. This would limit, but not eliminate, his ability to misuse the technology – for example, to secretly make HEU.

- The safeguards approach should be based on risk. Currently, the safeguards approach is similar at all GCEP's inspected by IAEA – clearly with account being taken of the capacity of a plant. Some argued strongly that the inspection approach should depend on factors such as: whether a state has signed an *additional protocol* agreement with IAEA, including allowing *complementary access* inspections; or whether IAEA has reached a *broader conclusion* about the complete and peaceful nature of a state's nuclear activities.

- Inspections should be triggered by information. This is an extension of the above concept. Where inspections are unannounced, then maybe the timing of an inspection should depend on information reaching inspectorates - from whatever source, rather than being chosen at random.

- A modified *continuous enrichment monitor* (CEMO) installed on a unit header could possibly replace attended *non-destructive analysis* (NDA). The current CEMO is designed to be installed on the header of individual cascades. However, a modified CEMO could be developed to be installed on the unit header (i.e. for a group of cascades).This could potentially give an accurate estimate of the enrichment of product and tails material made, and could replace NDA monitoring of cylinders, which is a time-consuming inspection activity. However, a disadvantage over the current CEMO is that product could potentially be withdrawn before it reaches the monitor.

- Operator's equipment/data could be used. This could give a way of gathering safeguards data more cheaply and reliably than if inspectorates install their own monitoring equipment. Such supply of safeguards data would need to be authenticated by the inspectorates.

- Cylinder tracking could be automated. The tracking of UF6 cylinders by a plant operator (and the verification by inspectors) around a nuclear site is mainly by manual means. Automated tracking would give benefits in terms of consistency, cost, accuracy and reduction of risk of falsification. Many different ideas for how to track cylinders are currently under discussion.

- Load cell monitoring could help detect undeclared feed. If cylinders of UF6 are fed to a GCEP from stations where the cylinders weights are continuously monitored by load cells for plant operational reasons, and if the load cell data were provided automatically to the safeguards inspectorates, this information could be used to count the number of cylinders actually fed to the plant. This count should agree with the operator's declaration. This would give added confidence that the operator was not feeding undeclared uranium to the plant.

Not all of these ideas were discussed in all four working groups, and not all conference delegates agreed with the ideas. Nevertheless, all of these ideas warrant further study.

6. Lack of enthusiasm

There was little, or mixed, enthusiasm for the following safeguards technologies:

- Cascade *header enrichment monitor* (CHEM).This instrument has been used to measure the U235 enrichment in cascade header pipes during limited frequency unannounced access (LFUA) inspections for many years in Japan and UK (although the instrument in use in UK became unreliable and was withdrawn in 2008). The instrument is used to confirm the presence of LEU. Whilst delegates could see that CHEM was useful for detecting HEU production, many thought that the instrument seemed cumbersome to use and that the effort was hardly worth the limited information gained from it. Nevertheless, others were in favour of upgrading the current instrument, to improve its usability, by replacing liquid nitrogen cooling by an electrically-powered cryostat.

- Current *continuous enrichment monitor* (CEMO). This instrument has been used to continuously to measure the U235 enrichment in 22 cascade product header pipes in UK for many years. Many thought that the instrument was too expensive, and that its old software made it difficult for inspectors to use. Most seemed to prefer a modified version of CEMO, which would be installed on a unit, rather than on each cascade (as detailed in section 5 above).

- Flow monitoring. An instrument could be developed to monitor the flow of UF6 gas in a pipe. Most were not interested in this idea, because they thought in unnecessary or too intrusive to monitor the flows of UF6 in pipes, or because the flows could be measured more easily by load cell monitoring.

- *Radio frequency identification devices* (RFID's). In theory, a RFID could be fitted to each UF6 cylinder to track its location on a GCEP site. There are many different types of commercially available RFID's, and these have been tested extensively in recent years - both in the laboratory and in the field. The conference generally felt that such a device held promise for the longer-term future, but that all of the current RFID's had limitations which would prevent their routine use in the near term.

These reservations need to be understood better before these technologies are developed further for safeguards use. Alternatively, the ideas should be dropped.

7. Concerns

Some – but certainly not all – delegates expressed concerns, which warrant further debate:

- How can clandestine plants be detected? The conference was devoted to the topic of how to apply international safeguards to a declared, known GCEP, in order to ensure that it is not misused. However, such safeguards can be bypassed altogether if a GCEP is built and operated in secret. Some argued that there ought to be a limit to the thoroughness of safeguarding a declared GCEP, as after a point, a state will simply build a secret plant. Methods of how to detect a secret GCEP were however outside the scope of the conference and were not discussed.

- There is unfairness due to a lack of a level playing field. Most of the uranium enrichment plants in nuclear weapons states are not subject to international safeguards – either because the state concerned has not made them available for safeguards verification under their *voluntary offer safeguards agreement*, or because IAEA has chosen not to safeguard them. As these plants constitute around three-quarters of the enrichment capacity in the world, some felt that this was rather unfair on those operators whose plants are safeguarded. A few thought that the whole concept of safeguards was undermined when so much of the world capacity for uranium enrichment was outside the scheme.

- Process monitoring could spread sensitive information. There was a fear that detailed monitoring of the enrichment process could compromise sensitive information on centrifuge enrichment technology, and that this could be potentially harmful for nuclear weapons proliferation or for competitive reasons.

- Operators feared that new safeguards monitoring equipment could be unreliable and might give spurious false alarms. Government regulators feared that equipment could breach security or safety regulations. It was stated that proposed new equipment must take account of operator and regulator requirements.

- Whilst all employees of the European Commission (including Euratom) and the enrichment companies have to be security cleared by their host country, employees of IAEA are not security cleared. Some were concerned that there was a risk of IAEA inspectors, and maybe other IAEA staff, leaking sensitive information on GCEP technology. Put simply, some thought: "If people are not security cleared, then how can they be trusted with sensitive information?"

8. Conference follow-up

After the conference:

- All delegates were invited to complete a feedback questionnaire – and a surprisingly large number did fill these in!

- The proceedings of the conference – which comprise all of the PowerPoint presentations, including the breakout session summaries and the conference summary – were published to conference delegates on URENCO's web site, four days after the conference ended.

- A two-hour long video film of the conference was issued on DVD by post to those who requested one (around half of the conference delegates). The DVD's were mostly received within a month of the end of the conference.

- This paper constitutes the formal summary of the conference.

9. Acknowledgements

I particularly thank the following:

- Dunbar Lockwood and Michael Whitaker, who led the NNSA-sponsored workshop on demonstration of safeguards technologies at ORNL in July 2008 [1]. URENCO deliberately copied aspects of the format of that workshop: particularly the working groups and feedback sessions.
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- Bart Dal, Geoff Dickinson, Mike Beaman and Brian Boyer, who chaired the four working groups so enthusiastically and professionally – we are so grateful for their hard work, especially as none of them had any idea beforehand of how demanding the task would be. The working groups were the key to the success of the conference.

References

[1] *Demonstration of Safeguards Technologies for Uranium Enrichment Plants Workshop*, by Janie McCowan, Oak Ridge National Laboratory.Paper #298 presented to 49th INMM Annual Meeting; Nashville, Tennessee; July 2008.

Note: This paper will be presented at the *Symposium on International Safeguards: Preparing for Future and Verification Challenges*, IAEA Vienna, 1-5 November 2010.